Environmental science in the new millennium: a model to give structure and guidance

James M. Lipuma
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ABSTRACT

ENVIRONMENTAL SCIENCE EDUCATION IN THE NEW MILLENNIUM: A MODEL TO GIVE STRUCTURE AND GUIDANCE

by

James M. Lipuma

This work proposes a template for successful interdisciplinary Environmental Science (EVSC) programs at four-year American learning institutions. The first conclusion reached is that there is no one “perfect” program. Only by identifying clear goals for EVSC can programs improve. It was determined that a clear definition of EVSC and mission statements related to these definitions are necessary first steps to allow improvement to occur. One major outcome of the work is the educational model built to understand EVSC education. The model identifies methods by which the goals and objectives of EVSC can be identified and accomplished. The research found that several common objectives—content knowledge, problem-solving, communication, and interdisciplinarity—have constant methods of being accomplished at institutions—curriculum, faculty, extracurricular activities, and external advisement—which provide a program the ways to transfer knowledge to students in order to achieve the specified outcomes listed in the mission statement. Each of these areas was explored and means for improving them are given. One major finding relates to using a management model for promoting faculty improvements.

A common thread identified in all programs was problem-solving and its related skills. In every program, at all levels, the need for students to master the skills related to problem-solving were highlighted as important. To this end, a student guide is included in the appendix to assist in the teaching and improvement of student problem-solving skills.
ENVIRONMENTAL SCIENCE EDUCATION IN THE NEW MILLENNIUM:
A MODEL TO GIVE STRUCTURE AND GUIDANCE

by
James M. Lipuma

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This dissertation is dedicated to my family without whose help, understanding, and support this work would not have been possible.
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CHAPTER 1
INTRODUCTION

1.1 Introduction

In education, determining one’s goals is vital to the evaluation of progress and the determination of success. Destination is dependent upon a clear specification of goals. With regard to this dissertation, the primary goal is to understand the process of Environmental Science (EVSC) education and describe the elements of an effective educational program in that field. When this dissertation began, its purpose was far less clear and defined. Over time, the ideas contained within were distilled out of the vast quantity of information that had been gathered from the wide range of fields consulted during the research process. Only after examining the goals and objectives of all environmental education and that of a university-level education in general could teaching Environmental Science be understood. As this dissertation discusses the many related topics of education, it is important to understand that each is related to the other. Though they are presented in a linear fashion, the research was conducted in a more iterative way in that information from one area supported and informed all others.

The process of education is at the heart of any program and thus at the center of this dissertation. In theory, a program of study, at any level, at any college or university, has the intention of transforming students into something they were not at the start of their academic careers. This change is accomplished through a variety of means. In whatever way it is accomplished, a successful program has students enter as a raw material and should transform them into some end-product specified by the goals and objectives of the program’s curriculum. Whether the program is a day, a course, a degree, or a lifetime of
education, upon completion, the student should have become accomplished at what was specified as the goals of the educational process. This result, however, may not be the case in every instance. So dynamic is the interaction being discussed that many see no way to clearly look at it other than to say it is a “black box.”

Later in this dissertation, a model of the educational process for Environmental Science will be presented and discussed. At this point, though, it is helpful to say a few things that can assist in the understanding of what is to be presented herein. No matter how complex an issue may seem, it can be broken into component parts and examined as a set of units. The overall system has goals and each sub-unit has sub-goals. When used to examine education as a process, this goal delineation is very revealing.

All education shares a common set of goals—to provide students with knowledge, skills, expertise, and understanding in order to transform them into something they were not before. The motivation of the students, the means of accomplishing the goals, and the outcome of the process may be varied, but the process itself should always have this large overarching goal. Since learning is a change in thinking, a successful educational process changes the way students think. This, in and of itself, is not nearly enough to clarify what lies in the “black box” of education. Rather, it is necessary to examine the interconnected and intertwined processes that comprise education. By looking at programs, it is possible to see many different ways of identifying and exploring goals that they have. At this point, however, this work will only look at some general areas.

Before delving deeper into the topic, it is useful to discuss the main goals put forth by programs as might be seen from the students’ perspective so that a baseline set of measures can be established. Any program can be said to provide a student with three
major outcomes. The first is awareness. Some courses have the goal of informing and raising the awareness of its students. Many times this awareness is simply an introduction to a much larger subject or issue that the student can pursue through self-driven action or further course work. A second outcome of the education process is to create a deeper understanding in students in order to enlighten them about a topic or field of study. Finally, the most practical end of education is to provide students with useable skills that will assist them in securing employment. Far too often, this final outcome is the only one sought by students or promoted by universities.

Beyond these goals, and to some extent a part of them, are other objectives that the educational process hopes to attain in order to produce well-rounded and complete students. The idea of improving analytical and thinking skills is of particular concern. Also, other important facets such as social skills and civic responsibility may be included as goals of some experiences promoted by higher education. However, these other goals may be seen as part of the three major goals.

Whatever the outcomes of courses or programs, the question must become what objectives are set so that these larger goals are reached. It cannot be hoped that any of these three—awareness, enlightenment, or employment—can be achieved just by forcing students to memorize facts or to enroll in a prescribed set of courses. Instead, each discipline outlines a more refined set of goals that are to be achieved by students upon completion of the program. This dissertation hopes to determine what objectives should be set for EVSC programs as well as give some methods for accomplishing these objectives and the overall goals of education. Beyond that, some means of implementing those methods will be given to bring the dissertation full circle. What began as an endeavor to
This dissertation is different from many in the field of EVSC because this work is the first in the policy track of the Environmental Science Doctoral Program at the New Jersey Institute of Technology (NJIT). This work combines the rich scientific understanding that is obtained from the completion of the rigorous requirements of the EVSC program with the insights provided by the many other disciplines at NJIT including Humanities, Social Science, and Management. Though this work does not restrict itself to the more technically oriented intellectual endeavors traditionally related to EVSC, the work it contains is as important to and necessary for the continued improvement of EVSC.

By incorporating a variety of fields and utilizing tools from many disciplines, this dissertation allows an introspective and descriptive analysis of the current state of EVSC programs in America. The ultimate outcome of this work is to understand what can be done to improve EVSC education at all levels and in all types of programs.

Rather than just reviewing programs, actual program directors and other personnel have been asked their opinions about EVSC as part of this work. This undertaking is important to the improvement of EVSC programs in general. In addition, it is necessary to help understand what is involved with meeting the new higher standards of those involved in the EVSC education process including those set by accreditation boards, enlightened students, and demanding employers. In the end, the dissertation can be used as a guide to those hoping to create a program, assess their current status, or find ideas about how to improve their existing program.
1.2 Overall Topic

Before moving further, it is important to have a general view of the topics of interest—in this case, the “black box” of education—to understand how the specific areas being discussed fit together. Though the dissertation will discuss the specifics of Environmental Science, this does not mean the general education process or that used for general Environmental Education (EVED) does not apply. Rather, EVSC education is a specific case of these more general areas. Like the set of concentric circles shown in Figure 1.1 below, all the tools and lessons used to teach students generally about any subject and those lessons that all students must learn about the environment are equally as important to the EVSC student.

Figure 1.1
Environmental Education as a Subset of Other Educational Schemes.

KEY

GENERAL EDUCATION

ENVIRONMENTAL EDUCATION

ENVIRONMENTAL SCIENCE

Figure 1.1 shows how Environmental Science, like many other academic programs, can be seen as a subset of larger educational programs or the overall educational process.

Beyond the general lessons learned as part of the larger educational system are a set of skills, knowledge, and expertise that EVSC students must also master so that they can accomplish the goals of an Environmental Scientist. It is these methods of teaching and, more generally, the objectives that they hope to attain that this dissertation endeavors to
understand. To that end, the study begins with the goals and methods of general education. Once these have been specified, the field of Environmental Education in its various forms and levels will then be examined. With these two more general areas examined, the dissertation will then focus on the many aspects of EVSC.

It is important to provide perspective about the scope and importance of the research topic. To do this, the goals of the dissertation and education in general must be more clearly specified. In addition, certain simplifying assumptions and parameters must be set so that the field can be described, examined, and then understood by those who read this work.

1.3 From a Student's Perspective

To uncover what the goals of good educational processes are, it was at first thought helpful to look at the problem from the perspective of the student. When first exploring the ideas that underlie this dissertation, it was important to examine what a prospective college student might face when making a decision to become part of the field of EVSC.

As a person contemplates the question of what college to attend and what major to choose, many options are presented and, thus, many decisions must be made. A student who wishes to enter a field related to the environment is faced with these dilemmas as well as several others. To assist the students and their families with the process of comparing and choosing, many tools, guides, rankings, and other systems have been developed to show them leading schools in the country (Critical Comparison, July 1997; Peterson's, 2000; U.S. News and World Report, 2000; National Research Council, 2000; National Center for Educational Studies, 2000; Student Conservation Association, 1997; Princeton Review Publishing, 2000).
Unfortunately, many of these tools base their assessments on reputation, statistics, and past performances of students. A good example of this is the U.S. News and World Report’s ranking system which now has sixteen different measures. These measures fall into the following seven categories: academic reputation (based upon surveys of University Deans and Presidents), retention of students, faculty resources, student selectivity (based upon test scores, GPA and admission rates), financial resources, alumni giving, and graduation rate performance (for national universities and liberal arts colleges) (U.S. News and World Report, 2000). Even as students use these rankings and other tools to choose an institution, many colleges put forth these statements as proof of their accomplishments. Few, if any, try to explain to the student what will be asked of them, what they will receive in return, and what the university or college is attempting to do as they educate. More importantly, most rankings or comparisons that exist do not address specific programs but rather try to judge the overall institution on some comparative set of criteria.

Even if the systems currently in place or those being developed to replace them could accurately determine the amount of value a university gives to a student, these rankings are for overall institutions. In no way does a university provide the same education to every student in every major. To claim this is to claim the institution is an assembly-line producing identical precision-crafted pieces rather than individual thinkers. In order to achieve an assessment that better reflects what a program provides a student, an evaluation must look at curricular and programmatic issues rather than institutional-based and student-based ones. Though a comparison may be made between the former and the latter, this relationship will be used more to reveal differences to those who must choose rather than give a ranking that is meant to be used as a marker of the “best” choice.
1.4 Narrowing the Search

With little useful knowledge utilizing a student's perspective, another approach was sought. No rankings existed that could classify the programs related to the environment that currently exist. As the search for exemplary Environmental Science programs moved forward, it quickly became evident that this seemingly simple task was more difficult than one might imagine. A wealth of listings, evaluations, comparisons, and databases exist describing existing programs in many fields. Some listings included those fields that in some way have environment in the title or that might relate to the environment even tangentially. Numerous analyses, with diverse opinions, have published comments and critiques of these rankings as well (Casper, September, 1996; Education and Social Science Library University of Illinois at Urbana-Champaign, 2000; Levin, 2000; Paul, 2000). It was difficult, however, to find visionary guidance for those attempting to choose a future in the fairly young and still burgeoning field of EVSC.

Rather than examine what exists, what is taught, and how more can be added to the mass of questionable information, it is important to look towards the future to see what should be taught. Until there is something created to steer students and program developers towards what should be in a program, a lack of direction and a general chaos will remain. Several articles and new ideas have emerged in the past five to ten years concerning the idea that a new method of educating students at the university level is needed (Angelo, 2000; Seaman, October 26, 1998). In addition, and more important to this discussion, is the belief that some type of accreditation for environmental programs should be developed and a means of certifying graduates from these programs should be instituted.
Unfortunately, there is not a great deal of existing material concerning assessment.

1.5 Goals of the Dissertation

With more confusion than clarification, other avenues of research had to be pursued in order to help specify the goals of this dissertation. As well, the sheer immensity of the related topics required some simplifying assumptions and parameters to be specified. To that end, it is the intention of the author, through this dissertation, to determine what are the aspects and content of an effective program for the study of Environmental Science at the post-secondary level at four-year degree granting institutions in the United States. These programs are relatively young, and present a unique programmatic situation that needs to be viewed separately from many of the traditional programs found at institutions of higher education.

By utilizing the tools of social science coupled with the understanding of Engineering, Environmental Science, Policy Studies, and Education, as well as the many great works that form the cornerstone of environmental literature, the author hopes to produce a template for the evaluation of programs in Environmental Science. Among other topics that will be discussed are the balance needed to be struck between breath of knowledge and depth of knowledge, the minimum set of skills and tools needed by Environmental Scientists, and disciplinary versus multidisciplinary and interdisciplinary skills that are required to understand the fields discussed.

To accomplish these goals, extensive research has been completed, including the review of numerous existing programs and the administration of a two-phase set of surveys. The first of these surveys was used to determine schools that have good programs
for the general education of students in Environmental Science. From the results of this first survey, a second survey designed to determine what the goals and content of an effective Environmental Science curriculum should be was then administered. All of this research is compiled and presented as the final outcome of this dissertation with the clear understanding that any educational process has many variables, including students, professors, resources, and time. Nonetheless, the final outcome of this dissertation can serve as a blueprint for assessing programs and improving the quality of Environmental Scientists produced by American colleges and universities.

1.6 Dissertation Overview

Before presenting the specific findings regarding EVSC education, it is important to describe the objectives of the dissertation. Chapter Two presents a brief discussion of background materials related to the many topics discussed in the dissertation and used to help develop the models and tools. The background material will begin with a discussion of program assessment and rankings to present some of the existing tools being implemented. From there, a review of the recent shift in curriculum accreditation, the move to certify environmental professionals, as well as the overall assessment of environmental programs and people, will be conducted.

With this background established, the dissertation will move on to explain the interrelated areas of General Education, Environmental Education for all individuals, and, finally, Environmental Science Education. Chapter Three will discuss the aspects of General Education. This chapter will focus on the development of an operational model for General Education drawn together from the existing literature. This model will be
presented and explained so that a firm groundwork for the remainder of the dissertation can be established.

An overview of the state of Environmental Education will be undertaken in Chapter Four. This is a vital part of all EVSC education since environmental messages are being infused into the entire curriculum for students of all ages. This chapter looks at the history of the environmental movement in America and the current state of general Environmental Education.

With this historical survey in place the dissertation can move to the discussion of the specifics of EVSC education in Chapter Five. Having set the stage and described the situation that exists today, the remainder of the dissertation concerns the primary research conducted to understand what should be included in EVSC programs. In the remainder of the dissertation, the fundamentals of Environmental Science programs will be discussed, and the research conducted to determine the structure and content of good EVSC programs is presented.

Chapter Six presents the methodology of the study conducted by the author to evaluate the existing EVSC programs at four-year colleges and universities in America. In order to build a model program for the future, research into existing programs as well as literature and other sources that contribute to the field of EVSC has been examined. Chapter Seven examines the data that was provided by the series of surveys and follow-up phone calls conducted as part of the dissertation. More than just a descriptive analysis of what exists today concerning EVSC programs, this dissertation synthesizes current materials in order to develop a blueprint for the creation of new programs, guidance for
existing programs, as well as a set of criteria that can be used by accrediting boards and certifying agencies when examining EVSC programs around the nation.

Chapter Eight presents the conclusions of the survey research. Chapter Nine gives some methods of assessment and evaluation that can be used to test the model or assist in implementing aspects of it in existing programs. The dissertation proposes a template for the development of truly interdisciplinary EVSC programs that transfer knowledge of tools and skills to students, trains them to think critically about environmental problems, prepares them to communicate and interact with the various disciplinary experts that are needed to address environmental problems, and prompts them to utilize all their acquired skills and knowledge to successfully solve problems. Finally, Chapter Ten examines the constraints placed upon the dissertation and discusses ways that research may be continued and expanded by other researchers. Beyond that, this chapter gives some potential research projects that can be pursued in the future.
CHAPTER 2
BACKGROUND ON PROGRAM ASSESSMENT

2.1 Introduction

Before discussing the various aspects of education, it is important to examine the way educational programs in America are evaluated. This background in the evaluation process is vital to understand how the remainder of the dissertation proceeds and also shows why it is difficult to simply designate a program as "good." Evaluations can be comprised of many different types of processes utilizing a wide range of different scales. There are rankings, assessments, and accreditation standards that colleges and universities undertake and participate in from both internal and external boards and agencies. These evaluations are intended to demonstrate effectiveness and determine accountability. As a result, having an understanding of how and why these evaluations are conducted is useful when examining programs and choosing the best aspects of those being examined.

This chapter begins with a discussion of the systems used to rank various colleges in America. After that, it moves to a more in-depth discussion of the need for evaluation. Finally, a description of the theory and practice of evaluation is given. With this clear understanding established, the dissertation can then examine various educational theories and practices that directly and indirectly play a role in EVSC education and program development.

2.2 Rankings

Our discussion begins with the idea of college and university rankings. There is much controversy surrounding the way academic programs at universities, and even the universities themselves, are evaluated and ranked. Some analysts propose that the rankings
are inaccurate, spurious, or even arbitrary. In September 1996, Gerhard Casper, President of Stanford University, wrote a private letter to James Fallows, editor of U.S. News and World Report, to express his concerns about the way colleges and universities are rated by that magazine. In the letter, Caper says, "much about these [U.S. News & World Report annual college ranking issue] rankings - particularly their spurious formulas and spurious precision - is utterly misleading" (Casper, September 1996). He goes on later to say, "Alas, alumni, foreign newspapers, and many others do not bring a sense of perspective to the matter. I am extremely skeptical that the quality of a university... can be measured statistically." This letter is a representation of the undercurrent of discontent which exists regarding the measurement of student performance, a university’s ability to teach, and many other intangible factors which have been ranked by U.S. News and many other sources such as Peterson’s Guide, Barron’s, and the Princeton Review, among others.

Even as this debate rages, others have sought different ways to evaluate and compare universities. Casper quotes from U.S. News & World Report’s own magazine about the idea of the value added to a student by a university. “Researchers have long sought ways to measure the educational value added by individual colleges. We [U.S. News] believe we have developed such an index” (Casper, September, 1996). Unfortunately, the way this index is developed relates to graduation rates, monetary expenditures, SAT/ACT scores, and other statistical measures (U.S. News and World Report, 2000).

In the October 1998 issue of Time, this issue of rankings was addressed. “What is wrong, [with current systems of ranking] many say, is that the conclusions are based too much on input—the current reputation of each school and the attributes of incoming
students. More helpful, they [university presidents] say, would be a measure of output—what consumers (that's what applicants really are) are likely to get” (Seaman, 1998). The article goes on to discuss some of the drives for output-based assessment as well as some of the more innovative ranking systems that attempt to assess this output. For example, “New York State has announced that it is developing a system to measure, among other things, the value of a degree” (Seaman, 1998). This type of assessment is important, but does not provide the complete picture of what can be done or what is needed.

New research into an advanced system of outcomes assessment has been ongoing at the University of Pennsylvania by Robert Zemsky. Zemsky is working on a report, due out soon, that will rate schools on “how their graduates fare after they leave school” (Seaman, 1998). From several sources (University at Buffalo, 2000; State of Virginia, 2000; Institute for Research on Higher Education, 2000), it is possible to understand how this new system of assessment is different from the typical rankings that may exist. The study looks at what graduates do after graduation and attempts to correlate this with the quality of the educational experience. Though outcome is an important part of assessment, making output the measure of a university does not seem to be any better than inputs. In either case, the goals of education and the process used to attain those goals is almost entirely overlooked. It is this idea that must be examined and, if possible, evaluated.

2.3 Evaluation

2.3.1 Introduction

There are two issues that need to be discussed when speaking about evaluation. First, we may ask why there is a need for evaluating educational programs dealing with Environmental Science? Second, we may ask what is meant by evaluation? In particular,
the latter question focuses on the methods needed to examine educational programs in
general and EVSC programs in particular.

When looking into the need for evaluation of EVSC programs, several reasons
surface. First, the Accreditation Board of Engineering Technology (ABET) has changed
the way it accredits programs (Accreditation Board for Engineering and Technology,
December, 1997). The shift from credit hour requirements to a more outcomes oriented
systems has increased the need for evaluation of programs. Moreover, there has been a
continuing discussion about making shifts in the way higher education is conducted
(Angelo, 2000; The Higher Education Information Resource Alliance, 1996 Association of
Research Libraries, Association of America Universities, & Pew Higher Education
Roundtable, 1998; Toombs, & Tierney, 2000).

In an age of cost-cutting and accountability, calls from within university
departments and administrations for new ways of assessing programs and, in particular,
student benefits from small classes and innovative teaching styles has led to many changes,
including new evaluation systems some of which are outcome oriented (Collins & Romjue,
Spring 1995; Engel & Dangerfield, 1998; Grimmett, Fall 1996; National Science Board
and the Government-University-Industry Research Roundtable, July 1994; Romjue, &
Collins, September 1996; Western Carolina University, 2000). Also, students want more
than just requirements that will lead to an uncertain outcome. They are seeking an
education that has value added for time and money invested (Barron, 1992; Brown, 1997;
Paulsen, 1999). With such pressures, designers and reviewers of curricula are being asked
to make hard choices and justify decisions with reports and evaluations of class outcomes
(Iowa State University, 1998-99; Hendricks, 1999; Waddington, 2000).
Narrowing the focus to environmentally related programs only adds reasons to the list of why a new methodology is required. In 1994, the House of Representatives took the first steps towards regulation of the environmental industry (Richardson, Jan/Feb 1994). The law called for oversight by the Environmental Protection Agency (EPA) of any organization that offers certification of environmental professionals. This act also suggests that programs in environmentally related fields need to be accredited. Shortly after that, John Lemons reviewed the ideas underpinning the need for accreditation and certification of environmental programs in an article in the July, 1994, issue of Bioscience. He states, “Generally speaking, the more narrowly bounded the subject matter of a discipline, the easier it is to define a coherent core in a curriculum. Because environmental subjects require knowledge from a multitude of specialties, defining a coherent core curriculum for environmental programs is problematic” (p475). As can be seen from these examples as well as others, there is a need for evaluation (Levin, Lazorack, & Sears, Spring/Summer 1989; Perrin, 2000; Porter, 2000; Regan, July 1998).

2.3.2 The Idea of Evaluation

This brings us to the idea of what is evaluation and what content and materials are being evaluated. In their book, Evaluation, A Systematic Approach, Peter Rossi and Howard Freeman (1989) define evaluation as well as several terms that are key to understanding these types of program assessments. Evaluation, for them, “is the systematic application of social science research procedures for assessing the conceptualization, design, implementation, and utility of... programs” (p.18). In order to evaluate a program, that program must have a goal, as well as have systems in place to reach objectives that lead to that goal. “Programs can be developed only in relation to a goal. For evaluation purposes,
goal setting must lead to the operationalization of the desired outcome—a statement that specifies the condition to be dealt with and establishes a criterion of success (objectives)” (Rossi & Freeman, 1993). When a long-term overall goal is broken into sets of tasks, they are referred to as objectives. It is these objectives that must be set by a program and evaluated by the researcher.

In general, the National Board of Education lists three goals of education. According to their website, “The dimensions of evaluation as applied by the NBE are efficiency, effectiveness and economy” (http://www.edu.fi/e/oph/arvioi.html). These three terms are defined by the NBE in specific ways for evaluators to follow. These terms give general guidance to the goals that must be reached by a curriculum. According to the NBE,

Education is efficient, when the functionality, flexibility and scheduling of the education system, administration, and practical arrangements are as appropriate as possible. Education is effective when the skills it produces advance the mental growth of the individual and the development of society, culture and working life. Education is economical when resources are appropriate and put to optimum use in production of educational services. (http://www.edu.fi/e/oph/arvioi.html)

The NBE provides a detailed list of measures that can be used to evaluate these three general goals. A program, new or existing, must meet these criteria; however, the specifics of how they meet them are left to the program assessment experts. Unfortunately, these goals tend to evaluate how a program is run to accomplish its goals and objectives rather than assess what a program attempts to accomplish and judge how well it has accomplished those goals and objectives. The NBE scores the delivery method, not the senders and receivers of the message being delivered or the message itself.
As we discuss the fields of Environmental Education and Environmental Science further, more specific goals will come to light. In the same way that the NBE says that the goals they have identified should be the basis for evaluation, more area-specific goals can, and should, become the basis of evaluation in Environmental Science.

In the end, however, it is important to remember that an evaluation does not stand by itself. No matter what the criteria of evaluation, or the program being evaluated, the results must be scrutinized and compared to research that has come before. As was reported "Stresses on Research and Education at Colleges and Universities: Institutional and Sponsoring Agency Responses Report of a Collaborative Inquiry" (1994),

Educational experiments often take place on a single campus. They are rarely studied or evaluated by other colleges or universities that stand to profit from knowing about them. Inter-institutional cooperation in educational experimentation ought to become more common. It is possible for a group of institutions to plan specific educational reforms jointly, to try out variants of these on individual campuses, to monitor these experiments, and to learn from them. These experiments would then be the common concern of all the institutions involved. Each would have invested funds and manpower resources. Each would have an interest in incorporating into its own programs the results achieved. (National Science Board and the Government-University-Industry Research Roundtable, July 1994)

However, for educational reform to occur, there must be a blueprint or model for such cooperation. By drawing on various fields, it is the hope of the author that this dissertation will be able to do just that. Before going further, it is important to present the theories on which this research will be based.

2.3.3 Theory

Traditional rankings, such as those undertaken by U.S. News & World Report (2000), break down aspects of the university community and try to assess their worth. The
various scores are weighted to give an overall score that can be compared to other schools’ totals. Other rankings, such as that conducted by the Princeton Review, rely upon survey results from students to assess other aspects of college life such as dorms, leisure, and teachers (Princeton Review Publishing (2000). These survey results are scored and totaled to comparatively rank the participant universities. In either case, the university is seen to be somehow a sum of component parts. Students are only as good as their statistics, professors as good as their wages and curriculum vita, and universities as good as their reputation, resources, retention rate and selectivity. Nowhere is the idea of the interplay of students, teachers, administrators, courses, and curriculum ever considered. The goals of courses, the worth of a curriculum, and the overall ability of a university to inform, educate, and improve students is somehow overlooked.

In the university model that this dissertation proposes to use, the measure of the university is goal attainment. Looking at the university from the student’s frame of reference, each student comes to a particular class to accomplish a desire. This might be gaining knowledge, skills, and expertise; fulfilling a requirement; getting a good grade; or moving along a required track towards a degree. At the same time, professors come to class with other goals that they wish to accomplish. In the same way that students’ goals are varied, so are those of the professors. Once the class begins, however, some goals may change while others remain constant. The goal of completing the course and learning the course content should stay constant throughout. Beyond the goals of the day-to-day operation of the class exists the greater goals of the entire course. These goals move from attending each class to learn that day’s materials, to successfully completing the course and attaining the many objectives set by the instructor.
Any one course is part of a larger sequence of classes that is the program or curriculum of study. That curriculum exists within a department that is part of an overall degree track. At some time, teachers, program chairpersons, administrators, and many others have come together to develop a program that is designed to attain goals—to succeed at transferring knowledge, preparing students, and promoting acquisition of skills. Overall, the success of the program is seen when students demonstrate that they are prepared for some greater task of learning and problem-solving that is to be accomplished outside the university setting.

At every level and at every interface, there are many goals and many measures of success. Students come to classes for various reasons that are ever-changing. Professors teach in a myriad of ways and for a variety of reasons, attempting to attain a variety of goals. To simply judge this complex interrelated model by assessing and evaluating a few variables such as inputs (students, professors, money, and resources), and outputs (graduates, retention, research, and placement) is an unreliable method at best. At worst, it attempts to reduce the complexity of the problem such that a divergent set of variables is made convergent by a set of restrictive simplifying assumptions.

Choices are made continually at the university by each participant in the model, making any assessment unreliable to some degree. Nonetheless, recommendations can be made for a way to view the university that might allow some measure of understanding. Unfortunately, most assessments are qualitative, or statistical, rather than qualitative. Statistics that attempt to measure existing tangible or semitangible variables, levels of attainment, and other such quantities do not clearly define what is important in education.
These statistics give factual answers to simple questions about education but leave out the complex and more important questions about the "why and how" of education.

Instead of just asking if a professor has a Ph.D., acquired grants, or published articles, the question of whether the professor relates ideas, instills knowledge, or motivates understanding might be asked as well. Instead of asking if students scored highly on the SAT's or have a high GPA, the questions might be whether they have a desire to communicate ideas, solve problems, adapt to situations, and think for themselves. The true measure of a university needs to be centered around the production of ideas and thinkers not people who can answer questions that have already been asked and answered by all those who have come before them. The true task of education is to prepare students and challenge the academic community as a whole to answer the questions of the next decade, the next century and the next millennium. We are producing the solvers of future problems.

The author suggests viewing a university as a complex set of linkages and interconnected operations. These processes deal with inputs and outputs, such as students, faculty, research, money, time and effort. At any interface is a set of unique students, faculty, programs, and institutions operating together to produce a product. Within this system is a set of unit operations that can be described by other unit operations. Eventually, as with other engineering evaluations, a small box is drawn around the individual actor—the student, professor, administrator, class, program or institution for example. No further delineation can be made at that point. It is then we see the near impossibility of statistically modeling the decision-making process because of the large number of influences acting on the decision-maker.
In this almost unimaginably confusing system must be found a new way of looking at and assessing the situation. If the whole system is seen as a set of innumerable choices leading to the successful completion of a degree, education can be seen from a new perspective. Instead of speaking about the value of a school with good libraries, the top ten percent of high school students, or the best parties in the country, the goals that the school hopes to have their students attain can be examined. General and specific requirements of programs and faculty can be discussed so that students can have an understanding of what is required to achieve "success."

In an age of shared information, distance learning, the Internet, and continuing education, should the value of a university be measured by the knowledge of its instructors or by the ability of those instructors to guide students to an understanding of how and where the answers to questions can be found? Education is more than lecturing. It must be concerned with the creation of programs that set attainable goals, and then works with students to have them attain those goals. The successful university would then no longer just be one that graduates bodies, but rather one that produces bodies of knowledge, applied technology, a better community, and equips people to adapt, solve problems, and think independently.

In order to accomplish this task, a new envisioning of education is needed. The classroom must be seen as a workplace where education is the goal trying to be attained. In this work setting, students are part of a team and the professor is the manager. The administration acts as upper management giving direction to the teams to instruct them on the goals that need to be attained and the methods and resources available for their
attainment. This view of education brings together many disciplines in an attempt to improve the educational process.
CHAPTER 3

GENERAL EDUCATION MODEL

3.1 Introduction

Having reviewed literature, a model of educational programs with good learning practices began to be developed. It was clear that there were certain aspects that must be included in any educational program for it to be successful. Though the literature gave insight, it was important to understand what already existed as well. To this end, the researcher examined the home pages of 400 colleges and universities to determine what was offered currently. Aspects such as the types of classes, organization of departments, advisory boards, program assessment, internships, hands-on experience, the background of faculty and staff, as well as many others were found. Since students of EVSC are part of the broader educational system, much of what comprises the learning experience for these students can be seen as common to all disciplines.

This chapter presents a discussion of the objectives of general education as it works to teach students and assist them in attaining the overall goals of the education. After a description of the objectives of general education, a framework will be presented and explained. Though the areas described by the model herein are broad, they provide a first step towards a more in-depth and structured understanding of what needs to be in a comprehensive EVSC program.

This framework is an attempt to lend order to the "black box" of education. Each of the component parts of the model can be examined to assist in the clearer delineation of the methodology of education processes. With this model, the blueprint for EVSC that appears at the end of the dissertation can be easily understood and implemented. To show
how this model is tied to EVSC programs, each objective will also be expanded to show how it relates to the field of EVSC. Though it is almost impossible to separate out the various operations of education so they can be seen in a completely disconnected way, the model attempts to classify different parts or units so that their function can be understood and thus utilized in an effective, efficient, and economic manner to teach EVSC.

To build the model, it was important to consult a variety of different sources. The first sources of interest are texts related to teaching and learning. The texts, *Learning To Teach* (Arends, 1994) *Educational Psychology* (McCarthy, 1994) and *Educational Psychology* (Slavin, 1994) all provide a good background to the fundamentals of the educational process. These served as a good starting point to help give a basis from which to work. Also, articles like, Leamnson’s “Learning Science Without Majoring in It” (Mar-Apr 1996), Marcinkowski’s “America 2000 and Reform in Science Education: Where Does EE Fit?” (Win 1992), Marcus’ “Self-Study In Higher Education: The Path to Excellence” (1999), and “How We Teach Is as Important as What” (O’Donnell, 2000) provided several perspectives on the education process especially that related to science education.

These works were not nearly enough so the search was broadened to encompass material related to various aspects of higher education and curriculum development. Books such as *Interdisciplinary Research* (Committee on Promoting Research Collaboration, 1990), *Interdisciplinary Curriculum: Design and Implementation* (Jacobs, 1989) and *Interdisciplinarity: History, Theory, and Practice* (Klein, 1990) gave more insight. General articles were also consulted such as “How Can We Teach Critical Thinking?” (Carr, 2000), “Critical Thinking in Community Colleges,” (Hirose, 1999) and
“University-Industry Interactions: Room for Diversity” (Killoren, 1994). These works provided more information and were helpful in providing a picture of general education. Yet they did not complete the picture of an educator.

A theoretical background was also sought. To assist in this endeavor, material related to the psychology and philosophy of teaching was sought out. Texts such as If the Shoe Fits... Developing Multiple Intelligences in the Classroom (Chapman, 1993), Basic Psychology (Gleithman, 1992), Seven Ways of Teaching: The Artistry of Teaching With Multiple Intelligences (Lazar, 1991), Dimensions of Thinking: A Framework for Curriculum and Instruction (Marzano, et al, 1988), and Psychology and Life (Zimbardo, 1985) all provided information about the various aspects of the education process including how learning is accomplished and how the mind works. In addition, some useful articles were found as well. “How Dry Is the Desert? Nurturing Interdisciplinary Learning,” by Tchudi and Lafer (September 1993), “Understanding Student Experiences of Environmental Education Programmes” by Clacherty & Ballantyne (Jan-Mar 1990), and “Integrative Education” by Walker (1999) show new trends in education and help provide a better understanding of both the student and faculty components of educational systems.

Even with this background, the model was still quite unspecified. Material focused on the specific area of environmental education gave the clearest guidance. These articles and texts provided examples and helped delineate the “black box” that the dissertation needed to present. The sources of information related to general environmental education and EVSC education gave a well-rounded view of the areas needed to help create the model. Texts such as David Orr’s book Ecological Literacy: Education and the Transition to a Postmodern World (1994) was a good start. Other texts such as Guide to Curriculum
Planning in Environmental Education by Engleson (1985), Environmental Education in New Jersey: A Plan of Action by the New Jersey Environmental Education Commission (April 1993), Handbook of Environmental Education by Saveland (1976), and Environmental Education: Strategies Towards a More Livable Future by Swan and Stapp (1974) all gave solid accounts of the various parts of the educational model that needed to be addressed to effectively teach about the environment. Many articles were used to supplement this information. Some articles that were consulted include: "Environmental Education: Academia's Response" (Kormondy & Corcoran, 1997), "Environmental Education Materials: Guidelines for Excellence" (November 1996), "The Concept of Cycles for Environmental Education" (Boschhuizen & Brinkman, 1995), "Teaching Environmental Science: Alternatives to Whole-Class Instruction" (Bowyer, Jan/Feb 1995), "Recent Developments in College Level Environmental Studies Courses and Programs" (Disinger, 1988), "Acquired Skills Profiles for Environmental Science Students" (Harrison & Grieve, Jul-Sep 1996), "Environmental Studies and Environmental Careers" (Heilich, 1999), "Context, Connection and Opportunity in Environmental Problem Solving" (Oppenheimer, June 1995), "The Inter-Dependence of Environmental Education, Economic and Industrial Understanding, and the Other Cross-Curricular Themes Within the School Curriculum" (Oulton, & Scott, Jan-Mar 1992), "Environmental Science: A Foundation for the Future" (Paldy, November 1996), "Recommended Competencies for Outdoor Educators" (Richardson & Simmons, 1996), "Impediments to Implementing Environmental Education" (Samuel, Fall 1993), "Environmental Education, Social Studies, and Education Reform" (Simmons, Sep-Oct 1995), "Toward a Preventive Environmental Education Curriculum: The Washington State University Experience" (Simpson & Budd,
Winter 1996), "Integrators: An Outcome of Environmental Education" (Thomas, Winter 1992), and "Region 8 Environmental Education Program" (United States Environmental Protection Agency, 1999). Many of these articles were helpful in developing the final model of a good EVSC program.

Though many sources have been listed here, many more were consulted as the model was developed and refined. It is difficult to say that any one work was vital to the model. Much of the literature that appears in Chapter Four related to the background of the environmental movement provide the philosophical underpinnings to much of what drives this dissertation.

At this point, it is important to explain the model and let it be judged as it stands. The remainder of the dissertation rests upon it, but, at the same time, works to both explain and reinforce it. Having said this, the model of general education follows.

3.2 General Education Goals

As stated earlier, for all fields, the overarching end goals of education are the same—awareness, enrichment, and employment. Along with these are other collateral outcomes such as intellectual development, sociability, civic responsibility, and maturity. It is important to understand what is meant by each of these terms and how they fit into the general education model.

Awareness is defined as the intent to inform students about a subject area. Many times, the opening material in a course is intended to introduce a subject and thus raise awareness. Also, in many institutions, there are entire introductory courses that satisfy general university requirements. These courses are also intended to inform and introduce students to subjects that are not within their discipline. Though few educational programs
have awareness as their only goal, raising awareness is part of the set of goals of educational programs.

In a similar way, enrichment or depth of understanding is another important goal of educational programs. In this case, some classes are intended to provide deeper understanding and a more in-depth exploration of a topic to students. Students are asked to delve further into a topic than was presented in a class oriented towards awareness or simple skill transfer. Classes intended to enlighten are taken to enrich the students learning experience or provide better understanding of a topic beyond that needed to accomplish tasks and solve problems. Elective classes frequently are not necessary to complete a degree but still provide a great deal to the student. This goal of education is vital to a well-rounded and well-prepared student. As classes geared towards awareness can broaden the breadth of knowledge, classes oriented towards enlightenment give greater depth to student learning.

The third major goal of education is to prepare students for employment. The educational process transfers skills, knowledge, and expertise to students to prepare them for a profession. Often, students see this end as the most important, and sometimes only, outcome of the educational process. Obtaining a degree provides students with the certification that they have attained a certain level of accomplishment in a particular field. With that certification, the educational system is preparing them for the application of these skills to an end; employment. Though this assessment is broad, the goal of employment brings together many parts of the educational system and focuses it on a single end. However, some might say that there are other goals of programs, but those
ends can be seen as part of the process of preparation for employment, expanding the
breadth of knowledge, or increasing the depth of knowledge of the student.

One of the most important collateral goals is intellectual development. In order to
attain the other three goals listed above, it is important for students to have the ability to
think, reason, and problem solve. Intellectual development is a vital part of the ability of
these students to attain employment as well as be enlightened and thus gain a deeper
understanding of a topic.

In addition, there are several other goals that the educational process may attain
whether they are specified or actively sought. As students attend classes, they interact with
others, are asked to manage their time, and are introduced to responsibility at many levels.
These experiences help to teach social behavior, civic responsibility, and maturity. While
none of these in and of themselves are particular ends of education, they all play a part in
the enlightenment and eventual employability of students.

Having discussed all of these goals, it is important to see that none are given as the
sole outcome of education. The process of learning is so complex, and has so many
variables that any of these simple categories is not sufficient to describe it completely.
However, as students grow over their four or more years that it takes to achieve a degree,
they are constantly working towards some or all of these ends by being part of the
educational process. Even though the goals may not be easily identifiable or quantifiable,
the objectives set to attain them can be described.

### 3.3 General Education Objectives

Having discussed the overall goals of general education, it is now necessary to look at
some objectives that are set to attain these goals. One of the most obvious and important
objectives is the transfer of specific disciplinary knowledge of the field being studied to the students. It would make no sense to teach chemical engineering without the classes dealing with mass balances, chemistry or other knowledge and expertise that are used by the students in this field. In the same way, EVSC students must be taught the lessons of environmental chemistry, toxicology, and many other environmentally related fields. However, though it is necessary for students to have content knowledge, skills, and expertise, they must also be given many other important skills, some of which may be far less tangible. For EVSC students, these will, of course, relate to a wide range of skills needed to deal with the various issues of science and the environment. The four major objectives that have been identified in the literature and from reviews of existing programs deal with the following: content knowledge transfer; problem-solving ability; the effective use of various communication skills; and interdisciplinary understanding.

In general, content knowledge is the disciplinary knowledge, skills, and experiences that are imparted to students by a particular class or set of classes. Usually, content knowledge relates to specific disciplinary information, methods, or techniques that assist students with the mastery of the overall discipline.

In addition to content knowledge, all students should be problem-solvers. No matter what the particular discipline might be, the objective is to have the student be able to apply the tools of the discipline to problems, both known and unknown, in order to arrive at a workable solution. Simply knowing facts and being able to identify objects is not enough. Students, especially those in EVSC, must be able to apply the content knowledge that has been learned as they work to solve problems and arrive at viable and effective solutions.
Problem solving can be defined as the ability to follow a systematic method for examining a situation, and determining a potential solution for it. This skill includes several abilities needed to carry out the process of problem solving. These other skills include: critical-thinking, decision-making, and research. Critical thinking is the ability to objectively examine a problem, identify motivations behind decisions, and rationally evaluate different facets of a problem or issue as well as the potential solutions to that problem. Decision-making is the process by which informed choices are made in order to evaluate, narrow, refine, or choose between alternatives. Finally, research is investigation either through literature sources or direct/indirect observation. It is used to gather information, test hypotheses, and assist in the evaluation of choices. All of these skills can be easily seen to apply to EVSC. Moreover, since EVSC focuses on solving both existing and potential problems with the environment, problem-solving skills are of utmost importance. In addition, due to the complexity of many environmental problems, these skills must be honed to a high degree so that EVSC students can meet the challenge that problems of the environment pose.

Beyond these two objectives is the ability of students to effectively communicate with others. Though equally as important as the first two objectives, the ability to communicate is often overlooked or given less emphasis in the educational process. Though the importance placed upon these skills by students may vary, even someone in the most isolated discipline must have some contact with others and be able to communicate. Each discipline has its own jargon, tools, and means of communication. Beyond that, the necessity to interface with and understand other disciplines requires both written and spoken communication skills. Whether asking for assistance or relating a solution to a
problem, this interchange can only be accomplished through communication. A successful learning process relies upon the ability of teachers and student to communicate effectively.

In EVSC, these skills are even more important due to the wide range of contact that the scientist has with multiple audiences. The environmental scientist must know how to interface with the wide range of individuals that are involved with the solution of an environmental problem. This includes the highly technical specialist who may assist in sampling, problem delineation, or remediation, the members of governmental agencies or politicians creating and enforcing laws dealing with the environment, or the technically uninformed citizen affected by any of a variety of environmental problems. Effective communications in all arenas is essential.

In every field these objectives are key. However, another area must also be considered to be equally important. Due to the complexity of environmental problems, environmental scientists must have an understanding of more than one discipline. In truth, they must be interdisciplinary to be successful.

No matter how interdisciplinarity is seen, it is a vital part of EVSC education. Multi/Interdisciplinarity is the understanding of the interplay between and among various fields of study such that one can operate at the interface between them. Interdisciplinarity also includes the idea of having the skills, knowledge, and expertise to operate in and communicate with people from more than one discipline as well as being able to draw upon and use the tools of these various disciplines.

More and more, other fields of study have seen that a broad interdisciplinary understanding of material so that content knowledge can be seen in context is a vital link in the overall education process. Too many times, this view of interdisciplinarity is
misunderstood. For many, disciplines are like marbles and being interdisciplinary means having a bag full of marbles. Instead, disciplines should be seen, metaphorically, as the leaves of a tree. Though one discipline functions as a unit, it is part of a greater whole. In this case, being interdisciplinary simply means being a branch with several leaves on it. Perhaps, if individuals are completely interdisciplinary and able to interface with all disciplines, then they might be said to be the trunk of the tree from which all else comes.

In practice, very little can be accomplished without interdisciplinarity. Few new advances can be achieved without an understanding of the past accomplishments of others. Without basic knowledge and an understanding of the interactions of the many areas of learning, far less can be accomplished in any program of learning.

3.4 Attaining These Objectives

Now that the objectives of general education programs have been identified, it is important to understand how these objectives and the larger overarching goals can be attained. In order for a program of study to assist students to attain these objectives, four major areas have been identified within programs: curriculum, faculty, extracurricular activities, and external advisement.

Curriculum is the prescribed set of courses that students work through to transform themselves in such a way to attain the goals and objectives set down in the mission statement of the program. Depending on the level of education and the complexity of the field, programs vary in the number and kind of courses required and suggested. Though it is the main instrument of student transformation, curriculum is not the only tool.

Faculty are the persons who assist the students with their transformation. Rather than be seen as simply instructors or evaluators, faculty are the managers of students
throughout their educational careers who are charged with guiding the student to the correct outcomes. As well, faculty are the leaders who must direct students towards the proper goals and assist them to successfully navigate around obstacles to education as they accomplish the objectives of the courses in the curriculum. By being models, faculty through shared research and instruction provide students with assistance at various levels as they move through the educational process.

Extracurricular activities are those things beyond the classroom that add to the learning experience and assist the student in grasping the content knowledge. These activities can highlight lessons from courses, foster a deeper understanding of course material, promote teamwork and collaboration, as well as expose students to material from a more advanced setting that they may one day find themselves in, such as advanced research or workplace situations. Examples of extracurricular activities include activities such as seminars, clubs, field trips, workshops, conferences, and plant trips or tours.

Finally, External advisement plays an important role in the learning experience. It can assist the faculty and the students alike. By having input from outside the program, new techniques, current research and methods, as well as many other new perspectives can be brought to the classroom and the curriculum in general. External advisement can keep a program on the cutting edge as well as assist students in becoming more aware of what their potential employers expect of them. At the same time, these same students gain access to equipment and expertise that is invaluable to their learning. Access to experts and their knowledge is a key to good education. Though no program should simply be a training course for a particular industry, an understanding of what are the current needs of employers as well as the state-of-the-art or even cutting-edge in technology, and other
areas, is vital to the effectiveness of the educational process. In addition, a program that keeps itself current and can offer real-world, hands-on examples and training experience gives its students more than just facts and processes. The program that interfaces with the outside world allows students to make the transition to the working world an easy one and one that facilitates continued learning and on-going education.

3.5 Model of Education

The following model was developed to show graphically what has been described above. To help clarify and specify the components of the model for Environmental Science, the research that is included in the following chapters was conducted. In order to help the reader understand the remainder of the dissertation and, in particular, the model on which it is based, a brief description of the model is contained in Figure 3.1 below. Following that is a list of definitions that can assist readers in understanding the model as well as be used as a quick reference.
Figure 3.1 is a graphical representation of the general educational model that leads to successful attainment of goals and objectives by students.
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<th><strong>Definitions</strong></th>
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<td><strong>Communication:</strong></td>
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<td><strong>Extracurricular Activities:</strong></td>
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<td><strong>External Advisement:</strong></td>
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Figure 3.2 is a list of the definitions for the terms presented in the model of education shown above in Figure 3.1.
CHAPTER 4
GENERAL ENVIRONMENTAL EDUCATION

4.1 Introduction
This chapter will give a background of environmentalism in America and then discuss the ideas of the modern environmental education of citizens in America. This is a vital part of the understanding of EVSC education for many reasons. First, understanding the history of environmentalism gives some baseline for understanding how EVSC came into existence. Beyond that, this chapter will explain why there are two different types of environmental education. One type of education is intended for all Americans no matter their age, education, or occupation. The other type of education that will be discussed in the next chapter relates to EVSC and other disciplines devoted to solving problems of the environment.

This chapter starts at the beginning of environmentalism and moves through a brief discussion of the roots of environmentalism in America. Having done this, it moves to a philosophical review of the works that support the need for general environmental education and EVSC education specifically. The ideas contained here relate to the shift that was and in many cases still is needed. This shift begins with awareness and moves to motivation. By the end of this chapter, it will be evident that general environmental education is vital to protection of the environment and so is a vital part of EVSC.

4.2 From the Beginning of Time

4.2.1 Introduction
In America, environmentalism may be said to have emerged during the colonial period. The North American continent was a storehouse of the bounty of nature.
However, as the country developed and became civilized, awareness of the loss of nature and the destruction that was being caused became more clear to those living at that time. By the turn of the twentieth century, views of nature and how it is to be dealt with began to change. As the century moved forward toward the millennium, the awareness and interpretation of nature continued to change and grow. From 1900 to late 1960, many writings reached the population helping to bring about the formation of the first Earth Day on April 22, 1970. This day was intended to create awareness of environmental issues that faced our world.

During that entire century, the government responded to the changing attitude of its citizens by enacting a variety of laws. These rules and regulations steadily grew in scope and intensity. Since the first Earth Day, environmentalism has gathered importance. To that end, many new disciplines related to the environment have been developed to deal with the many problems that have become evident with the environment. To assist in the understanding and solution of these problems, environmental education has been undertaken and fostered at various levels of the educational system—from elementary school to graduate school.

It is this history and development of environmental concern in America that the next section of the dissertation will discuss. Though the discussion could extend far into the past, the milestone that has been chosen is the first great debate over the fate of natural areas in America. For many years, the government of America had been setting aside portions of land in National Parks and National Forests. National Forests were intended to be areas used by the public for recreation and education as well as used for regulated commercial interests such as mining, lumbering, and grazing. National Parks, on the other
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hand, were to be used only for public use as education and regulation and enjoyment.

However, this interpretation of National parks came into question just after the great San Francisco earthquake of 1906 when the mayor of that city wished to enter the National Park and build a dam.

4.2.2 Preservation, Conservation, and Exploitation

As our country entered into the twentieth century, it was faced with a crisis like none it had ever faced. A dam was to be built on the Toulumne River that ran through the Hetch Hetchy valley in Yosemite National Park to provide water for San Francisco. For many like Gifford Pinchot, the champion of the Conservationists and first chief of the United States Forest Service, the dam was a prime example of how the natural world could be managed efficiently for the benefit of humans. Conservationists believed that natural resources should be used for the benefit of humans but never wasted. The interests of humans today as well as in the future had to be considered as the nation’s resources were consumed. As with the industry of that age, the conservationists preached efficiency and scientific management. However, some people, like John Muir, the leader of the Preservationists and founder of the Sierra Club, protested the dam saying that the National Parks of our country should not be intruded upon by commercial interests. They felt humans should not disrupt the natural state of the parks; instead, they believed that the parks should remain in their natural state. The Preservationists felt that a part of nature must be maintained in its unchanged natural state so that it could revitalize and restore those who could experience this unaltered nature.

What began as a solution to San Francisco’s water problems quickly became a national debate about the issue of wilderness protection. As these two sides debated, the
American public was made aware of the natural world and the idea it might be wrong to exploit it. Though the debate took place in the beginning of the new century the issues being discussed were first brought to light many years before.

More than twenty years before in 1890, the census bureau declared that the frontier was closed. Until this point, any American who was adventurous enough could set out for wild country. Now, that was no longer possible. America had grown up with wilderness as part of the culture and now it was disappearing. Fredrick Jackson Turner reflected the concerns of the time by saying that the loss of the frontier and, in turn, wilderness was a dangerous thing. The frontier gave America character, democracy, and many other important parts of its culture. Though much of America still wanted progress and industry, a portion of its citizens began to question the overriding assumptions of the age. Some feared progress. Others just wanted to keep a piece of the wilderness safe. Many diverse groups for a variety of reasons saw the need to set wilderness aside safeguarding it for the future.

The modern age just after the turn of the 20th century still valued the ideas of efficiency, industry, and utilitarianism. However, the culture also saw that the continued exploitation of America’s natural resources coupled with unbridled greed and industrial progress could destroy the country. In response to these fears, many wilderness clubs and societies began to appear. Some worked for the complete preservation of the natural world as John Muir suggested. Other looked for a more scientific management of the country’s natural resources as Gifford Pinchot had put forth. Both groups lobbied Congress and were successful in protecting large portions of the Federally owned land at the time. Both the Conservationists and Preservationists wanted to stop the wholesale destruction and waste
of the modern age. However, they did not agree about the way that this should be accomplished.

When the issue of the damming of the Hetch Hetchy Valley came into the public arena, these two groups took up opposing sides. Though both agreed that the National Park should be protected, Pinchot felt a dam was a valid use of the land. Muir did not. He felt that National Parks should be preserves that are not used for anything but recreation, if that. The idea that the land should be exploited was quickly dismissed by the general public and only the two positions—conservation versus preservation—remained to be fought over. In the end, the Congress of the United States sided with Pinchot and approved the dam. However, the significance of the debate reached much further than the floor of the Senate.

Through the process of the debate, Muir had brought the issue of wilderness preservation into the minds of Americans across the country. Wilderness was no longer an afterthought or abstract concept. He made it something people at the time discussed and debated for themselves. Then too, his words were so convincing and his fight so ferocious, never again would anyone think to intrude into the National Parks of our country. Thanks to Muir, the definition of a National Park was set. This fact was codified in 1916 by the National Parks Service Act.

The most important outcomes of the debate are still being felt today. By questioning the status quo and fighting for wilderness preservation, John Muir and the other preservationists helped change our culture. By the time Muir was able to speak to the public, over ninety percent of the virgin forests in our country had been destroyed. Wilderness, nature, and the environment were abused to pave the way for the future.
Thanks to Muir, the people of that age saw that it might be a good idea to save something for the people of tomorrow. Our attitudes towards the natural world stem largely from the concerns of Muir and Pinchot.

4.2.3 Summary of Laws and Regulations

This great environmental debate gave way to many more environmental laws and regulations as well. The ideas first put forth by Muir and Pinchot led to many other debates and new concerns for the environment. These concerns were manifest in the laws of the nation over the decades to come. The laws that were passed began with a call for research and support for state initiatives. In the end, as more was known about the problems of the environment, the laws became more encompassing and protective of the environment and responsive to the specific problems identified along the way. Today, there are several major regulations intended to protect the environment.

Though many of these laws were passed at different times, they are periodically reviewed and amended. Some of the most important of the environmental laws include: National Environmental Policy Act (NEPA), Clean Air Act (CAA), Clean Water Act (CWA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), Safe Water Drinking Act (SDWA), Toxic Substances Control Act (TSCA) (United States Environmental Protection Agency, May 8, 2000). In 1969, President Richard Nixon used his executive order to empower NEPA and compelled the government to address the problems caused by people in the environment. This marked a major change in the protection of the environment. As a result, the other laws were strengthened over time to reflect the growing awareness of
America to the problems of the environment and the ways that these problems could be solved.

The CAA and CWA both had existed as laws before NEPA, but after this executive order was passed, between 1970 and 1974, the CWA, CAA, RCRA, SDWA, and TSCA were strengthened. All of these acts were intended to protect a portion of the environment. This process has continued until today. In 1980, Congress took another step in environmental protection with the passage of CERCLA, also known as Superfund. This law was created to handle toxic waste disposed of throughout America that were polluting land, air, and water. The government stepped in to remove these toxins from the environment and dispose of them safely to protect human health and the environment. Since CERCLA and the other laws, many new visions of how to regulate persons and preserve the environment have come about. These first laws were intended to stop pollution and fix the problems that were being caused. After time, the new laws were intended to find better ways of producing items without causing pollution—preventing pollution before it was created. In the end, humans have become more in balance with the natural world. Rather than fix the problems that were being caused, it was seen that humans needed to stop causing the problems and find ways to live more harmoniously with nature.

The change in the intent of the laws and their power to set policy is related to the general American population’s view of environmental protection. In the 1970s much of the regulations were command-and-control regulations used to force polluters to comply and stop polluting. As time has passed, the need for this force has reduced and new
collaborative efforts have been undertaken between industry and government. Each has learned much about the environment and each other’s goals and objectives.

In the end, no matter what the intent of the regulations, awareness is vital to its success. To achieve awareness, education of the populous is vital. Many of the laws provide for education at all levels, from community awareness to programs in schools of all types. No matter what else the laws might hope to achieve, the newest ideas for environmental protection must be that laws cannot simply repair the effects of pollution. Rather, the causes of pollution must be dealt with in order to eventually live in balance with the world. Only by educating all those who might contribute to the problems of the environment can we hope to protect the environment. It is human actions that cause environmental problems and thus human actions and self-control that will be needed to solve those problems.

4.3 Foundations Of Environmental Education

Though Earth Day is now seen as the celebration of the environment, in 1970 it was the first attempt to raise the awareness of the general populous with regard to the problems of the environment. Even before that day, however, several influential texts had been written that discussed the idea of the environment. These texts form the foundation of environmental thought and are important to environmental education.

4.3.1 Fundamentals of Ecology

In his book Fundamentals of Ecology, Eugene P. Odum (1971) reminds us that ecology existed for many thousands of years before it was formalized into a science. He continues along this line of reasoning by describing the beginnings of the formalization and the early
inception of this new and vital science. Human interaction and comprehension of its environment is vital to survival.

Odum is often credited with the wide acceptance of the field of ecology as a science as well as giving the fledgling field a great deal of definition. In his own words, “To many, ecology now stands for the total of man and environment”(Odum 1971, 4).

4.3.2 Aldo Leopold’s Land Ethic

Before there was a well-established science of ecology, Aldo Leopold spoke about concern for our environment in the form of a Land Ethic. In 1949, A Sand County Almanac was published. Several years later, in 1953, the Round River essays were added to the text making it one of the most important environmental books of our time. In the book, Leopold writes of the beauty of nature, the lack of understanding many people have of the world around them, and the high and unjustified cost that must be paid for progress.

Within the book, Leopold speaks of the Round River, which is an elegant metaphor for the biosphere. The water of the river is the energy of life that flows through the biotic community. Humans are said to be riding logs upon the Round River. Leopold uses the story of the river to bring out his point of conversation. He says that “from our tenderest years, we are fed with facts about the soils, floras, and faunas that comprise the channel of the Round River, (biology) about their origins in time, (geology and evolution) about the techniques of exploring them, (engineering and agriculture)” (Leopold, p189). In Leopold’s eyes, this is a narrow and even dangerous view. The expertise of science does not provide enough information about the failing of humans and their relationship to nature.
To accomplish a workable interaction with nature, Leopold feels humans must work perpendicularly to the current movements of science. "This calls for a reversal of specialization; instead of learning more and more about less and less, we must learn more and more about the whole biotic landscape" (189). The environmental sciences have attempted to do this. Unfortunately, they are still a science and fall into the rigors of that field. Too often, scientists fall into the trap of over-analysis and become lost in the minutia of a problem. The statements made by Leopold suggest that it is necessary to step back and look at the problem in a more interdisciplinary and holistic way.

Later, in the same book, the Land Ethic is discussed. Leopold puts forth the idea that "all ethics so far evolved rest upon a single premise; that the individual is a member of a community of interdependent parts" (239). He continues later to say, "The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively, the land" (239).

The ideas put forth by *A Sand County Almanac* were meant to broaden the minds of those reading the text. Leopold was trying to show that human needs were tied to the needs of the rest of the biotic community. Though he only spoke of a land ethic, his ideas relate to the entire biosphere, yet this concept had not yet been envisioned before Leopold.

He suggests that humans are plain members of the biotic community. This does not mean human survival should be compromised for nature, but in cases that do not concern the death of humans, moral concern should be extended to the nonhuman world. Moreover, he suggests that when judging human actions, an action is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise (Leopold, 292).
It is this type of message that must be taught so that any other environmental message be understood and applied to daily life. If everyone was aware of their place in the biotic community and had respect for the ecosystem they are part of, environmental education would not be as necessary. Unfortunately, this is not the case.

4.3.3 Small is Beautiful

Twenty years after the first publication of the combined essays of Aldo Leopold, another landmark book was published. Small is Beautiful: Economics as if People Mattered by E. F. Schumacher made an impact on environmental thought when it was published in 1973. Rather than talk of science or ethics, Schumacher’s book was centered on economics, but did not limit itself to that topic. In the study, Schumacher discusses economics, philosophy, technology, as well as many other fields that are all interrelated to economic development and growth. He attributed this development to humans not nature. Though natural resources are utilized, it is human thought, ingenuity, and work that allows it to be utilized. The learning and building of knowledge, in Schumacher’s mind, is what allows for the wealth of human development. This leads him to say, “In a very real sense, therefore, we can say that education is the most vital of all resources” (Schumacher, 1973, 60).

Knowing that education is a vital link in development is important, but not enough. Schumacher continues his discussion about education by discussing two types of problems—convergent and divergent. Convergent problems can be solved with reason while divergent ones cannot. Too often, however, humans try to solve divergent problems by reducing them to easier convergent problems that can be handled with reason. This approach does not work according to Schumacher. “The true problems of living are...
divergent problems and have no solutions in the ordinary sense of the word. They demand of man not merely the employment of his reasoning powers, but the commitment of his whole personality” (Schumacher, 1973, 77). This means that humans cannot simply rely on science to provide easy answers to difficult questions. Instead, humans must work together to find compromises and just solutions to these difficult divergent problems that arise.

Taking this discussion to a higher level, it becomes the role of educators to teach students to look at problems in a more advanced way. No longer should everything be reduced to simplest terms. No longer can everything have a right and a wrong answer. No longer will there always be one right answer. Finally and most importantly, no longer will there be problems that science can solve with a simple fix of technology and intellectual endeavor. Environmental problems call for humans to work together to reach a consensus and find a solution that works. Human thought and interaction will be the way complex issues can be resolved rather than through the sheer force of new and more advanced technologies.

Beyond solving environmental problems, Schumacher also puts forth the ideas related to the remedy for the many problems of development and, in turn, the environment. He suggests that the goal of technology and development must be understood in order to better solve the problems. Too often, the goal is chosen incorrectly. As a result, the path to the solution causes more problems and never leads to the desired solution. This process of goal setting is vital to environmental education because misconstrued or poorly selected goals can lead to poor solutions and more problems as well.
4.3.4 The Limits to Growth

Besides the problems of overly specialized education and reductionist thinking described by Schumacher, the problem of perspective must also be addressed. Donnella Meadows tied many of the problems of the world to population and human perspective in Limits to Growth: A Report to the Club of Rome’s Project on the Predicament of Mankind (1972). Many of the problems relate back to the human perspective of the world. Problems that exist in the future or seem to affect others alone do not have the impact of immediate endangerment of life, or property. According to Meadows, “The majority of the world’s people are concerned with matters that affect only family or friends over a short period of time. Others look farther ahead in time or over a larger area, a city or a nation. Only a very few people have a global perspective that extends far into the future” (1972, p.4). The problem arises when people are faced with a problem that is global in nature and the impact of which will not be felt for several years. Too often, a person must resolve more local and pressing problems before attention can be turned to large problems. The difficulty arises when no one is willing to deal with the global problems that confront everyone. This idea of a global perspective becomes important when looking at the impact of society upon the natural world. Unless a problem is identified as critical, resources will not be spent and time will not be invested to find a solution. This idea is essential to environmental education and EVSC education as well.

4.3.5 Earth in the Balance

More recently, Vice-president Al Gore’s book, Earth in the Balance (1992), highlights the interconnectedness of many global environmental problems. His book examines and explains many worldwide environmental problems as well as the cycles of life that interact
throughout the biosphere. The text describes the relationships between many environmental problems throughout recorded history. By explaining what has happened in the past, he points out trends in the past as well as the present. These trends are extrapolated out into the future to show what might happen. With ease, predictions about the dire consequence of human actions can be made and supported.

*Earth in the Balance* also shows how a regional solution to global problems would be difficult. Though each individual can work tirelessly, communities of individuals must come together to make a global solution work. Since every person living today is part of the same biosphere, the actions of any one cannot be taken separately from the actions of the rest. This idea of a global community is a vital part of any environmental problem solving model. Without this type of perspective the solutions to global problems will remain beyond the reach of those trying to grasp them.

### 4.4 From Philosophical Roots to Environmental Education

#### 4.4.1 Introduction

The books spoken of above are but a few of the many great works of environmental literature. These few, however, provide insight into the foundation of environmental thought that exists today. These texts provide a great deal of useful information and insight into the technological problems and challenges of our world as well. All of these books spoke of some type of awareness, education, learning, or knowledge either indirectly, by making references or directly, through deliberate statements. Every one of these texts put forth education as the hope for the environment of the planet.

The North American Association of Environmental Education (NAAEE) is working towards that goal of a sustainable and productive future. During the opening
ceremonies of a NAAEE conference, Arthur B. Sacks made a speech about the direction of environmental education in North America. In it he said, “If we are to optimize environmental education’s affect to advance humankind to a sustainable future, we must find new and better ways to cooperate among ourselves as well as with our brethren and sisters within the decision-making community” (1986, p6). This idea of cooperation is vital to any solution. Without forethought and cooperation by large numbers of individuals, solutions may be impossible. Though the books already mentioned serve as an excellent primer on the problems of the environment and the ways environmental education can be accomplished, other books can still give more insight into what needs to be accomplished.

4.4.2 Environmental Education Curriculum Planning

One of the most useful texts for understanding principles of environmental education is The Guide to Curriculum Planning in Environmental Education written in 1985 by David C. Engleson. This book provides a great deal of insight into how environmental concern can be instilled into students and taught so that it is carried away from the classroom in the everyday lives of those who are being taught. The author writes of infusing an environmental ethic into an existing curriculum. Rather than trying to add a class, an existing class must be given an environmental component. In this way, the students are learning about preserving the integrity of the environment as they learn about the subject which they will use during their lives.

From research into environmental education, four central ideas became apparent. First, the idea of environmental concern must be infused into an existing curriculum. Teaching these types of ideas without a context is difficult and often does not carry into the
fields where it is most needed. Second, the treatment of the material should be diverse and interdisciplinary to allow for the greatest understanding and applicability. Third, the information being taught needs to be accessible by the students. To accomplish this accessibility, the material should be presented in an interesting and thought provoking way. Over-technical language should be used only when unavoidably necessary. Fourth, the material must be tied to the everyday lives of the students through examples and real-world explanations.

Though all of these principles are true, they are for the general education of students with regard to the environment. A more in-depth discussion must be undertaken to better understand the specifics of undergraduate and graduate level environmental education. It is the students of these programs who are the ones to provide the messages that must be infused. These same students are the ones to solve the problems created by society. Though all of the ideas put forth above are true, other more advanced issues must be addressed as well.

All of these ideas are echoed in the Environmental Education in New Jersey: A Plan of Action. (New Jersey Environmental Education Commission, April 1993) This document discusses how environmental messages must be infused into all walks of life to educate the citizenry about the environment and show how their actions impact it. This idea, coupled with that of the curriculum review, shows that at all stages of life and in all aspects, environmental education is charged with teaching people about this problem. However, many people do choose to pursue the knowledge and actively attack the problems facing the environment. Nonetheless, there are many ways in which this knowledge can be sought. It is important for this dissertation that the areas similar to, but
still distinct from EVSC are examined to understand what is being taught in those areas and why those messages are important to EVSC education as well.

4.5 Environmental Education

Since the early 1970’s, awareness has grown about issues involving environmental protection. During this same period of time, a tremendous amount of effort has been focused on the elementary and secondary environmental education. Young students and members of the community had to be informed about the issues facing them related to their environment and the problems that the environment was facing (New Jersey Environmental Education Commission April 1993). Today the general field of Environmental Education (EVED) can be seen as addressing a list of interconnected ideas:

- EVED incorporates a human component in exploring environmental problems and their solutions
- Environmental solutions are not only scientific—they include historical, political, economic and cultural perspectives. This also implies that the environment includes buildings, highways and ocean tankers as well as pine trees and coyotes. EVED rests on a foundation of knowledge about social and ecological systems
- Knowledge lays the groundwork for analyzing environmental problems, resolving conflicts, and preventing new problems from arising
- EVED includes the affective domain: the attitudes, values, and commitments necessary to build a sustainable society (North American Association for Environmental Education, 2000)

This general understanding of EVED has helped to bring a greater understanding of the environment to the general public and the academic community. However, for many years, the idea of EVED was not seen as a separate discipline from the traditional fields taught at the undergraduate and graduate levels. The prevailing means of teaching environmental ideas was to infuse environmental concepts into the existing curriculum such that environmental ideas were taught in context. This is effective for spreading the
environmental message but not truly training students to solve environmental problems in an interdisciplinary way. When a disciplinary approach to a problem was used, the concerns for the environment were also taken into account. This did not make the creation of separate free-standing programs easy. Traditionally, as a need arose for environmentally-minded professionals, existing programs expanded to fill the need. In this way, environmental tracks in disciplinary programs opened and grew to solve problems.

As time passed, an entirely new set of programs developed. In the 1970s and 1980s, the field of Environmental Studies emerged. By the 1990's the field of Environmental Science and several others had been added as well. These fields require their own sets of criteria for evaluation and presented their own problems for evaluators, teachers and administrators to solve. With the creation of these new programs came a need for evaluation. However, as Ian Thomas said at that time, “Few Environmental Education programs have been [evaluated] because of a lack of suitable evaluation criteria” (Winter 1990, p. 262). Though the need was present, the criteria and ability to do so were not.

4.6 Environmental Studies

Having had a brief introduction to EVED, it is now possible to look at Environmental Studies and Environmental Science. In particular, it is important to know what the goals of these programs are and what skills these fields try to teach students. In the 1980's, a series of articles was published examining the field of Environmental Education majors. (Thomas, Winter 1989-1990; Disinger, 1988) An entire issue of The Environmental Professional (North American Association of Environmental Professionals, 1987) was devoted to this exact topic. Research into the field was summarized by John Disinger in his article, “Recent Developments in College Level Environmental Studies Courses and
Programs," first published in 1988. In this article, Disinger states, "Environmental studies is a term that began to be used in the 1960's to describe some courses and programs, and if not a new discipline, a set of disciplines." Along with this description, Disinger gives a set of criteria for identifying a program which can be called Environmental Science. He says, "Criteria usually associated with the term include the following:

(1) the study of humans as they affect and are affected by their environment
(2) concern for the TOTAL ENVIRONMENT including social, cultural, economic, aesthetic, physical and biological aspects
(3) INTERDISCIPLINARY APPROACHES
(4) clarification of OPEN-ENDED OPTIONS for environmental concerns, rather than short-term solutions
(5) integrated environmental management that expresses ethical dimensions

Disinger separates Environmental Studies from Environmental Science in his article saying, "Environmental studies can encompass, but are not synonymous with the environmental sciences. Environmental studies seek to bring perspective to both the sciences and the arts."

In this way, Disinger separates the study of environmental science from the study of the environment. Unfortunately, when looking at current environmental science programs, it becomes difficult to distinguish a separation between arts and sciences when solving interdisciplinary problems. As human understanding and these two fields have grown, the skills needed to work within one have become very similar to the skills of the other. Knowledge of arts and sciences are needed to address environmental problems as interdisciplinary solutions are forged.

As a part of the article explaining the success of some programs, Disinger lists several characteristics that have led to their continued vitality. Though not all are
applicable to this study, many bear important similarities to the criteria that will be laid out in the next section as common factors with healthy, effective, efficient, economical programs that teach EVSC. According to Disinger,

“Programs that have survived and have grown tend to share several of the following characteristics:

(1) the program is dynamic and responds to changes within the fields the program represents as well as changes that occur as society relates to the environment
(2) the program has both theoretical and applied emphases
(3) the program provides both breadth related to the environment and depth in a field of interest
(4) the program is clearly interdisciplinary in its emphasis
(5) the primary funding source for the program is the institution
(6) the institutional administration values and supports environmental studies
(7) the program has strong staff leadership
(8) the program has been recognized for its academic quality and/or its contribution to environmental activities
(9) the philosophy of the program shows a definite commitment to environmental education values and actions
(10) the program staff works closely with other academic units. The academic home (college or department) of the program was not a distinguishing characteristic

Though many of these characteristics can also be seen in Environmental Science programs, it is important to look at literature about these programs that has been published recently to gain an idea of what exists. More importantly, it is important to be able to evaluate the programs beyond the single measure of longevity or continued existence. As a result, it was necessary to examine literature and programs related to EVSC to help understand what existed and what was working.

Unfortunately, innovative interdisciplinary programs in areas related to the environment pose problems for those looking to conduct evaluations. As Ian Thomas said at that time, “Few Environmental Education programs have been [evaluated] because of a lack of suitable evaluation criteria” (Winter 1989-1990, p. 4). Though the need was
present, the criteria and ability to do so were not. This dissertation hopes to identify some of these areas.
CHAPTER 5
ENVIRONMENTAL SCIENCE EDUCATION

5.1 Introduction

Every program, in order to be described and assessed, needs to have goals and objectives specified. Vital to this goal and objective delineation is the idea of clear definitions. For this study, the first step was to clearly define what was meant by an Environmental Scientist. From that point, the definition can be transformed into a set of goals with underlying objectives that would allow students to achieve what the definition sets out. Beyond that, the various components that comprise the educational program that help to attain these goals can then be discussed and examined.

A good place to start is with the definition of EVSC. However, when searching for a single definition, many versions may be found. The definition is complex and varies according to those who are asked because of the many different connotations that the field has in terms of its goals. By consulting two reference books, the Encyclopedia of Environmental Science and Engineering as well as The Facts on File Dictionary of Environmental Science, two similar but distinct definitions were found. According to the Encyclopedia of Environmental Science and Engineering:

Environmental science is concerned with the entire biosphere and with all the external influences to which organisms are exposed, both physical(abiotic) influences and those originating with other organisms (biotic)... Humans and other organisms are subjected to many environmental conditions; their responses are varied and range from fairly simple to extremely complex. Identifying and solving problems that may arise are the concerns of both scientists and engineers... Environmental science is concerned with identifying and characterizing the problems, while environmental engineering is concerned with finding the solutions. (Parker, & Corbitt, 1991, Preface)
The Dictionary of Environmental Science states:

The field of environmental science explains the adverse effects of human activities on human health, wildlife, or ecosystems. The vocabulary of the science includes terms used in the definition, control, remediation, and prevention of harm to public health and the environment. Some of the many subject areas that fall within environmental science are the chemical contamination of air and water, species preservation, the environmental transmission of human disease, natural resources conservation, the stability and diversity of natural ecosystems, pesticide risks, workplace health and safety, waste management, and the effects and control of ionizing radiation. (Stevenson & Wyman, 1991, Preface)

Neither definition is complete. The goals specified by both are ambiguous and leave out many of the important facets of the discipline.

Nonetheless, all might agree that there are certain aspects that remain common no matter who is making the definition. It is the overall goals of education and EVSC that will be discussed here. Later, at the end of the dissertation, after the results of the surveys have been discussed, a more concrete and workable definition with goals and objectives will be given. This mission statement for Environmental Science will reflect the ideas presented here with others that come out of the research itself.

5.2 Environmental Science

In a similar way to the description of the status of Environmental Studies presented above, a survey of the state of Environmental Science was published in 1990 in Environmental Science & Technology. Rather than a summary of the years of research data, this article is a summary of a study undertaken by Judith Weis that examined the existing programs with particular attention paid to the directors and other administrators of the programs. In her own words, "Given the magnitude and the multiplicity of environmental problems, there is a need for broadly trained scientists. Narrowly trained specialists will be unable to come to
grips with many of these problems, and there is a job market for environmental scientists at
the Bachelor's, Master's, and Ph.D. degree levels” (p 1116).

In the article she quotes W. H. Glaze's assessment of the individuality of
Environmental Science. Rather than see it as a part of another discipline, Glaze says,
“What is needed now is for universities and society as a whole to recognize that
environmental science is one of the distinctive, essential features of the search for
knowledge; that holistic, integrated approaches are necessary for research in this area to
flourish; and that irregular, patchwork, cross-departmental programs are not enough. In
short, environmental sciences must be 'canonized' into the structure of universities”
(1116).

To support this view, Weis says, “Virtually all programs required courses in
biology, chemistry, and earth science or physics. The majority of ‘environmental science,’
as well as almost all the ‘environmental studies’ programs also required courses in the
social sciences or law” (p. 1117)

If Environmental Science is to be an independent discipline, then it must have its
own curriculum that can be evaluated and codified. The criteria for evaluation will be goal
attainment along with a specific set of goals that are to be the objectives for students in
Environmental Science.

According to Weis'(1996) study, the chairpersons of departments report rigorous
and demanding science courses and also said that their curriculum was geared toward
solving environmental problems from a science perspective. In addition to this depth of
knowledge, these same directors felt that their programs gave a breadth of knowledge in
environmental areas as well. Weis states that, “The aim of the Environmental Sciences
group major is twofold: 1. An understanding of the physical environment, human impact on it, and the difficult choices that must be made at all levels of society as we move into an era of limits; and 2. Developing tools with which to solve the critical environmental challenges facing the world.” (p 1117)

With this perspective it may become difficult to see clear lines between Environmental Science and many other disciplines. As the goal of the program becomes broader, the need to understand and interact with a larger set of disciplines becomes more vital to the success of the student. “Environmental problems are often multifaceted and contain biological, chemical, social, historical, psychological and economic elements which must be addressed” (Wies, 1990, p. 1117). No longer can a simple disciplinary solution be used for any environmental problem. Neither can a student trained in a single discipline be expected to find the interdisciplinary solution that is most likely needed to solve today’s environmental problems without expanding their view to understand and utilize the insights of others.

In the opinion of the author, all Environmental Science students and, for that matter, all students who are facing environmental problems need to be armed with an interdisciplinary education. As part of this education, they must be trained to examine problems rationally and with a general problem-solving process. However, it is not clear that a consensus exists today as what Environmental Science students should be learning. Though a great deal of suggestions have been made about what should be in EVSC programs, nowhere is there a coherent and complete set of guidelines for the development or revision of the curriculum to meet the newest set of ABET accreditation criteria much less the interdisciplinary problems of today.
The main focus of this dissertation will be to examine the undergraduate EVSC programs existing today at four year colleges and universities in America. It is the author's hope that this analysis will provide a clear set of criteria that can be used to measure programs. With these objectives to help foster student success, it will be possible to create a set of guidelines for the EVSC curriculum. These guideline will assist existing programs as well as any programs that are formed as we enter the next millennium.
CHAPTER 6
PROJECT METHODOLOGY

6.1 Introduction

Several important questions about Environmental Science programs remain even after reviewing many web pages and the literature discussed previously. The major question centers around curriculum and what should be taught. A balance must be struck between breadth and depth of programs. While disciplinary knowledge is vitally important, EVSC must be distinct from the courses in Environmental Chemistry, Management, Engineering, and any of the other fields that have emerged since the 1970's. There is agreement that all EVSC students need some level of interdisciplinary breadth and disciplinary depth to help them solve problems and think critically about environmental concerns. However, where this balance lies still remains to be determined. It is this question that will be examined with this dissertation.

Many programs with varied curriculum and differing levels of interdisciplinarity and missions call themselves Environmental Science. By using the tools of social science it is my intention to evaluate the existing programs that are designated as Environmental Science to find common threads and concensus about what is needed in an Environmental Science program. At the same time, interviews will be conducted with program directors to determine what still needs to be added to curriculum so that as the field continues to grow and become more refined, Environmental Science can meet the challenges of the future. In the end, the dissertation will make recommendations concerning what is and what should be the curriculum of a good EVSC program. In this way, when any student successfully completes the program, they will have a certain set of skills, tools, and
understanding of ideas, that demonstrates both breadth and depth of knowledge related to the environment. Also, these same students will have the ability to think critically about environmental problems, communicate effectively with all those involved with the problem-solving process, as well as be equipped to solve these problems from an interdisciplinary perspective. To assist the reader, Appendix 1 contains samples of the survey results for both Survey 1 and 2.

6.2 Parameters and Assumptions

In order to even begin thinking about the evaluation of the field of EVSC, it is important to realize that there needs to be some set of restrictions placed upon the study to narrow it and make it manageable. Some of these parameters and assumptions have already been discussed. Others may not become evident until much of the research has already been gathered. At this point, however, several must be listed before any further steps can be taken. The first decision to be made concerned the specific field that would be evaluated. When first investigating programs referred to as Environmental, many variants were presented. In the COLLEGEQUEST database, for example, the following listings were given. Environmental and Business Economics, Environmental Biology, Environmental Design, Environmental Education, Environmental Engineering, Environmental Engineering Technology, Environmental Health/science, Environmental Science, and Environmental Studies. (Peterson’s, 2000) Due to the enormity of the field of EVED, it has been decided to choose only programs that designate themselves as Environmental Science. This is partially because this designation has both technical and nontechnical components that make it ideal for a study that attempts to determine the requirements of an interdisciplinary program that has adequate breadth and depth. Also, it is important to
realize that this researcher is working towards a doctorate in Environmental Science and so this field is of particular interest. Using accessible guides such as Peterson's Guide To College Programs or COLLEGEQUEST, it is easy to find a list of colleges that state they offer a major entitled Environmental Science.

Next, it was necessary to choose a country and a level of attainment that the students must have in order to attend a university. In this case, the decision was made to narrow the search to four-year colleges and universities in the United States (US). This choice was made for practical reasons such as accessibility, ease of information exchange (no language barrier) as well as continuity of results among participants. Any further restriction at this point might have unduly limited the study. Before narrowing the research any further, it was important to formulate the study instruments which would be used to investigate the topic.

6.3 Choosing the Schools for Analysis

It is important to describe the methods that were used to gather the data utilized in the dissertation. The data collection portion of the dissertation consisted of two surveys designed to obtain data from the schools around the nation that have programs in the Environmental Sciences at the undergraduate or graduate level. The schools used for the initial sample were taken from the 1999 edition of lists of degrees and Majors (Barrons, 1999) and then were cross-referenced with other sources such as Peterson’s on-line and other web search engines. Figure 6.1 contains a list of the schools used for the survey.
Figure 6.1
Environmental Science Programs in the United States

Bachelors, Masters, & Ph.D.—12

Cornell University
Drexel University
Florida Institute of Technology
Lehigh University
Ohio State University: Columbus Campus
University of Maryland: Eastern Shore

University of Minnesota: Twin Cities
University of Nevada: Las Vegas
University of Rhode Island
University of Virginia
Washington State University
Yale University

Masters & Ph.D.—11

Jackson State University
New Jersey Institute of Technology
Oklahoma State University
Rutgers, The State University of New Jersey:
   New Brunswick Graduate Campus
State University of New York
   College of Environmental Science and Forestry

University of California: Berkeley
University of Cincinnati
University of Illinois at Urbana-Champaign
University of New Hampshire
University of North Texas
University of Wisconsin-Madison

Bachelors & Masters—37

Alaska Pacific University
American University
Arizona State University
Baylor University
Bemidji State University
Bradley University
Brown University
Christopher Newport University
Evergreen State College
Florida International University
Lamar University: Beaumont
Long Island University: C.W. Post Campus
Louisiana State University and
   Agricultural and Mechanical College
Loyola Marymount University
Marshall University
New Mexico Highlands University
New Mexico Institute of Mining and Technology
Rochester Institute of Technology

Shippensburg University of Pennsylvania
Southwest Texas State University
Stephen F. Austin State University
Texas A&M University-Corpus Christi
Tuskegee University
University of Houston: Clear Lake
University of Idaho
University of Maryland: College Park
University of Michigan
University of Nevada: Reno
University of New Haven
University of San Francisco
University of Tampa
University of Tennessee: Chattanooga
University of Texas at San Antonio
University of Wisconsin-Green Bay
Wesleyan University
West Texas A&M University
Western Washington University

Bachelors & Ph.D.—1

University of California: Santa Cruz

Bachelors ONLY—283

Abilene Christian University
Adams State College
Alabama A&M University
Albright College
Alderson-Broaddus College
Allegheny College
Antioch College
Aquinas College

Penn State Lehigh Valley-Berks Lehigh Valley College
Penn State University Park
Philadelphia College of Textiles and Science
Phillips University
Pittsburg State University
Plymouth State College
Point Park College
Polytechnic University
Auburn University
Averett College
Barnard College
Bellevue University
Bennington College
Bethel College
Black Hills State University
Bloomfield College
Boston University
Bradford College
Brenau University
Brigham Young University
Bryn Mawr College
Cabrini College
California Polytechnic State University: San Luis Obispo
California State University Sacramento
California State University: Stanislaus
California State University: Chico
California University of Pennsylvania
Calvin College
Carroll College
Castleton State College
Catawba College
Centenary College of Louisiana
Central Connecticut State University
Central Methodist College
Chapman University
Charleston Southern University
Chatham College
Chestnut Hill College
City University of New York: Medgar Evers College
City University of New York: Queens College
Clarion University of Pennsylvania
Clinch Valley College of the University of Virginia
Colby College
Colgate University
College of Santa Fe
College of the Atlantic
College of the Southwest
Colorado College
Columbia University: Columbia College
Concordia College
Concordia University at Austin
Creighton University
Curry College
Dana College
Davis and Elkins College
De Paul University
Defiance College
Delaware Valley College
Dickenson College
Polytechnic University: Long Island Campus
Prescott College
Principia College
Purdue University
Quincy University
Ramapo College of New Jersey
Rensselaer Polytechnic Institute
Richard Stockton College of New Jersey
Rocky Mountain College
Rutgers University
Salem-Teikyo University
Salish Kootenai College
Salve Regina University
Sam Houston State University
Scripps College
Shaw University
Shenandoah University
Shepherd College
Shorter College
Sierra Nevada College
Simmons College
Simpson College
Slippery Rock University of Pennsylvania
Sonoma State University
Southeastern Oklahoma State University
Southern Methodist University
Southern Oregon University
Southern Vermont College
Springfield College
Spring Hill College
St. Bonaventure University
St. John's University
St. Joseph's College
St. Joseph's University
St. Leo College
St. Louis University
St. Mary's College
St. Norbert College
St. Paul's College
St. Vincent's College
State University of New York at Binghamton
State University of New York at Purchase
State University of New York College at Brockport
State University of New York College at Oneonta
State University of New York College at Plattsburgh
State University of New York Maritime College
Sterling College
Stetson University
Sul Ross State University
Susquehanna University
Swarthmore College
Syracuse University
Dominican College of San Rafael
Dominican University
Dordt College
Duke University
Eastern College
Edinboro University of Pennsylvania
Elizabethtown College
Elmira College
Elon College
Emory and Henry College
Fairleigh Dickinson University
Ferrum College
Fitchburg State College
Florida Southern College
Florida Gulf Coast University
Furman University
Gannon University
George Washington University
Georgetown College
Gettysburg College
Grinnell College
Harvard and Radcliffe Colleges
Hawaii Pacific University
Howard Payne University
Indiana University of Pennsylvania
Inter American University of Puerto Rico:
Iowa State University
Ithaca College
Jacksonville University
John Brown University
Johnson State College
Juniata College
Kent State University
Kutztown University of Pennsylvania
Lake Superior State University
LaRoche College
LaSalle University
Louisiana State University in Shreveport
Louisiana Tech University
Lubbock Christian University
Lyndon State College
Manchester College
Mankato State University
Mansfield University of Pennsylvania
Marietta College
Marist College
Marlboro College
Mary Washington College
Maryville College
Maryville University of Saint Louis
Marywood University
McMurry University
Taylor University
Tennessee Technological University
Texas A &M University
Texas A&M University-Commerce
Thiel College
Thomas College
Thomas Edison State College
Trinity College
Trinity College of Vermont
Tri-State University
Troy State University
Tulane University
Tuvalu College
United States International University
United States Military Academy
Unity College
University of Findlay
Universidad Metropolitana
University of Alaska: Fairbanks
University of Arizona
University of Arkansas at Pine Bluff
University of California: Davis
University of California: Riverside
University of California: Santa Barbara
University of Charleston
University of Colorado at Boulder
University of Connecticut
University of Delaware
University of Dubuque
University of Evansville
University of Findlay
University of Florida
University of Indianapolis
University of Kentucky
University of La Verne
University of Maine at Farmington
University of Maine at Machias
University of Maine at Presque Isle
University of Massachusetts Amherst
University of Miami
University of Michigan: Dearborn
University of Michigan: Flint
University of New England
University of North Carolina at Willmington
University of Oregon
University of Pennsylvania
University of Pittsburgh at Greensburg
University of Puerto Rico
University of Redlands
University of Scranton
University of South Florida
University of Southern Maine
<table>
<thead>
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<th>Ph.D. ONLY—2</th>
</tr>
</thead>
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</tr>
<tr>
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<td>Bard College</td>
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<tr>
<td>College of Charleston</td>
</tr>
<tr>
<td>Columbus State University</td>
</tr>
<tr>
<td>Duquesne University</td>
</tr>
<tr>
<td>Hardin-Simmons University</td>
</tr>
<tr>
<td>Longwood College</td>
</tr>
<tr>
<td>Miami University: Oxford Campus</td>
</tr>
<tr>
<td>Montclair State University</td>
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</table>

<table>
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</tr>
<tr>
<td>Miami University: Oxford Campus</td>
</tr>
<tr>
<td>Montclair State University</td>
</tr>
</tbody>
</table>

Figure 6.1 consists of a list of schools having some type of program in Environmental Science.
The initial list of schools was then used to review program homepages and verify the listings in order to find a place to distribute the survey. After this review was complete, survey one was constructed and distributed. In order to develop surveys that gather meaningful data, the areas of interest must be specified such that questions can be developed to determine if these areas are addressed by the programs surveyed. To assist in the survey construction, the text, *Evaluation: A Systematic Approach* (Rossi, & Freeman, 1993) was used in conjunction with *The Practice of Social Research* (Babbie, 1995) to create and refine the survey instruments.

### 6.4 Survey 1

#### 6.4.1 Instrument and Methodology

The initial surveys are geared to obtain an understanding of the existing programs in general. From the information gathered during the literature search and review of the program home pages, the initial survey instrument was constructed. Its main intention was to reduce the number of school which would receive the second, more in-depth survey.

The first survey, entitled “Environmental Science Program Survey 1,” was distributed to all the programs listed in Figure 6.1 via electronic mail (e-mail) or standard postal (snail) mail. A total of 236 surveys were successfully distributed and 81 responses were received for a response rate of 35%. At this point, it is important to see the instrument used to gather data as well as know how it was constructed and administered.

#### 6.4.2 Survey Instrument

This is the introductory survey to assess the general status of EVSC programs in the United States. There is an undergraduate and graduate portion of the study to help differentiate
between these degree offerings within schools and programs. The survey consists of a series of Yes-No style questions geared to determine very broad characteristics of the programs surveyed as well as some free-response questions to help focus subsequent surveys towards the appropriate audience.

In order to build the first survey, several different questions had to be used to determine what parts of a good Environmental Science program each surveyed school might contain. However, before the programs could be assessed, it is important to gather some demographic information about the programs such as the name of the person filling the form, the name of the institution, and the degree(s) offered by the program in order to double check the data obtained from the Baron’s guide (header information & question 1).

As stated earlier, in order for a program to be successful, it needs to have a clearly stated goal. Without goals, and objective, it is difficult for a program to be assessed and thus almost impossible to deem it successful. For programs at a university, the goals take the form of the mission statement and so are assessed by question 2. Overall, EVSC program mission statements should reflect the goals of a ‘good’ program that were revealed by the literature search conducted for this dissertation. Nevertheless, it is an important first step for a program to have a mission statement before that mission statement is modified to reflect the goals of a “good” program. Student assessment by the program to determine if the goals have been attained by graduating students is also important. As a result, the presence of a required senior project is important (question 3). Though the mere presence of either of these two aspects does not guarantee a good program, their absence may denote problems and make assessment of students and the program itself difficult for researchers, employers, and others.
The next six questions of the survey (4 through 9) are geared to determine more about various aspects of the areas revealed by the existing literature about good EVSC programs and education in general. Question 4 asks about problem solving in a specific course offering. Other questions of this nature designed to gather responses about curriculum will be asked in more detail by Survey 2. The remaining questions all give insight into the various areas described above and shown in Figure 1.1. It is difficult to separate out one aspect from the other. Therefore, these questions all give an overall marker of success or failure of a program in the extracurricular areas as well as some indication of the accomplishment of the curriculum.

The last two questions (10 & 11) are open-ended. Question 10 asks about employment of students. The answers to this question may provide areas for further investigation into the pursuits of EVSC students after graduation. In addition, it shows whether or not a program tracks graduates and may show a continuing influence on students. Unfortunately, it is difficult to correlate this type of activity with EVSC programs, and so this particular piece of information was not included in the evaluation process to choose subjects for Survey 2. Also, as stated earlier, outcome assessment poses problems and has many weaknesses and unaccounted costs and problems.

The last question (11) is designed to allow surveyed persons to provide information that may not be thought of by the researcher and which may be invaluable. In addition, as it is difficult to have a good feel for a program from only a few questions, this question allows for a better understanding of programs which may provide useful and innovative ways of looking at the EVSC programs.
When sent to the intended subjects, a cover letter and instruction sheet accompanied the survey instrument. Below is a copy of the material sent.

![Image of a page from a document](image)

**Figure 6.2**

**Environmental Science Programs Survey 1 Distribution**

June 25, 1999

Dear Faculty Member(s):

I am a Ph.D. candidate in Environmental Science at the New Jersey Institute of Technology (NJIT). I am writing to ask your help in completing the following survey; the survey is being used as part of my dissertation research. My dissertation concerns the state of existing Environmental Science (EVSC) Programs in the United States.

My research is designed to describe the existing state of EVSC programs as well as develop a model of effective EVSC programs. As part of this project, it is necessary to gather data regarding the general state of current programs. To accomplish this work, the enclosed one page survey has been developed and should take only a few moments to complete. You can be assured that your responses will be kept completely confidential. Upon completion of the survey, please return it in the self addressed envelope provided, via Fax to the number below, or by reply e-mail.

Your contribution to the success of this study will be greatly appreciated. If you feel it would be more appropriate for someone else at your institution to complete the surveys, please feel free to forward a copy to them. If there are any questions, please do not hesitate to contact me at the address listed below. Thank you for your time and invaluable help.

Sincerely,

James M. Lipuma
New Jersey Institute of Technology
Newark, NJ 07102
(973) 642-4743
(973) 642-4689 FAX
lipuma@admin.njit.edu

**INSTRUCTION SHEET**

The following surveys are designed to gather general information about programs at either the undergraduate or graduate level. As a result, if you administer a program which offers both levels of degrees, it is necessary to answer two separate surveys as they are lightly different and will be handled separately.

For the Yes/No questions below, please put an X next to the answer that best represents your response to each question. For those questions which require a written response, please feel free to provide as much information as you feel comfortable typing. Once again, thank you for your cooperation and time.

Name:   Title:  
Institution:

Environmental Science Program Survey 1 (Undergraduate)

1) What degrees does your program offer? (BA, BS, and/or Others)
2) Does your program have a mission statement outlining the goals and objectives of the program in Environmental Science?
   _____ YES   _____ NO

3) Does your program curriculum contain a course in which the students demonstrate mastery of the skills, knowledge, and expertise outlined in the mission statement such as a capstone, senior project, or senior thesis?
   _____ YES   _____ NO

4) Does your program contain a course which teaches a systematic problem-solving methodology for real-world problems and their solutions?
   _____ YES   _____ NO

5) Do courses in your program utilize real-world case studies to assist in the teaching process?
   _____ YES   _____ NO

6) Does your program encourage students to participate in extracurricular activities related to the field of Environmental Science? Do these activities encourage students to discuss current problems and solutions in the field? Do these activities include seminars, workshops, academic societies, and field trips?
   _____ YES   _____ NO

7) Does your program or department offer internships or other workplace experiences to students?
   _____ YES   _____ NO

8) Does your program or department have an external advisory board? (i.e. individuals from industry or government to give direction and aid to the program)

   Program:   _____ YES   _____ NO
   Department:   _____ YES   _____ NO

9) Do the faculty in the program publish articles each year?
   _____ YES   _____ NO

10) Upon graduation, what types of companies or educational programs do your graduates enter?

11) Is there a unique or innovative part of your program you wish to explain or discuss?

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Name:   
Title:   
Institution:   

Environmental Science Program Survey 1 (Graduate)

1) What degrees does your program offer? (please list all including MA, MS, Ph.D., and/or others)

2) Does your program have a mission statement outlining the goals and objectives of the program in Environmental Science?
   _____ YES   _____ NO

3) Does your program curriculum contain a course in which the students demonstrate mastery of the skills, knowledge, and expertise outlined in the mission statement such as a Master’s project or thesis?
   _____ YES   _____ NO
4) Does your program contain a course which teaches a systematic problem-solving methodology for real-world problems and their solutions?

_____ YES  _____ NO

5) Do courses in your program utilize real-world case studies to assist in the teaching process?

_____ YES  _____ NO

6) Does your program encourage students to participate in extracurricular activities related to the field of Environmental Science? Do these activities encourage students to discuss current problems and solutions in the field? Do these activities include seminars, workshops, academic societies, and filed trips?

_____ YES  _____ NO

7) Does your program or department offer internships or other workplace experiences to students?

_____ YES  _____ NO

8) Does your program or department have an external advisory board? (i.e. individuals from industry or government to give direction and aid to the program)

Program:  _____ YES  _____ NO

Department:  _____ YES  _____ NO

9) Do the faculty in the program publish articles each year?

_____ YES  _____ NO

10) Upon graduation, what types of companies or educational programs do your graduates enter?

11) Is there a unique or innovative part of your program you wish to explain or discuss?

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * 
Figure 6.2 is the material sent to each program identified in Figure 4 as part of Environmental Science Programs Survey 1.

6.5 Results for Survey 1

6.5.1 Introduction

Once Survey 1 was distributed, six months were allowed for responses to be returned. As stated above, 80 usable results were received and processed. These results were broken into four categories depending upon the degrees offered by the respondents. These categories are: Undergraduate Degrees, Graduate Degrees, Both Undergraduate and Graduate Degrees, or None.
The results of Survey 1 are listed below. A “N” represents a response of “No” and a “Y” represents a response of “Yes.” If no response was given a blank was left in the space. In some cases, free responses were included with the marked answers. In these cases as well as with the answers for questions 10 and 11, the information is not presented here but was used to help develop the material that follows in the dissertation.

6.5.2 Survey 1 Data

The information from Survey 1 has been reported as accurately as possible. The column entitled ‘Total’ listed the total number of ‘Yes’ responses for that particular institution.

This data will be used to direct the distribution of Survey 2.

**Figure 6.3**

<table>
<thead>
<tr>
<th>Institution</th>
<th>Degree</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8P</th>
<th>8D</th>
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<td>Y</td>
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<td>Y</td>
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<td></td>
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<td>7</td>
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<td></td>
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Figure 6.3 is a table counting the results from Survey 1 for institutions with Undergraduate programs Environmental Science only.

**Figure 6.4**

Graduate Degree Programs Results

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Figure 6.4 is a table counting the results from Survey 1 for institutions with Graduate programs Environmental Science only.
**Figure 6.5**

**Combined Undergraduate and Graduate Degree Programs Results**

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<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>8</td>
</tr>
<tr>
<td>University of Idaho</td>
<td>BS</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>7*</td>
</tr>
<tr>
<td></td>
<td>MS</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>7*</td>
</tr>
<tr>
<td>University of Illinois, Urbana-Champaign</td>
<td>BS</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>MS, PHD</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>8</td>
</tr>
<tr>
<td>University of Michigan: Natural Resources &amp; Environment</td>
<td>BS</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>MS, PHD</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>7</td>
</tr>
<tr>
<td>University of New Hampshire</td>
<td>BS/MS</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>MS, PHD</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>7</td>
</tr>
<tr>
<td>University of Virginia</td>
<td>BA</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>MS-PHD</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>7</td>
</tr>
<tr>
<td>Yale University Studies in the Environment</td>
<td>BA, BS</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>MS, PHD</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>8</td>
</tr>
<tr>
<td>Youngstown State University</td>
<td>BS</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>7</td>
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<td></td>
<td>Certificate</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>7</td>
</tr>
</tbody>
</table>

Figure 6.5 is a table counting the results from Survey 1 for institutions with both Undergraduate and Graduate programs Environmental Science.
Figure 6.6
Other Degree Program Results

<table>
<thead>
<tr>
<th>Institution</th>
<th>Degree</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8P</th>
<th>8D</th>
<th>9</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Montana</td>
<td>BA Studies</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td></td>
<td>7</td>
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<tr>
<td>Evergreen State College</td>
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<td></td>
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<td></td>
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<td></td>
<td>0</td>
</tr>
<tr>
<td>Fairleigh Dickinson U - Madison</td>
<td>NONE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Swarthmore College</td>
<td>Concentration</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>NA</td>
<td>Y</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>U of CA- San Diego</td>
<td>MINOR</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 6.6 is a table counting the results from Survey 1 for institutions with programs that do not offer a degree in Environmental Science.

Though the responses were useful in identifying programs for Survey 2, the answers given also provide insight into differences and similarities among programs. To assist the reader, the responses have been brought together below in Figure 6.7.

Figure 6.7
Report of Data for Survey 1 Results

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>%</th>
<th>No</th>
<th>%</th>
<th>NA</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programs Offering Undergraduate Degrees</td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>Mission statement</td>
<td>46</td>
<td>82</td>
<td>10</td>
<td>18</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Capstone, senior project, or senior thesis course</td>
<td>44</td>
<td>79</td>
<td>11</td>
<td>20</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Systematic problem-solving methodology</td>
<td>42</td>
<td>75</td>
<td>11</td>
<td>20</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Utilize real-world case studies</td>
<td>53</td>
<td>95</td>
<td>3</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Encourage participate in extracurricular activities</td>
<td>51</td>
<td>91</td>
<td>5</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Offer internships or other workplace experiences</td>
<td>52</td>
<td>93</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>External advisory board—Program</td>
<td>10</td>
<td>18</td>
<td>36</td>
<td>64</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>External advisory board—Department</td>
<td>9</td>
<td>16</td>
<td>31</td>
<td>55</td>
<td>16</td>
<td>29</td>
</tr>
<tr>
<td>Faculty in the program publish articles</td>
<td>38</td>
<td>68</td>
<td>16</td>
<td>29</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Programs Offering Graduate Degrees</td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>Mission statement</td>
<td>30</td>
<td>97</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Capstone, senior project, or senior thesis course</td>
<td>29</td>
<td>94</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Systematic problem-solving methodology</td>
<td>26</td>
<td>84</td>
<td>5</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Utilize real-world case studies</td>
<td>29</td>
<td>94</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Encourage participate in extracurricular activities</td>
<td>30</td>
<td>97</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Offer internships or other workplace experiences</td>
<td>27</td>
<td>87</td>
<td>4</td>
<td>13</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>External advisory board—Program</td>
<td>10</td>
<td>32</td>
<td>17</td>
<td>55</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>External advisory board—Department</td>
<td>10</td>
<td>32</td>
<td>15</td>
<td>48</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td>Faculty in the program publish articles</td>
<td>28</td>
<td>90</td>
<td>3</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 6.7 is a table counting the analyzed results from Survey 1 for all institutions.
Having reviewed the data, it was then time to construct Survey 2 which would ask more in-depth questions of the best of these programs.

6.6 Survey 2

6.6.1 Instrument and Methodology

The second survey, entitled “Environmental Science Program Survey 2,” consists of more in-depth questions that are intended to determine more about the particular programs that have been identified as having all, or nearly all, of the desired aspects listed in Survey 1. This will be determined by choosing those programs that have scored a seven or more “yes” responses on Survey 1 for questions 2-9 as listed in the tables above. The survey is composed of both a written and oral portion in hopes of capturing more data. Questions include demographics, Yes-No, Likert scale, and free-response questions. In addition, open-ended responses are followed-up by more in-depth questions handled during a recorded phone interview with those participants who were willing to speak with the researcher.

Figure 6.8

Programs Scoring 7 or Above On Survey 1

Abilene Christian University
Ball State
Central Connecticut State University
Dominican College
Florida Gulf Coast University
Maryville University-St. Louis, MI
Messiah College
Purdue University
Queens College (CUNY)
Saint Norbert College
Simpson College
Southern Oregon University Ashland
University of Massachusetts at Amherst
University of Minnesota
University Southern CA (USC)
Virginia Polytechnic Institute
Washington State University

Miami University, Oxford, OH
Southern Illinois University- Edwardsville
University of CA. Santa Barbara
University of Charleston
University of Colorado at Denver
University of Maryland
University Of North Texas
University of Rhode Island
Alaskan Pacific University
Boston University
CA State University Chico
New Jersey Institute of Technology
Rutgers University
University of Cincinnati
University of Idaho
University of Illinois, Urbana-Champaign
University of Michigan
Figure 6.8 lists the programs identified by Survey 1 as being ‘good’ programs in Environmental Science. These institutions were sent Survey 2.

6.6.2 Sampling

Utilizing the data from Survey 1, the above list of programs was generated. This gives a sample size of 42 programs out of the 75 responses received from the initial 236 surveys sent. These 42 programs are the ones which have the desired aspects of EVSC programs and thus are deemed as acceptable for the further study. Each of these programs was asked to participate in the survey originally and again as part of this follow-up survey. This second survey was sent to the respondents so that they had an opportunity to review and complete it. As part of the instructions for this survey, the persons completing it were asked to signify if they would be willing to discuss their responses in a phone interview. Once the surveys were returned and reviewed, real-time phone interviews were arranged to discuss and expand the responses received.

Before the survey was sent to prospective program personnel, it was field tested at several levels. First, the e-mail delivery mechanism and readability of the material was tested. This test was accomplished by simulating test conditions with a professor at NJIT, Dr. John Coakley, a professor of English at the New Jersey Institute of Technology. The document was sent to Dr. Coakley via e-mail as well as hand-delivered so that the two versions could be compared. Dr. Coakley then commented upon the content of the survey as well as its readability and ease of access via the e-mail delivery system.

After he commented on the procedure, the next test was run with two subjects simultaneously to determine the suitability and workability of the survey and delivery
system. Dr. Daniel Watts and Ms. Vicki Wolfe were sent the material via e-mail to simulate actual conditions. Dr. Watts is the Director of the Center for Sustainable Green Manufacturing at NJIT. He is well versed in the project and many areas of environmental education in general. Ms. Wolfe is conducting a similar survey regarding the infusion of environmental ideas into general course curriculum. She has a familiarity with the subject but no other tie to the project or schools in the study. Her review will provide the most independent critique of the survey instrument. After receipt of the survey, they reviewed and completed it. Their comments were incorporated into the final survey and the material was sent to the prospective survey respondents.

6.6.3 Survey Instrument 2

This is the in-depth survey attempting to assess the specific aspects needed to educate students in EVSC. When sent to the intended subjects, the above cover letter accompanied the survey instrument which was sent as an attachment to the e-mail. Below is a copy of the material sent.

Figure 6.9

Environmental Science Programs Survey 2 Distribution

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Dear Dr. Barat:

Hello and thank you for taking time to assist me again with my research. I am writing you as a follow-up to the survey that you were kind enough to participate in several months ago.

As you may recall, I am a Ph.D. candidate in Environmental Science at the New Jersey Institute of Technology (NJIT). I am writing to ask your help with my dissertation research once again because your program has been identified by my preliminary survey as one of the best in the country.

I am sending along with this letter a more in-depth survey (EVSCsurvey2.doc), that I wish you to complete. It is saved as a Word 6.0/95 protected document so that you should be able to open it with your word processor. After you have had an
opportunity to complete the survey, I would like to arrange a time to speak with you about your answers in order to understand your program and opinions better. This real-time interview should take approximately 30 minutes. Your responses will be used to help me develop an understanding of what should be included in a model Environmental Science Program. Even if you cannot make the time to speak with me in person, please complete as much of the survey as you can and return it to me so that your views can be included in my final assessment.

Your contribution to the success of this study will be greatly appreciated. If there are any questions or problems with accessing the survey, please do not hesitate to contact me at the address listed below. Thank you for your time and invaluable help.

Sincerely,

James M. Lipuma
New Jersey Institute of Technology
Newark, NJ 07102
(973) 642-4743
(973) 642-4689 FAX
jlipuma@webspan.net

Attachment: Environmental Science Program Survey 2

The following survey allows us to learn more about your institution’s programs in Environmental Science as well as your opinions regarding the aspects of an effective program in Environmental Science. Completion of the survey will take approximately thirty minutes. Please try to answer all the questions to the best of your ability. At any time, feel free to give additional comments or provide more in-depth information to clarify answers.

The survey contains questions with four types of responses: Yes/No, multiple choice, ranked—from very unimportant to very important on a 1-6 scale, and open-ended response. You can move between fields by using your computer mouse, arrow keys, or tab key. For the Yes/No and multiple choice questions, you can simply type ‘X’ when the appropriate box is highlighted or use the mouse to point at the appropriate box and then hit the left mouse button to enter your answer. For the other types of questions, highlight the answer space using the keyboard or the mouse and then type your answer. The space will adjust itself to accommodate your response. For those questions which require a written response, please provide as much information as you choose. If you have no opinion for any ranked or open-ended question, please mark the question with the letters ‘NA.’

Please begin by typing your name, your title, and the name of your institution on the bottom of this page so that each survey response can be handled properly when it is received. When you have completed the survey, please e-mail it back to me as an attached
file. If you are unable to return it via e-mail, you can also fax it to my attention at 973-642-4689, or send it via conventional ground mail to:

Mr. James M. Lipuma
Center for Technology Policy Studies
NJIT
Newark, NJ 07102

If there are problems, please contact me at 973-642-4743. In advance, thank you for agreeing to participate in this important project.

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Your Name: _____

Your Title: _____

Institution Name: _____

If you would be willing to discuss your answers during a phone interview, please list a telephone number where you can be reached as well as a convenient time to call.

Phone #:______  Convenient time to call: ______

ENVIRONMENTAL SCIENCE PROGRAM SURVEY 2

Section 1. Background Information

The first section of this survey asks you to describe your program in Environmental Science to give us a sense of the program. If you find the questions too narrow, please annotate any of your answers.

1. What degrees do you offer in Environmental Science?

<table>
<thead>
<tr>
<th>Bachelor of Arts</th>
<th>Bachelor of Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Master of Arts</th>
<th>Master of Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Doctor of Philosophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐</td>
</tr>
</tbody>
</table>

If you offer another degree not included in this list, please provide the degree awarded.

2. Which of the following statements best describes the administrative location of your Program?

<table>
<thead>
<tr>
<th>The Environmental Science program is located within a specific academic department.</th>
<th>☐  Department Name:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>The Environmental Science program is located within a specific campus research center.</th>
<th>☐  Center Name:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>The Environmental Science program is interdepartmental.</th>
<th>☐  Department Names:</th>
</tr>
</thead>
</table>

If the administrative location of your Program is not included in the list above, please provide the location.

3. Please tell us about your Program's history and admissions criteria.

   A. For Undergraduate Degrees

      a. When was your Program begun (i.e., approved to be offered by the institution)?

         ☐ a. before 1950
         ☐ b. 1951-1961
c. 1962-1972
■ d. 1973-1993
■ e. 1994-present

b. Are standardized scores (i.e. SAT or ACT) required for acceptance to the Program?

[ ] YES [ ] NO

If so, what is the minimum standardized score? _____ on the _____ (name examination)

c. Is a minimum high school grade point average (GPA) required?

[ ] YES [ ] NO

If so, what is the minimum grade point average? _____ out of _____ (total GPA)

d. Are letters of recommendation required?

[ ] YES [ ] NO

e. How many students enter the Program in one calendar year (fall through summer semesters)?

[ ] a. fewer than 10 students
[ ] b. 11-21 students
[ ] c. 22-32 students
[ ] d. 33-43 students
[ ] e. more than 44 students

B. For Graduate Degrees

a. When was your Program begun (i.e., approved to be offered by the institution)?

[ ] a. before 1950
[ ] b. 1951-1961
[ ] c. 1962-1972
[ ] d. 1973-1993
[ ] e. 1994-present

b. Is a minimum grade point average required for admission into the graduate program?

[ ] YES [ ] NO

If yes, what is the minimum grade point average? _____ out of _____ (total grade point average)

c. What type of bachelor’s degree does a student need to gain admission to the graduate Environmental Science program?

[ ] a. A degree in Environmental Science is required.
[ ] b. A degree in a field related to Environmental Science is required.
[ ] c. A degree in a field unrelated to Environmental Science is acceptable.

d. Are standardized scores (i.e. GRE) required for admission to the graduate program?

[ ] YES [ ] NO

If yes, what is the minimum standardized score? _____ on the _____ (name examination)

e. Are letters of recommendation required?

[ ] YES [ ] NO

f. How many students enter the Program in one calendar year (fall through summer semesters)?
4a. How many full-time faculty (i.e. tenured, full-time non-tenured, and tenure-track) teach in the Program?
   - a. 5 or fewer faculty
   - b. 6 to 11 faculty
   - c. 12 to 17 faculty
   - d. 18 to 22 faculty
   - e. more than 22 faculty

4b. How many part-time faculty (i.e., adjuncts, special lecturers, and visiting lecturers) teach in the Program?
   - a. fewer than 5 faculty
   - b. 6 to 11 faculty
   - c. 12 to 17 faculty
   - d. 18 to 22 faculty
   - e. more than 22 faculty

5. Of those faculty who teach in the Program, what percent of their time is committed to working with the Environmental Science Programs?
   - a. less than one-quarter time
   - b. one-quarter time
   - c. half time
   - d. three quarters time
   - e. full time

6. Which of the following statements applies best to the use of part-time faculty in your Program?
   - a. Part-time faculty are rarely used to teach courses in the Environmental Science.
   - b. Part-time faculty are occasionally used to teach courses in Environmental Science.
   - c. Part-time faculty are frequently used to teach courses in Environmental Science.

7. Which of the following statements best describes the fields of your faculty?
   - a. The majority of the faculty hold degrees in Environmental Science.
   - b. The majority of the faculty hold degrees in areas related to Environmental Science (i.e. Environmental Studies, Environmental Biology, or Environmental Management).
   - c. The majority of the faculty hold degrees in fields unrelated to areas of the environment.

8. What is the mission statement for your Program. If you wish, you may simply include the URL for the program web page that contains the statement or send a copy of it via fax or US mail.

Section II. Student Abilities
With this background information, we would like you to consider the outcomes of the Program. That is, what abilities do you believe students should master by graduation? Please mark the answer that best describes your assessment of that skill and explain how the program teaches the students these skills.

9a. Students should have strong quantitative skills.

9b. How do you teach students to have strong quantitative skills.
10a. Students should be able to convey ideas and communicate effectively with the written word.

<table>
<thead>
<tr>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
</table>

10b. How do you teach students to convey ideas and communicate effectively with the written word?

11a. The students should be able to convey ideas and communicate effectively by means of oral presentations.

<table>
<thead>
<tr>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
</table>

11b. How do you teach students to convey ideas and communicate effectively by means of oral presentations?

12a. Students should be able to evaluate literature in the field critically.

<table>
<thead>
<tr>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
</table>

12b. How do you teach students in your program to evaluate literature in the field critically?

13a. Students should be able to utilize a process to approach, research, analyze, and solve problems.

<table>
<thead>
<tr>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
</table>

13b. What process for approaching, researching, analyzing, and solving problem does your program teach to its students?

Section III. Subject Areas
The next series of questions asks you to evaluate content areas of Environmental Science programs. Please rank the importance of each of the selected disciplines listed below to an effective Environmental Science program according to the following scale:

6=very important 3=somewhat unimportant
5=moderately important 2=moderately unimportant
4=somewhat important 1=very unimportant

14a. Here are the selected disciplines of study:

<table>
<thead>
<tr>
<th>Biology</th>
<th>Ecology</th>
<th>Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry-analytical</td>
<td>Economics</td>
<td>Microbiology</td>
</tr>
<tr>
<td>Chemistry-basic</td>
<td>English</td>
<td>Philosophy</td>
</tr>
<tr>
<td>Chemistry-physical</td>
<td>Geography</td>
<td>Physics</td>
</tr>
<tr>
<td>Communications</td>
<td>Geology</td>
<td>Political Science/Law</td>
</tr>
<tr>
<td>Computer Science</td>
<td>History</td>
<td>Psychology</td>
</tr>
<tr>
<td>Earth Science</td>
<td>Management</td>
<td>Sociology</td>
</tr>
</tbody>
</table>

14b. Are there subject areas that are not listed above which you think should be included? Are there any comments that you would like to make about these subject areas or your ratings?

Section IV. Laboratory and Field Experiences
Beyond the didactic world of the classroom, many programs offer opportunities for laboratory experiences and fieldwork. Please evaluate each of these opportunities for applied experiences in Environmental Science according to the following scale:

<table>
<thead>
<tr>
<th>Score (6-1)</th>
<th>6=very important</th>
<th>5=moderately important</th>
<th>4=somewhat important</th>
<th>3=somewhat unimportant</th>
<th>2=moderately unimportant</th>
<th>1=very unimportant</th>
</tr>
</thead>
</table>

15a. Here are the areas for laboratory and field work experiences:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Score (6-1)</th>
<th>Offered in the EVSC Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Science (biology/chemistry/physics) laboratory experience.</td>
<td>YES</td>
<td>☐</td>
</tr>
<tr>
<td>Basic Science (biology/chemistry/physics) field experience.</td>
<td>YES</td>
<td>☐</td>
</tr>
<tr>
<td>Environmental laboratory experience.</td>
<td>YES</td>
<td>☐</td>
</tr>
<tr>
<td>Environmental field experience.</td>
<td>YES</td>
<td>☐</td>
</tr>
<tr>
<td>Social science laboratory experience.</td>
<td>YES</td>
<td>☐</td>
</tr>
<tr>
<td>Social science field experience.</td>
<td>YES</td>
<td>☐</td>
</tr>
<tr>
<td>Independent research projects with faculty members.</td>
<td>YES</td>
<td>☐</td>
</tr>
<tr>
<td>Internships or other off-campus work experience.</td>
<td>YES</td>
<td>☐</td>
</tr>
</tbody>
</table>

15b. Are there any subjects that are not listed above which you think should be included? Are there any comments that you would like to make about these subjects or your ratings?

Section V. Capstone and Thesis Requirements

In addition to field experiences, graduate programs may require capstone courses and submission of a formal thesis. Please answer each of the following questions regarding these program requirements.

16. The graduate Program requires a capstone or other synthesizing experience in which the student brings together aspects of his/her work in the program culminating in the investigation of a single topic.

   YES ☐ NO ☐ Not Applicable ☐

17. The Program requires a formal thesis that is reviewed, approved, and retained by the department or institution.

   YES ☐ NO ☐ Not Applicable ☐

Section VI. Distance Learning

The next set of questions deal with any learning handled in a format that does not require face-to-face contact between students and teachers.

18. How many courses in the Environmental Science program are offered in a distance learning format?

   ☐ a. No courses are offered in this format
   ☐ b. 1-3 courses
   ☐ c. 4-6 courses
   ☐ d. 7-9
   ☐ e. more than 10 courses are offered in this format

19. May a student take all the course work required for the degree in a distance learning format?

   YES ☐ NO ☐
Section VII. External Advisement

20a. How often does your program receive external advisement and input concerning your Environmental Science Program? In this case, the input can be meeting with an advisory board, external reviewers, outside consultants or others who are intending to improve the program through oversight and guidance.

☐ a. Fewer than once a year
☐ b. Yearly
☐ c. Semiannually
☐ d. Quarterly
☐ e. Monthly

20b. What groups or individuals provide the external advisement guidance for your program?

21. Are there any areas of Environmental Science that you feel the survey did not cover or any other information about your program that you would like to include to help understand what you feel would make a good Environmental Science program?

Thank you again for your participation in this study. I hope to speak with you soon.

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Figure 6.9 is the material sent to each program scoring above a seven on survey 1 as part of Environmental Science Programs Survey 2.

Once the surveys were returned, phone interviews were conducted with those respondents that indicated willingness. A list of potential questions was sent. That list appears below in figure 6.10.

Figure 6.10

Phone Interview Questions for Environmental Science Programs Survey 2

Dr.

I would like to set up a time to interview you that would be convenient so we can speak about my survey.

To make the interview easier, I am forwarding a list of the types of questions I have for the interview so you can look at them before we speak. These are just some rough areas about which I am trying to gather more information.

Thank you and I look forward to speaking with you.

Jim Lipuma
NJIT
732-388-6764
***************
1) I have developed a descriptive model of education. My model suggests that the general goals of educational programs in the broadest terms are employment, awareness, and enlightenment. Do you agree? Are there other outcomes you think should be included?

2) Environmental Science has the goals stated above along with others that are more specific to the inner-working of EVSC programs. What types of things do you feel Environmental Science programs should attain?

3) As part of my assessment, it has become clear that there are many definitions of Environmental Science. I have developed the following definition:

Environmental Science (EVSC) is the study of human interactions with other humans and their surroundings. Particular interest is focused upon the influence of humans and their impact on the ecosystems in which they live. The goal of EVSC is to describe and understand existing and potential problems with the ecosystem as well as develop solutions to remediate and prevent these situations. In addition, EVSC is aimed at providing a better understanding of human interactions with one another and the world so the ecosystemic effects can be foreseen and lessened. To accomplish these goals, those studying EVSC must have a depth of disciplinary knowledge complemented by broad and interdisciplinary experiences so that they can utilize tools and processes from these many disciplines. Also, these scientists need to understand how to solve a variety of problems and communicate with experts and lay persons from a wide range of disciplines in order to gather research and disseminate findings. All Environmental Scientists should be interdisciplinary problem-solvers and decision-makers with the ability to clearly and effectively communicate.

How do you define EVSC? Do you agree with my definition?

4) I suggest that the following objectives are used to attain the goals of EVSC education programs.

Overall Objectives:
- Breath and depth of curriculum. Content issues
- Problem solving, critical thinking and decision making
- Inter/multidisciplinarity
- Communication

What are the objectives to obtain these goals of EVSC education? Are there other objectives that you feel the EVSC program should try to achieve to attain the goals?

5) In order to attain the goals and objectives of a curriculum, the program faculty and administrators have several tools to use to accomplish the attainment of the program goals. The following are the general aspects that have been identified as tools to accomplish the goals of a program.

Ways to accomplish this:
• Curriculum
• Faculty
• Extracurricular activities
• External Advisement

Do you have any other aspects to add?

6) Do you feel that there are other ways to accomplish the goals of the program?

There are some other areas that I want to ask you about as well.

7) Do you feel interdisciplinarity can be taught by a disciplinary set of instructors?

8) Should faculty members have a breadth of knowledge or is depth of knowledge sufficient within a program?

9) What types of case studies and examples are employed in your program?

These questions are talking points to assist me in finding out more about what should be in EVSC programs.

I look forward to speaking with you in the near future.

Figure 6.10 is the follow-up questions used during the phone interview to gather more information about EVSC programs as part of Environmental Science Programs Survey 2.

If the survey was not responded to after one month, follow-up e-mails were sent and phone calls made to elicit responses. Below, in figure 6.11, is an example of the follow-up letter that was e-mailed to those institutions that had not returned a survey after one month and again after three months.

Figure 6.11
Follow-up Letter for Non-respondents to Environmental Science Program Survey 2

May 24, 2000

Dear Dr. :

I am writing you as a follow-up to the survey that I sent you one month ago. As you may recall, I am a Ph.D. candidate in Environmental Science at the New Jersey Institute of Technology (NJIT) researching the state of Environmental Science Programs in America.
As of now, I have not received your responses. If you have sent the survey, please forward another copy to me or inform me that it was sent so I can determine why it was not received. If you did not receive the initial survey or have lost it, please let me know so I can send another copy for you to complete.

Your participation is vital to my research and your valuable input will be greatly appreciated. If there are any questions or problems with accessing the survey, please do not hesitate to contact me at the address listed below. Thank you for your time and invaluable help.

Sincerely,

James M. Lipuma
New Jersey Institute of Technology
Newark, NJ 07102
(973) 642-4743
(973) 642-4689 FAX
jlipuma@webspan.net

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

July 24, 2000

Dear Dr. : 

I am writing you as a follow-up to the survey that I sent you three month ago. As you may recall, I am a Ph.D. candidate in Environmental Science at the New Jersey Institute of Technology (NJIT) researching the state of Environmental Science Programs in America.

As of now, I have not received your responses. If you have sent the survey, please forward another copy to me or inform me that it was sent so I can determine why it was not received. If you did not receive the initial survey or have lost it, please complete the attached copy and return it to me via e-mail or conventional mail.

Your participation is vital to my research and your valuable input will be greatly appreciated. This will be the last time you will be contacted regarding this matter. If there are any questions or problems with accessing the survey, please do not hesitate to contact me at the address listed below. Thank you for your time and invaluable help.

Sincerely,

James M. Lipuma
New Jersey Institute of Technology
Newark, NJ 07102
Environmental Science Program Survey 2 attached

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Figure 6.11 shows the letters sent to programs that did not respond to the initial and/or follow-up letters asking for participation in Environmental Science Programs Survey 2.

6.6.4 Report of Data

After sending the surveys, e-mail reminders were sent and follow-up phone calls were made to increase the likelihood that responses would be received. After three months, the final reminder was sent and the period for accepting survey responses was closed.

Upon the close of the survey period, thirty-two responses of some type had been received for a response rate of 80%. Of these, a total of twenty-four completed surveys were returned, giving a response rate of 60%. The eight institutions that responded with some type of answer gave a variety of reasons for not completing the survey. This includes such things as busy schedules, a general lack of time, or other complications at the institution.

Of the twenty-four responses, only twelve had time and availability to actually participate in the phone interview. Of these, six were selected, times scheduled and interviews conducted utilizing the questions listed above. The next section of the dissertation will examine the results from Environmental Science Survey 2 to help inform the outcomes section of the discretion.
CHAPTER 7

RESULTS

7.1 Introduction

The purpose of this chapter is to present, explain, and interpret the results from Environmental Science Program Survey 2. Once these results are examined, a discussion of how they can be used to support the outcomes in Chapter 8 will be conducted.

There are two major objectives of this chapter. First, it is important to demonstrate that the results received can be treated as one group of respondents or sample rather than three groups—Undergraduate only, Graduate only, and combined Undergraduate and Graduate programs. After having established how the results can be categorized, it is necessary to interpret the results and understand how the answers given are related to one another. Once these two objectives have been reached, the results of the survey can be used to draw conclusions and support the recommendations made relating to what can be done to improve EVSC programs (discussed in Chapter 8).

7.2 Concepts of Interest

The first step in the description of the results is to understand why each question was asked and how the results from these questions are intended to be used. To assist with this, the chart in Figure 7.1 was constructed. Though other information can be obtained by reviewing the material provided by respondents to Survey 2, the four concepts listed below are the main focus of the analysis.
## Figure 7.1
From Concepts of Interest to Survey Results

<table>
<thead>
<tr>
<th>Concept of Interest</th>
<th>Citations</th>
<th>Survey Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Knowledge</td>
<td>ABET Engineering Criteria 2000.</td>
<td>14a. Disciplines of study?</td>
</tr>
<tr>
<td></td>
<td>Recent Developments in College Level Environmental Studies Courses and Programs</td>
<td>15a. Laboratory and field work experiences?</td>
</tr>
<tr>
<td></td>
<td>Acquired Skills Profiles for Environmental Science Students</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental Education: Academia's Response</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Principles of Environmental Education</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fundamentals of Ecology 3rd edition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Guide to Graduate Environmental Programs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Region 8 Environmental Education Program</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Status of Undergraduate Programs in Environmental Science</td>
<td></td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Principles of Environmental Education</td>
<td>9a. Strong quantitative skills?</td>
</tr>
<tr>
<td></td>
<td>Context, Connection and Opportunity in Environmental Problem Solving</td>
<td>13a. Utilize a process to solve problems?</td>
</tr>
<tr>
<td></td>
<td>The Guide to Graduate Environmental Programs</td>
<td>16. Have capstone or other synthesizing experience?</td>
</tr>
<tr>
<td></td>
<td>Region 8 Environmental Education Program</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Dimensions of Thinking: A Framework for Curriculum and Instruction</td>
<td>10a. Convey ideas and communicate effectively with the written word?</td>
</tr>
<tr>
<td></td>
<td>Environmental Education in New Jersey: A Plan of Action</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Principles of Environmental Education</td>
<td>11a. Communicate effectively by means of oral presentations?</td>
</tr>
<tr>
<td></td>
<td>Ecological Literacy: Education and the Transition to a Postmodern World</td>
<td>12a. Evaluate literature in the field critically.</td>
</tr>
<tr>
<td></td>
<td>The Guide to Graduate Environmental Programs</td>
<td></td>
</tr>
<tr>
<td>Interdisciplinarity</td>
<td>Interdisciplinarity: History, Theory, and Practice</td>
<td>14a. Disciplines of study?</td>
</tr>
<tr>
<td></td>
<td>Interdisciplinary Curriculum: Design and Implementation</td>
<td>15a. Laboratory and field work experiences?</td>
</tr>
<tr>
<td></td>
<td>Interdisciplinarity: History, Theory, and Practice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Principles of Environmental Education</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Inter-Dependence of Environmental Education, Economic and Industrial Understanding, and the Other Cross-Curricular Themes within the School Curriculum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental Science: A Foundation for the Future</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Engineering Education in the United States - Moving to a New Paradigm in 2000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental Education, Social Studies, and Education Reform</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Guide to Graduate Environmental Programs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Region 8 Environmental Education Program</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The Status of Undergraduate Programs in Environmental Science</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.1 is a conceptual model showing how the results from Survey 2 relate to the general model of education. It lists the concepts of interest as described in the general education model, literature references relating to each concept of interest, as well as the survey questions that corresponds to that concept.
This chart shows that most of the questions from Survey 2 provide information about content knowledge. The other three areas, problem-solving, communication, and interdisciplinarity are mainly addressed in the student abilities section of the survey covered in questions 9 through 13. The last area of interest, content knowledge, is addressed by the remainder of the questions and was the main focus of Survey 2. Though theories could provide insight into the other concepts of interest, questions regarding content knowledge benefit from the practical experience provided by those running effective programs such as those surveyed.

7.3 Analysis of Response Similarity

7.3.1 Demonstrating Sample Similarity for Survey 2

Having identified the concepts of interest for the survey question, it was necessary to code and order the results so they could be analyzed. The data were analyzed using SPSS 8.0 for Windows and basic data analysis tools including descriptive statistics, chi-square analysis, and non-parametric tests such as Spearman Rho. There were a total of twenty-four responses representing three types of programs; undergraduate (11 responses), graduate (6 responses) and combined programs (7 responses). Undergraduate programs are those who reported offering only undergraduate EVSC degrees. Graduate programs were those who reported offering only graduate EVSC degrees. Combined programs were those who reported offering some type of undergraduate as well as graduate EVSC degrees.

Through the selection of the sample as described earlier, the survey respondents were designated as similar and thus as part of one population for comparison purposes. Even so, it is helpful to present them as three different groups first in order to demonstrate
to the reader how their results from these categories compared to one another for each of these questions. After these comparisons have been made, the three populations will be condensed into a single respondent population for the purposes of the correlation analysis and further discussion of this chapter.

The first section of the survey provided the researcher with demographic data about the programs. This information showed that the sample was representative of schools of various sizes, offering a range of degrees, and representing programs of varying ages and with a range of requirements similar to the overall sample of EVSC programs taken at the beginning of the survey process. In addition, the size and make-up of part and full time faculty varied greatly as well as the types of degrees these faculty held.

For sections two, three and four, the respondents could rank each item in the respective sections from Very Important (6) to Very Unimportant (1) on a six point scale. To assist the reader, the appropriate questions are restated directly before each figure. The column under the category—Undergrad, Graduate, or Combined—shows the number of actual responses received for each of the ratings. At the bottom of this column is the mean for that set of responses labeled as ‘M.’ The column immediately to the right of this column is labeled ‘%’ and gives the percentage of the total number of responses that each actual number represents. At the bottom of this column is the standard deviation labeled as ‘s,’ that shows how widely the responses varied.

A small s means that the answers were all very close to the mean and one another. A larger s means that the answers varied more widely. In some cases, the means for each group vary greatly and the standard deviations are very large. Unfortunately, due to the small sample size, it is difficult to draw conclusions about these results. However, the
information is provided so that the reader can see the difference in the rankings attributed to the three categories and thus draw conclusions for themselves.

7.3.2 Sample Similarity in Section Two

Section two of the survey asks for opinions about general student abilities.

Questions 9 through 13 deal with general skills that EVSC students should have. Figures 7.2 through 7.6 show the average answers to each question for the three respondent categories.

9a. Students should have strong quantitative skills.

<table>
<thead>
<tr>
<th>Have strong quantitative skills</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>9</td>
<td>82</td>
<td>3</td>
<td>50</td>
<td>3</td>
<td>43</td>
</tr>
<tr>
<td>Moderately Important</td>
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<td>18</td>
<td>2</td>
<td>33</td>
<td>3</td>
<td>43</td>
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<td>0</td>
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<td>17</td>
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<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\[ M = 5.8 \quad s = 0.4 \quad M = 5.6 \quad s = 0.5 \quad M = 5.3 \quad s = 0.8 \]

Figure 7.2 reports the results of question nine from Survey 2.

10a. Students should be able to convey ideas and communicate effectively with the written word.

<table>
<thead>
<tr>
<th>Written word</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>8</td>
<td>73</td>
<td>6</td>
<td>100</td>
<td>6</td>
<td>86</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>3</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
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<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\[ M = 5.7 \quad s = 0.5 \quad M = 6 \quad s = 0 \quad M = 5.9 \quad s = 0.4 \]

Figure 7.3 reports the results of question ten from Survey 2.
11a. The students should be able to convey ideas and communicate effectively by means of oral presentations.

![Figure 7.4](image)

**Answers to Question 11**

<table>
<thead>
<tr>
<th>Oral presentations</th>
<th>Undergrad %</th>
<th>Graduate %</th>
<th>Combined %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>65</td>
<td>30</td>
<td>65</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>45</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 7.4 reports the results of question eleven from Survey 2.

12a. Students should be able to evaluate literature in the field critically.

![Figure 7.5](image)

**Answers to Question 12**

<table>
<thead>
<tr>
<th>Evaluate literature</th>
<th>Undergrad %</th>
<th>Graduate %</th>
<th>Combined %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>64</td>
<td>30</td>
<td>58</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>27</td>
<td>17</td>
<td>24</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 7.5 reports the results of question twelve from Survey 2.

13a. Students should be able to utilize a process to approach, research, analyze, and solve problems

![Figure 7.6](image)

**Answers to Question 13**

<table>
<thead>
<tr>
<th>Problem-solving</th>
<th>Undergrad %</th>
<th>Graduate %</th>
<th>Combined %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>73</td>
<td>83</td>
<td>76</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>9</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 7.6 reports the results of question thirteen from Survey 2.
As can be seen from the closeness of the means and similarity of the answers given, each group of respondents was not significantly different so that these sample groups can be treated as one population. Figure 7.7 shows the combined results for all twenty-four responses.

**Figure 7.7**
Results for Questions 9-13

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have strong quantitative skills</td>
<td>5.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Written word</td>
<td>5.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Oral presentations</td>
<td>5.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Evaluate literature</td>
<td>5.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Approach, research, analyze, and solve problems.</td>
<td>5.8</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Figure 7.7 shows the average score for questions nine through thirteen of Survey 2. A total of twenty-four responses were used to compute the averages.

7.3.3 Sample Similarity in Section Three

Section three of the survey asked for opinions about specific classes. The respondents were asked to evaluate content areas of Environmental Science Programs and rank the importance of the selected areas to producing an effective curriculum in Environmental Science. The answers ranged from very important(6) to very unimportant(1) on a six point scale. This section begins with Question 14 and deals with courses that EVSC students should have in general. The question is restated below to assist the reader.

14a. The next series of questions asks you to evaluate content areas of Environmental Science programs. Please rank the importance of each of the selected disciplines listed below to an effective Environmental Science program.

The following figures give some examples of disciplines where the answers were extremely similar for all three groups. The column headings and labels are identical to those used above in section two.
Figure 7.8 shows the average answers to question 14 for the discipline of Ecology. As can be seen from the means, this discipline received high scores from each category but they were not identical. However, the standard deviation for each mean is still relatively low when compared to other discipline scores.

<table>
<thead>
<tr>
<th>Ecology</th>
<th>Undergrad %</th>
<th>Graduate %</th>
<th>Combined %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>8</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 7.8 reports the results for the discipline of Ecology from question fourteen on Survey 2.

In other cases, the means are identical, however, the standard deviation for each result is larger and varied as shown in figure 7.9.

<table>
<thead>
<tr>
<th>Geology</th>
<th>Undergrad %</th>
<th>Graduate %</th>
<th>Combined %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>2</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 7.9 reports the results for the discipline of Geology from question fourteen on Survey 2.

In either case, the data are close enough to be considered similar and not significantly different according to tests of standard deviation. Some disciplines did vary
more than others. The widest variation was found for the field of management. Figure 7.10 shows the results obtained for this discipline.

**Figure 7.10**

*Answers to Management from Question 14*

<table>
<thead>
<tr>
<th>Management</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>33</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>2</td>
<td>18</td>
<td>2</td>
<td>33</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>3</td>
<td>27</td>
<td>1</td>
<td>17</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>2</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>2</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\[ M = 3 \quad s = 1.2 \quad M = 4.7 \quad s = 1.2 \quad M = 3.9 \quad s = 1.3 \]

*Figure 7.10 reports the results for the discipline of Management from question fourteen on Survey 2.*

This variability may be explained in several ways. First, the fact that the graduate degree programs have a management orientation, such as the program at Duquesne University, can influence the rankings. In addition, many programs focusing on graduate student education may place higher emphasis on management skills since the students enrolled in the program hold jobs in management and are seeking to engage in graduate level EVSC education that hones these types of skills. These ideas will be explored further in the next chapter. Even with this variability, the means for these three groups were within one standard deviation of one another and so could be characterized as similar.

Having shown the data to be similar, the data could be treated as one large set and reviewed as a whole. Figure 7.11 lists the means for each discipline along with the standard deviations for each mean.
### Figure 7.11
Results for Question 14

<table>
<thead>
<tr>
<th>Topic</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>5.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Chemistry-analytical</td>
<td>4.5</td>
<td>1</td>
</tr>
<tr>
<td>Chemistry-basic</td>
<td>5.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Chemistry-physical</td>
<td>5.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Communications</td>
<td>5.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Computer Science</td>
<td>4.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Earth Science</td>
<td>4.9</td>
<td>1</td>
</tr>
<tr>
<td>Ecology</td>
<td>5.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Economics</td>
<td>4.3</td>
<td>1.3</td>
</tr>
<tr>
<td>English</td>
<td>4.8</td>
<td>1.2</td>
</tr>
<tr>
<td>Geography</td>
<td>4.1</td>
<td>1</td>
</tr>
<tr>
<td>Geology</td>
<td>5</td>
<td>1.1</td>
</tr>
<tr>
<td>History</td>
<td>3.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Management</td>
<td>3.7</td>
<td>1.4</td>
</tr>
<tr>
<td>Mathematics</td>
<td>5.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Microbiology</td>
<td>4</td>
<td>1.2</td>
</tr>
<tr>
<td>Philosophy</td>
<td>3.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Physics</td>
<td>4.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Political Science/Law</td>
<td>4.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Psychology</td>
<td>2.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Sociology</td>
<td>3.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Figure 7.11 shows the average score for various course offerings listed in question fourteen of Survey 2. A total of twenty-four responses were used to compute the averages.

### 7.3.4 Sample Similarity in Section Four

Section four of the survey asks for opinions about field and laboratory experiences. The respondents were asked to evaluate various areas of Environmental Science programs and rank the importance of the selected areas to an effective Environmental Science program. The answers ranged from very important(6) to very unimportant(1) on a six point scale.

Question 15 deals with experiences that EVSC students may have that will enhance the learning experience. These questions are restated below to assist the reader.

15a. *Beyond the didactic world of the classroom, many programs offer opportunities for laboratory experiences and fieldwork.*

Figures 7.12 through 30 show the average answers to each question listed above for the three respondent categories. The column headings and labels are identical to those used above in section two.
**Figure 7.12**

Results for Basic Science Lab for Question 15

<table>
<thead>
<tr>
<th>Basic Science labs</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>10</td>
<td>91</td>
<td>4</td>
<td>66</td>
<td>6</td>
<td>86</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

$M = 5.6 \quad s = 1.2 \quad M = 5.5 \quad s = 0.8 \quad M = 5.9 \quad s = 0.4$

Figure 7.12 reports the results for Basic Science laboratory experience from question fifteen on Survey 2.

**Figure 7.13**

Results for Basic Science Field Experience for Question 15

<table>
<thead>
<tr>
<th>Basic Science field</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>7</td>
<td>64</td>
<td>3</td>
<td>50</td>
<td>4</td>
<td>57</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>1</td>
<td>9</td>
<td>3</td>
<td>50</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>2</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

$M = 5.2 \quad s = 1.3 \quad M = 5.5 \quad s = 0.5 \quad M = 5.3 \quad s = 1$

Figure 7.13 reports the results for Basic Science field experience from question fifteen on Survey 2.

**Figure 7.14**

Results for Environmental Science Laboratory Experience for Question 15

<table>
<thead>
<tr>
<th>Environmental lab</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>9</td>
<td>82</td>
<td>4</td>
<td>66</td>
<td>6</td>
<td>86</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

$M = 5.5 \quad s = 1 \quad M = 5.5 \quad s = 0.8 \quad M = 5.9 \quad s = 0.4$

Figure 7.14 reports the results for Environmental Science laboratory experience from question fifteen on Survey 2.
### Figure 7.15
**Results for Environmental Science Field Experience for Question 15**

<table>
<thead>
<tr>
<th>Environmental field</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>9</td>
<td>82</td>
<td>4</td>
<td>66</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>33</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\[ M = 5.5 \quad s = 1 \quad M = 5.7 \quad s = 0.5 \quad M = 6 \quad s = 0 \]

Figure 7.15 reports the results for Environmental Science field experience from question fifteen on Survey 2.

### Figure 7.16
**Results for Social Science Laboratory Experience for Question 15**

<table>
<thead>
<tr>
<th>Social science lab</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>33</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>2</td>
<td>18</td>
<td>1</td>
<td>17</td>
<td>4</td>
<td>57</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>3</td>
<td>27</td>
<td>3</td>
<td>50</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>2</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>2</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\[ M = 2.8 \quad s = 1.3 \quad M = 4.2 \quad s = 1.5 \quad M = 3.9 \quad s = 0.7 \]

Figure 7.16 reports the results for Social Science laboratory experience from question fifteen on Survey 2.

### Figure 7.17
**Results for Social Science Field Experience for Question 15**

<table>
<thead>
<tr>
<th>Social science field</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>33</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>2</td>
<td>18</td>
<td>1</td>
<td>17</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>3</td>
<td>27</td>
<td>3</td>
<td>50</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>3</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Unanswered</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

\[ M = 2.7 \quad s = 1.4 \quad M = 4.2 \quad s = 1.5 \quad M = 3.7 \quad s = 1.6 \]

Figure 7.17 reports the results for Social Science field experience from question fifteen on Survey 2.
Figure 7.18

Results for Independent Research Experience for Question 15

<table>
<thead>
<tr>
<th>Independent research</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>8</td>
<td>73</td>
<td>5</td>
<td>83</td>
<td>4</td>
<td>57</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>2</td>
<td>18</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>1</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

$M = 5.6 \quad s = 0.7 \quad M = 5.8 \quad s = 0.4 \quad M = 5.3 \quad s = 1$

Figure 7.18 reports the results for Independent Research experience from question fifteen on Survey 2.

Figure 7.19

Results for Internship Experience for Question 15

<table>
<thead>
<tr>
<th>Internships</th>
<th>Undergrad</th>
<th>%</th>
<th>Graduate</th>
<th>%</th>
<th>Combined</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Important</td>
<td>8</td>
<td>73</td>
<td>5</td>
<td>83</td>
<td>6</td>
<td>86</td>
</tr>
<tr>
<td>Moderately Important</td>
<td>3</td>
<td>27</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Somewhat Important</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Somewhat Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moderately Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Very Unimportant</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unanswered</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

$M = 5.7 \quad s = 0.5 \quad M = 5.8 \quad s = 0.4 \quad M = 5.9 \quad s = 0.4$

Figure 7.19 reports the results for Internship experience from question fifteen on Survey 2.

In this section, the responses for six of the eight questions were all similar and as expected. However, the means of the results obtained for Social Science Laboratory and Field experience varied greatly between categories and had large standard deviations. The small size of the sample groups can contribute to this happening, but other factors may also have been the cause. It seems that as the focus of programs shift towards the graduate schools, the importance of the Social Sciences increases. This may be attributed to differing views of the needs of EVSC students but also may relate to the types of programs being studied. Several of the graduate programs had Social Science focuses as part of their stated mission. In these cases, the programs would give more weight to these types of
experiences and thus rank the Social Science laboratory and field experiences more highly than the other programs being discussed. In any event, the scores for the Social Sciences were generally lower than those for the other experiences in all cases and at all levels.

Though these variations suggest that the three groups have given a varied set of answers, the survey methodology shows them to be similar for the purposes of these tests. Future research may wish to look at the groups surveyed to determine how similar the members of the differing categories are with regard to this one set of topics. However, for the purpose of this work, the results are anomalies rather than typical occurrences within the data and so are treated as aberrations.

Having noted these exceptions, the three groups were condensed into a single sample for purposes of comparison. Figure 7.20 lists the means and standard deviations for the ranks given to the hands-on experiences discussed in section four.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Science (biology/chemistry/physics) laboratory experience.</td>
<td>5.7</td>
<td>0.9</td>
</tr>
<tr>
<td>Basic Science (biology/chemistry/physics) field experience.</td>
<td>5.3</td>
<td>1</td>
</tr>
<tr>
<td>Environmental laboratory experience.</td>
<td>5.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Environmental field experience.</td>
<td>5.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Social science laboratory experience.</td>
<td>3.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Social science field experience.</td>
<td>3.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Independent research projects with faculty members.</td>
<td>5.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Internships or other off-campus work experience.</td>
<td>5.8</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Figure 7.20 shows the mean for areas listed in question fifteen of Survey 2. Twenty-four responses were used to compute the means.
7.4 Correlations Tests

7.4.1 Introduction

Although the means listed above provide much useful information about the general trends represented in the data, more information about the connection between the various questions was needed. To that end, the author utilized SPSS, the statistical analysis program to analyze the data.

Using SPSS, a Spearman Rho test of correlation was conducted (Schloesser, July 2000). The output of this test was a matrix that compared each variable in the survey to every other variable in the survey. Spearman Rho is a non-parametric data test utilized with ordinal data and produces a rank order coefficient of correlation. The test used was a one-tailed non-parametric correlations for the data because there is a limited range of responses in the survey responses. This is in contrast to a continuous and widely varied range of answers that might be expected from other types of data and open to other statistical analyses.

According to Spearman's Rho Test, "the test is a test of correlation, describing the relationship between, not the difference between two sets of scores, X and Y." The scores for X and Y are ranked and coded such that 1 is the lowest scoring rank. The difference between X and Y is then calculated and this number is then squared (labeled $d^2$). N is defined as the total number of cases for each variable. Spearman’s R coefficient $R$ is calculated as follows:

$$r_s = 1 - \frac{6(\Sigma d^2)}{N(N^2 - 1)}$$
7.4.2 Correlation Test Defined

The results of the analysis appear as a set of numbers that give the correlation coefficient, the significance, and the number of respondents for that variable. The correlation coefficient shows how well the two variables are related and the direction of that relation. The better the correlations, the closer to one (1) the coefficient will be. A positive correlation coefficient means the answers for the question increase as the answer for the variable in question increases. A negative correlation coefficient means the answers for the question increase as the answer for the variable in question decreases. The significance shows how close to one another the answers for the two variables are. The smaller the number the better. In this case, only correlations with significance in the 95% confidence interval (less than 0.05) were even considered. Those under 0.05 are labeled with one star (*) and those in the 99% confidence interval (less than 0.01) labeled with two stars(**). Finally, the number of respondents (N) is the number of surveys that gave some answer that was useable for that survey question.

Even with these parameters, many variables were shown to be significant but not all of them are useful. For example, many programs that require letters of recommendation also require test scores for entrance into the programs. In another case, the more students that enter the program correlates with a larger number of faculty and greater time they devote to teaching in the program. In other cases, the groups listed above become apparent in the correlations. The combined programs were shown to have a high correlation between the starting dates of the undergraduate and graduate programs in the same field. The correlations for this are near 1 (0.917) and the significance is almost 0(0.002). These types of obvious correlations are not discussed here. The following
section contains the listings of all those correlations that have proved to be both significant and helpful to the determination of the characteristics of good EVSC programs.

7.4.3 Spearman Rho Correlation Test Results

7.4.3.1 Introduction

Utilizing statistical analysis programs, the results from Environmental Science Program Survey 2 were correlated using the Spearman Rho Test. The results from the statistical analysis program for this test are contained in this section.

The test produced correlations between all of the variables. From these results, charts listing the results are given below. These charts are broken into sections similar to those on the survey: demographics, student abilities, courses, hands-on experiences and other information.

7.4.3.2 Demographics

The first set of questions that will be examined are related to the demographics. The first question being examined is, “When was the undergraduate program started?” Figure 7.21 shows those variables that correlated with this question.

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty time devoted to program</td>
<td>-0.483</td>
<td>0.029</td>
<td>*</td>
<td>16</td>
</tr>
<tr>
<td>Geography</td>
<td>0.506</td>
<td>0.019</td>
<td>*</td>
<td>17</td>
</tr>
<tr>
<td>Management</td>
<td>0.484</td>
<td>0.029</td>
<td>*</td>
<td>16</td>
</tr>
<tr>
<td>Social Science Field Experience</td>
<td>0.449</td>
<td>0.041</td>
<td>*</td>
<td>16</td>
</tr>
<tr>
<td>Independent Research</td>
<td>0.448</td>
<td>0.031</td>
<td>*</td>
<td>18</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.21 shows the Spearman Rho Correlation Test results for the variables related to the creation of the undergraduate program as listed in Environmental Science Survey 2.
The first variable, the amount of full-time faculty time devoted to the EVSC program, is inversely related to the age of the undergraduate program. This means that the older programs have more faculty time devoted to the program. The other variables, Geography, Management, Social Science Field Experience, and Independent research projects all correlated positively meaning that the newer the program the more highly they ranked these topics. Thus, newer programs may have less faculty time devoted to them, but have tended to give higher scores to some course work outside the 'hard' sciences. In both of these cases, drawing conclusions from the correlation may be difficult to understand because one or both of the variables may not be ranked data. The Spearman correlation works best with ranked data such as those provided for student skills, or course areas. In the case of when the program was started, the oldest programs are coded as a 1 and the newest programs as a 6. When the statistical program interprets this, it sees the coding as rankings even though they are not necessarily meant to be such. Cases such as this can create the inverse relationships seen in this and other tables in this section. In addition, Yes/No question are similarly coded and pose problems when correlated against ranked data. Since a no response is coded as a 2, it can be seen as ranked higher even though that is not necessarily what is intended as a higher rank. Therefore, some of the correlations presented are artifacts of the coding process rather than useful indicators.

The next questions is, “How many undergraduates enter the program in one calendar year?” Figure 7.22 shows those variables that correlated with this question.
Figure 7.22
Spearman Rho Correlation Test Results:
“How many Undergraduates enter the program in one calendar year?”

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td># Of graduate students enter program</td>
<td>0.686</td>
<td>0.044</td>
<td>*</td>
<td>7</td>
</tr>
<tr>
<td>Chemistry basic</td>
<td>0.411</td>
<td>0.045</td>
<td>*</td>
<td>18</td>
</tr>
<tr>
<td>Ecology</td>
<td>-0.429</td>
<td>0.038</td>
<td>*</td>
<td>18</td>
</tr>
<tr>
<td>Geography</td>
<td>-0.417</td>
<td>0.048</td>
<td>*</td>
<td>17</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0.447</td>
<td>0.036</td>
<td>*</td>
<td>17</td>
</tr>
<tr>
<td>Microbiology</td>
<td>0.558</td>
<td>0.012</td>
<td>*</td>
<td>16</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.22 shows the Spearman Rho Correlation Test results for the number of undergraduates entering a program in one calendar year as listed in Environmental Science Survey 2.

Two variables, Ecology and Geography, are inversely related to the number of undergraduate entering the program. This means that the fewer the number of undergraduates in a program the more importance the program would give these two areas.

The other variables, number of graduate students entering the program, Basic Chemistry, Mathematics, and Microbiology, all correlated positively with the number of students. The first correlation means that the larger the number of students entering undergraduate programs, the larger entering graduate programs. The other variables are all related to the importance given to course content areas. The larger the number of students entering, the more highly they ranked these areas.

The next questions is, “When was the graduate program started?” Figure 7.23 shows those variables that correlated with this question.
### Figure 7.23
Spearman Rho Correlation Test Results:
“When Was the Graduate Program Started”

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Bachelor's Degree required</td>
<td>-0.568</td>
<td>0.021</td>
<td>*</td>
<td>13</td>
</tr>
<tr>
<td>Basic Chemistry</td>
<td>-0.568</td>
<td>0.018</td>
<td>*</td>
<td>13</td>
</tr>
<tr>
<td>Physical Chemistry</td>
<td>0.594</td>
<td>0.016</td>
<td>*</td>
<td>13</td>
</tr>
<tr>
<td>Economics</td>
<td>0.746</td>
<td>0.002</td>
<td>**</td>
<td>13</td>
</tr>
<tr>
<td>Geography</td>
<td>0.685</td>
<td>0.007</td>
<td>**</td>
<td>13</td>
</tr>
<tr>
<td>Management</td>
<td>0.648</td>
<td>0.008</td>
<td>**</td>
<td>13</td>
</tr>
<tr>
<td>Social Science Field Experience</td>
<td>0.75</td>
<td>0.002</td>
<td>**</td>
<td>13</td>
</tr>
<tr>
<td>Independent Research</td>
<td>0.792</td>
<td>0.044</td>
<td>*</td>
<td>13</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.
** = Correlation is significant at the 0.01 level.

Figure 7.23 shows the Spearman Rho Correlation Test results related to the creation of the graduate program as listed in variables in Environmental Science Survey 2.

Two variables, type of bachelor's degree required and Basic Chemistry, are inversely related to when the graduate program was created. This means that the newer the program, the less importance they give to Basic Chemistry. This also means that the newer the graduate program, the greater the importance placed upon having an EVSC degree in order to be admitted to the program. The other variables, Physical Chemistry, Economics, Geography, Management, Social Science Field Experience, and Independent Research, all correlated positively with when the graduate program was created. What this means is that the newer the program, the more importance was given to these course content areas.

The next question is, “How many graduate students enter the program in one calendar year?” Figure 7.24 shows those variables that correlated with this question.
Figure 7.24
Spearman Rho Correlation Test Results:
“How many Graduate students enter the program in one calendar year?”

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum High school GPA required?</td>
<td>0.882</td>
<td>0.004</td>
<td>**</td>
<td>7</td>
</tr>
<tr>
<td># of undergrads enter the program</td>
<td>0.686</td>
<td>0.044</td>
<td>*</td>
<td>7</td>
</tr>
<tr>
<td>% faculty time committed to teaching in EVSC program?</td>
<td>0.497</td>
<td>0.042</td>
<td>*</td>
<td>13</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.24 shows the Spearman Rho Correlation Test results for the number of graduate students variables in Environmental Science Survey 2.

All three variables, Minimum High school GPA required, number of undergraduates entering the program, and % faculty time committed to teaching in the EVSC program, correlate with the number of graduate students entering the program. As with those listed earlier, the more students in the program, the more important were the variables. In this case, the same correlation was revealed, in that the more undergraduates enrolling in a program correlated with a larger number of graduates in a program. In the future, redundant correlations will not be discussed in detail. The second correlation related to the necessity for high school GPA. This was a correlation that though significant was most likely due to all respondents answering with a negative response. The similarity rather than the importance of the answer is what was recorded. Finally, the most telling correlation of the three for this section is the idea that the larger the number of graduate students, the more time faculty devoted to the program. This seems evident and makes sense since graduate students work with faculty and involved faculty support graduate students.

The next questions is, “What type of degree should a student have when entering the graduate program?” Figure 7.25 shows those variables that correlated with this question.
Figure 7.25
Spearman Rho Correlation Test Results:
“What Type Of Degree Should Students Have For Admission”

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Writing Skills</td>
<td>0.537</td>
<td>0.029</td>
<td>**</td>
</tr>
<tr>
<td>Physical Chemistry</td>
<td>-0.498</td>
<td>0.042</td>
<td>*</td>
</tr>
<tr>
<td>Geography</td>
<td>-0.785</td>
<td>0.001</td>
<td>**</td>
</tr>
<tr>
<td>Management</td>
<td>-0.0499</td>
<td>0.041</td>
<td>*</td>
</tr>
<tr>
<td>Sociology</td>
<td>-0.648</td>
<td>0.008</td>
<td>**</td>
</tr>
<tr>
<td>Social Science Field Experience</td>
<td>-0.484</td>
<td>0.047</td>
<td>*</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.25 shows the Spearman Rho Correlation Test results for the Bachelor’s degrees students should have as listed in Environmental Science Survey 2.

Five of the six variables, Physical Chemistry, Geography, Management, Sociology, and Social Science Field Experience, are inversely related to the type of degree required to enter the graduate program. This means that as the types of degrees become more widely varied, the lower the ranking given to the specified areas. Interestingly, though an EVSC degree is not required for entrance, those skills not related to EVSC are not given importance by the programs. Good Writing Skills is directly correlated with the type of degree, meaning that the more general the degree that is accepted for entrance the higher that institution ranked the importance of good writing skills to the EVSC student.

The next questions is, “How many full-time faculty teach in the program?” Figure 7.26 shows those variables that correlated with this question.

Figure 7.26
Spearman Rho Correlation Test Results:
“How Many Full-time Faculty Teach In The Program?”

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are standardized scores required ?</td>
<td>-0.520</td>
<td>0.019</td>
<td>**</td>
</tr>
<tr>
<td>Recommendation required</td>
<td>-0.555</td>
<td>0.013</td>
<td>*</td>
</tr>
<tr>
<td>Chemistry physical</td>
<td>0.429</td>
<td>0.026</td>
<td>*</td>
</tr>
<tr>
<td>Earth science</td>
<td>0.424</td>
<td>0.028</td>
<td>*</td>
</tr>
<tr>
<td>Independent research projects with faculty members</td>
<td>0.439</td>
<td>0.020</td>
<td>*</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.26 shows the Spearman Rho Correlation Test results for the full-time faculty that teach in the program as listed in Environmental Science Survey 2.
Two variables, "Are standardized scores required for entrance to the undergraduate program" and "Are recommendations required for entrance into the undergraduate program," are inversely related to the number of full-time faculty in the program. This means that the fewer the number of faculty the more the program will require tests and letters of recommendation. From the interviews and free-response questions, this was shown to be more of a general university requirement at the undergraduate level than a program specific requirement and so not as informative or useful. The other variables, number of graduate students entering the program, Basic Chemistry, Mathematics, and Microbiology, all correlated positively with the number of students. The first correlation means that the larger the number of students entering undergraduate programs, the larger entering graduate programs. The number 7 denotes that this statistic relates to those programs with both an undergraduate and graduate program. The other variables, Physical Chemistry, Earth Science, Independent research projects with faculty members, are all positively related, meaning that the more full-time faculty, the more important the variables have been ranked. The most obvious of these is the idea that more full-time faculty in a program creates a higher importance for students partaking in faculty research.

The next questions is, "How many part-time faculty teach in the program?" Figure 7.27 shows those variables that correlated with this question.
Figure 7.27
Spearman Rho Correlation Test Results:
“How Many Part-time Faculty Teach In The Program?”

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees offered</td>
<td>0.408</td>
<td>0.030</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Use of part-time faculty</td>
<td>0.379</td>
<td>0.041</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Convey ideas and communicate effectively in writing</td>
<td>0.379</td>
<td>0.041</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Communicate effectively orally</td>
<td>0.389</td>
<td>0.037</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>All courses required in DL format?</td>
<td>-0.507</td>
<td>0.008</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>External advisement</td>
<td>0.436</td>
<td>0.021</td>
<td>*</td>
<td>22</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.27 shows the Spearman Rho Correlation Test results for the number of part-time faculty that teach in the program as listed in Environmental Science Survey 2.

The variable, all courses required for a degree may be taken in a distance learning format is the only one inversely related to the number of part-time faculty teaching in the program. Though few programs had distance learning courses, the idea that fewer part-time teachers correlates with more distance learning classes is interesting. Again, the correlation between a ranked question and a Yes/No response is tenuous at best and should not be taken as meaning a great deal. The other variables, degrees offered, use of part-time faculty, convey ideas and communicate effectively in writing, communicate effectively orally, and external advisement, all correlated positively with the number of part-time faculty meaning as the number of part-timers increased so did the ranking of the variables. The first two correlations, degrees and use of part-time faculty seem quite obvious. As the number of degrees offered increases, so would the number of part-time faculty. As the number of part-time faculty increases so does the way in which they are used. The next two variables, the importance of written and oral communication, each increase as the number of part-time faculty increase. Though not directly stated, use of part-time faculty may necessitate the students to be more vocal and able to communicate problems with the administration of the program. In addition, a program that brings in part-time faculty may
endeavor to reach a wider audience and foster better communication skills in the students.

The last correlation is between external advisement and part-time faculty. This can be seen for several reasons. Many programs that are just beginning need to bring in part-time faculty to assist in starting the program and so also need outside advisement. Other programs that use these part-timers, bring them in from industry or the public sector to both teach and advise the program and thus having more part-time faculty leads to more external advisement. Finally, a larger program having a greater need for faculty is most likely more well developed and may already have ties to various outside sources of advisement. It is only natural that this correlation exists.

The next question is, "What percent of faculty time is devoted to the EVSC program?" Figure 7.28 shows those variables that correlated with this question.

Figure 7.28
Spearman Rho Correlation Test Results:
"What Percent Of Faculty Time Is Committed To Teaching In The EVSC Program?"

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Significance</th>
<th>p</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate program started</td>
<td>-0.483</td>
<td>0.029</td>
<td>*</td>
<td>16</td>
</tr>
<tr>
<td>Type of bachelor's degree for graduate program?</td>
<td>0.551</td>
<td>0.025</td>
<td>*</td>
<td>13</td>
</tr>
<tr>
<td># Graduate students enter in one calendar year?</td>
<td>0.497</td>
<td>0.042</td>
<td>*</td>
<td>13</td>
</tr>
<tr>
<td>Environmental lab experience</td>
<td>0.399</td>
<td>0.033</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Environmental lab experience offered in EVSC program?</td>
<td>-0.526</td>
<td>0.009</td>
<td>**</td>
<td>20</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.28 shows the Spearman Rho Correlation Test results for the percent of faculty time committed to teaching in the EVSC program as listed in Environmental Science Survey 2.

Two variables, when was the undergraduate program started and is environmental laboratory experience offered in EVSC program, are inversely related to the percentage of faculty time devoted to the program. This means that the older the program the greater the percentage of faculty time devoted to the program. In addition, the higher the percentage of time devoted to the program, the more likely the program will have environmental lab
experiences. The other variables, type of bachelor's degree needed for admission to the
graduate program, how many Graduate students enter in one calendar year, and importance
of environmental lab experience, all correlated positively with the percentage of faculty
time devoted to EVSC. As stated earlier, this means the higher the percentage of time
devoted to the program, the more widely varied the bachelor's degree may be, the more
graduate students enter the program as well as the greater importance placed upon
environmental lab experience.

The next questions is, “Describe the use of part-time faculty?” Figure 7.29 shows
those variables that correlated with this question.

**Figure 7.29**
Spearman Rho Correlation Test Results:
“Describe The Use Of Part-Time Faculty In The Program.”

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td># part-time faculty teach in the program?</td>
<td>0.379</td>
<td>0.041</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Have strong quantitative skills</td>
<td>0.492</td>
<td>0.012</td>
<td>*</td>
<td>21</td>
</tr>
<tr>
<td>Internships or other off-campus work experience</td>
<td>0.414</td>
<td>0.028</td>
<td>*</td>
<td>22</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.29 shows the Spearman Rho Correlation Test results for the use of part-time faculty in the program as listed in Environmental Science Survey 2.

All three of these variable are positively correlated and the first has already been
discussed. The other two variables, Have strong quantitative skills and importance of
internships or other off-campus work experience increase with the use of part-time faculty.
This means that the more frequently part-time faculty are used the greater the importance is
placed upon these two variables. It is difficult to know if this correlation denotes a trend
since none of the other questions correlated with it as well such as the number of part-time
faculty or number of students.

The next questions is, “What statement best describes the fields of your faculty?”
Figure 7.30 shows those variables that correlated with this question.
Figure 7.30
Spearman Rho Correlation Test Results:
"Which Statement Best Describes The Fields Of Your Faculty?"

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standardized scores required for Undergrads</td>
<td>0.463</td>
<td>0.035</td>
<td>*</td>
<td>16</td>
</tr>
<tr>
<td>Minimum HS GPA required?</td>
<td>0.449</td>
<td>0.041</td>
<td>*</td>
<td>16</td>
</tr>
<tr>
<td>Recommendation required</td>
<td>0.612</td>
<td>0.006</td>
<td>**</td>
<td>16</td>
</tr>
<tr>
<td>Biology</td>
<td>-0.447</td>
<td>0.019</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Ecology</td>
<td>-0.428</td>
<td>0.023</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Geology</td>
<td>-0.514</td>
<td>0.009</td>
<td>**</td>
<td>21</td>
</tr>
<tr>
<td>Mathematics</td>
<td>-0.378</td>
<td>0.046</td>
<td>**</td>
<td>21</td>
</tr>
<tr>
<td>Basic science field experience</td>
<td>-0.378</td>
<td>0.041</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Environmental field experience</td>
<td>-0.442</td>
<td>0.020</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Capstone course in graduate program?</td>
<td>0.439</td>
<td>0.027</td>
<td>**</td>
<td>20</td>
</tr>
<tr>
<td>Formal thesis is required in graduate program</td>
<td>0.454</td>
<td>0.019</td>
<td>**</td>
<td>21</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.30 shows the Spearman Rho Correlation Test results for the description of the fields of faculty as listed in Environmental Science Survey 2.

The variables Biology, Ecology, Geology, Mathematics, basic science field experience, and environmental field experience are all inversely related to the specificity of the degrees held by the faculty in the EVSC program. This means that programs with faculty holding degrees more directly related to EVSC tend to rank the listed variables as having greater importance compared to programs with faculty having degrees not as directly related to EVSC. The other variables are all Yes/No style questions and suggest that programs with faculty holding degrees in EVSC would answer affirmatively to all of these other questions.

7.4.3.3 Student Skills

The questions in this section deal with the fundamental skills needed by all students especially those in EVSC. Though all the significant correlations will be listed in the chart, only those not already discussed will be presented in the explanation following the figures.
Interestingly, all of the skills listed in this section correlated with several of the others in this section. In particular, problem-solving was shown to positively correlate with all of the others. These types of correlations show how each of these skills are seen as important by the respondents.

The first skill area deals with having strong quantitative skills. Figure 7.31 shows those variables that correlated with this question.

**Figure 7.31**
Spearman Rho Correlation Test Results:
Strong Quantitative Skills

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Significance</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communicate orally</td>
<td>0.47</td>
<td>0.012</td>
<td>* 23</td>
</tr>
<tr>
<td>Think Critically</td>
<td>0.353</td>
<td>0.049</td>
<td>* 23</td>
</tr>
<tr>
<td>Problem Solve</td>
<td>0.585</td>
<td>0.022</td>
<td>* 22</td>
</tr>
<tr>
<td>Basic Chemistry</td>
<td>0.436</td>
<td>0.19</td>
<td>* 23</td>
</tr>
<tr>
<td>Communication</td>
<td>-0.369</td>
<td>0.042</td>
<td>* 23</td>
</tr>
<tr>
<td>Social Science Lab experience</td>
<td>-0.4</td>
<td>0.033</td>
<td>* 22</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.31 shows the Spearman Rho Correlation Test results for having strong quantitative skills as listed in Environmental Science Survey 2.

Communication is inversely correlated with strong quantitative skills. This means that those who ranked this skill high also ranked the importance of communication lower.

The other variables, Basic Chemistry and Social Science Lab experience were both ranked higher by those who ranked strong quantitative skills highly.

The next skill area deals with the ability to effectively communicate orally and make presentation. Figure 7.32 shows those variables that correlated with this question.
Figure 7.32
Spearman Rho Correlation Test Results:
Communicate Orally

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong Quantitative Skills</td>
<td>0.47</td>
<td>0.012</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Write effectively</td>
<td>0.508</td>
<td>0.006</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Problem Solve</td>
<td>0.624</td>
<td>0.001</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Basic Chemistry</td>
<td>0.366</td>
<td>0.04</td>
<td>*</td>
<td>24</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.32 shows the Spearman Rho Correlation Test results for the ability to orally communicate effectively as listed in Environmental Science Survey 2.

Beyond the other basic student skills, oral communication only correlates with Basic Chemistry. This means that those who ranked oral communication highly also ranked Basic Chemistry highly.

The next skill area deals with the ability to effectively communicate with the written word. Figure 7.33 shows those variables that correlated with this question.

Figure 7.33
Spearman Rho Correlation Test Results:
Write Effectively

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communicate orally</td>
<td>0.47</td>
<td>0.012</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Problem Solve</td>
<td>0.585</td>
<td>0.043</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Computer Science</td>
<td>-0.475</td>
<td>0.009</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>English</td>
<td>-0.466</td>
<td>0.011</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>Geography</td>
<td>-0.56</td>
<td>0.003</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Geology</td>
<td>-0.416</td>
<td>0.024</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>History</td>
<td>-0.371</td>
<td>0.041</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Political Science/Law</td>
<td>-0.481</td>
<td>0.01</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Sociology</td>
<td>-0.441</td>
<td>0.02</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Social Science Lab experience</td>
<td>-0.595</td>
<td>0.001</td>
<td>**</td>
<td>23</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.33 shows the Spearman Rho Correlation Test results for the ability to write effectively as listed in Environmental Science Survey 2.

All the following variables, Computer Science, English, Geography, Geology, History, Political Science/Law, Sociology, and Social Science lab experience are inversely
correlated with the ability to effectively communicate with the written word. This means that these courses are all ranked lower by those who ranked writing highly. Most ironically, the course of English was listed among those classes that receive lower scores as writing skills received higher ones. This seems contradictory and may be explained by the idea that the goals sought are different from the methods used to accomplish these goals. Though good writing skills are important to have, the course of English as important to the EVSC curriculum is not seen as important. The other classes listed here are all related to the humanities and social sciences and would seem to relate to the writing skills but are given an inverse relationship as well.

The next skill area deals with the ability to evaluate literature from the field critically. Figure 7.34 shows those variables that correlated with this question.

Figure 7.34
Spearman Rho Correlation Test Results: Evaluate Literature Critically

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have Strong quantitative skills</td>
<td>0.353</td>
<td>0.049</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Problem Solve</td>
<td>0.59</td>
<td>0.002</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Basic Chemistry</td>
<td>0.589</td>
<td>0.001</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Basic Science Lab</td>
<td>0.488</td>
<td>0.008</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Internships</td>
<td>-0.39</td>
<td>0.03</td>
<td>*</td>
<td>24</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level. Figure 7.34 shows the Spearman Rho Correlation Test results for the ability to critically evaluate literature as listed in Environmental Science Survey 2.

The importance of internships is inversely correlated with the rankings for the critical evaluation of literature. This means that those who ranked internships highly also ranked the importance of evaluating literature in the field critically lower. The other variables, Basic Chemistry and Basic Science Lab were both ranked higher by those who ranked critical evaluation highly.
The final skill area deals with the ability to approach, research, analyze and solve problems. Figure 7.35 shows those variables that correlated with this question.

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong quantitative skills</td>
<td>0.585</td>
<td>0.022</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Communicate Orally</td>
<td>0.624</td>
<td>0.001</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Write effectively</td>
<td>0.585</td>
<td>0.043</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Think Critically</td>
<td>0.59</td>
<td>0.002</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Ecology</td>
<td>0.486</td>
<td>&lt;0.0001</td>
<td>**</td>
<td>23</td>
</tr>
</tbody>
</table>

*= Correlation is significant at the 0.05 level. **= Correlation is significant at the 0.01 level.

Figure 7.35 shows the Spearman Rho Correlation Test results for the ability to problem solve as listed in Environmental Science Survey 2.

The four other student abilities are directly correlated with problem solving. This means that as any of the skills are ranked higher by respondents, the tendency is to also rank problem-solving higher. Besides these skills, Ecology is also correlated with problem solving.

All of the correlations for the skills listed in this section provide insight into how the respondents are connected. The most telling is the well correlated connection between problem-solving and the other student skills. The overall averages listed above are important especially when viewed in conjunction with these correlations. All of these abilities are also related to critical thinking and demonstrate the importance of all the skills involved in problem-solving.

7.4.3.4 Course Offerings

The next set of questions that will be examined are related to the specific course offerings. The first of these courses is Biology. Rather than discuss each figure, the many interrelations will be looked at in a matrix presented in figure 7.57. All of the correlations...
are positive. The matrix gives a better understanding of how different skills are related.

Beyond that, some specific correlations will be explained and the charts for each course offering will be presented.

Figure 7.36 shows those variables that correlated with this question.

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of part-time faculty</td>
<td>-0.616</td>
<td>0.001</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Fields of your faculty</td>
<td>-0.446</td>
<td>0.018</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Physical Chemistry</td>
<td>0.434</td>
<td>0.019</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Communications</td>
<td>0.398</td>
<td>0.026</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>Ecology</td>
<td>0.411</td>
<td>0.022</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>History</td>
<td>0.523</td>
<td>0.005</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Philosophy</td>
<td>0.596</td>
<td>0.001</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Psychology</td>
<td>0.452</td>
<td>0.017</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Sociology</td>
<td>0.44</td>
<td>0.018</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Basic science field experience</td>
<td>0.487</td>
<td>0.007</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Environmental lab experience</td>
<td>0.429</td>
<td>0.018</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>Environmental field experience</td>
<td>0.530</td>
<td>0.003</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Social science lab experience</td>
<td>0.557</td>
<td>0.002</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Social science field experience</td>
<td>0.550</td>
<td>0.003</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Capstone course (graduate)</td>
<td>-0.446</td>
<td>0.018</td>
<td>*</td>
<td>22</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.36 shows the Spearman Rho Correlation Test results for the importance of Biology as listed in Environmental Science Survey 2.

Biology correlates with many things. Several of these were discussed earlier.

Some of the variables are yes/no questions and so a correlations is not appropriate because it is only informative if the data refers to ranked data. Even so, the data shows them to be inversely correlated because an answer of yes is coded as a 1 while an answer of no is a 2 so those who answer ‘yes’ would then rank the correlated variable higher. The remainder of these variables are positively correlated and describe how the rankings for biology move in a similar way to those for other course offerings.
In a similar way, the other twenty figures listed below relate these same ideas in
Figures 7.37 through 7.56. The demographics and other yes/no questions do not provide a
great deal of useful information. The other variables are correlated but no one sheds a
great deal of light when it is compared to others because the correlation are revealing
trends not outcomes or opinions. Rather than reiterate all of the same types of comments
as have already been listed, the charts will be presented and discussed at the end.

**Figure 7.37**

**Spearman Rho Correlation Test Results: Analytical Chemistry**

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications</td>
<td>0.379</td>
<td>0.033</td>
<td>*</td>
</tr>
<tr>
<td>Computer science</td>
<td>0.447</td>
<td>0.014</td>
<td>*</td>
</tr>
<tr>
<td>English</td>
<td>0.466</td>
<td>0.010</td>
<td>**</td>
</tr>
<tr>
<td>Geology</td>
<td>0.376</td>
<td>0.038</td>
<td>*</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0.482</td>
<td>0.009</td>
<td>**</td>
</tr>
<tr>
<td>Microbiology</td>
<td>0.520</td>
<td>0.006</td>
<td>**</td>
</tr>
<tr>
<td>Physics</td>
<td>0.353</td>
<td>0.048</td>
<td>*</td>
</tr>
<tr>
<td>Basic science lab experience</td>
<td>0.350</td>
<td>0.046</td>
<td>*</td>
</tr>
<tr>
<td>Environmental field experience offered?</td>
<td>-0.502</td>
<td>0.008</td>
<td>**</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.37 shows the Spearman Rho Correlation Test results for the importance of
Analytical Chemistry as listed in Environmental Science Survey 2.

**Figure 7.38**

**Spearman Rho Correlation Test Results: Basic Chemistry**

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong quantitative skills</td>
<td>0.436</td>
<td>0.018</td>
<td>*</td>
</tr>
<tr>
<td>Effective orally</td>
<td>0.365</td>
<td>0.039</td>
<td>*</td>
</tr>
<tr>
<td>Evaluate literature critically</td>
<td>0.589</td>
<td>0.001</td>
<td>**</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>0.410</td>
<td>0.025</td>
<td>*</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0.47</td>
<td>0.010</td>
<td>**</td>
</tr>
<tr>
<td>Basic science lab experience</td>
<td>0.427</td>
<td>0.018</td>
<td>*</td>
</tr>
<tr>
<td>Basic science field experience offered?</td>
<td>0.388</td>
<td>0.040</td>
<td>*</td>
</tr>
<tr>
<td>Capstone course (graduate)?</td>
<td>0.386</td>
<td>0.037</td>
<td>*</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.38 shows the Spearman Rho Correlation Test results for the importance of
Basic Chemistry as listed in Environmental Science Survey 2.
Figure 7.39
Spearman Rho Correlation Test Results: Physical Chemistry

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>0.434</td>
<td>0.019</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Earth science</td>
<td>0.407</td>
<td>0.026</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Ecology</td>
<td>0.319</td>
<td>0.068</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Geography</td>
<td>0.439</td>
<td>0.017</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Geology</td>
<td>0.542</td>
<td>0.003</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>History</td>
<td>0.619</td>
<td>0.0008</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Management</td>
<td>0.513</td>
<td>0.0072</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0.367</td>
<td>0.046</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.458</td>
<td>0.015</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Psychology</td>
<td>0.452</td>
<td>0.017</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Sociology</td>
<td>0.460</td>
<td>0.015</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Basic science field experience</td>
<td>0.424</td>
<td>0.021</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Basic science field experience offered?</td>
<td>-0.620</td>
<td>0.001</td>
<td>**</td>
<td>20</td>
</tr>
<tr>
<td>Environmental lab experience</td>
<td>0.410</td>
<td>0.025</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Environmental field experience</td>
<td>0.562</td>
<td>0.002</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Environmental field experience offered?</td>
<td>-0.468</td>
<td>0.016</td>
<td>*</td>
<td>21</td>
</tr>
<tr>
<td>Social science lab experience</td>
<td>0.636</td>
<td>0.0005</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Social science field experience offered?</td>
<td>-0.367</td>
<td>0.050</td>
<td>*</td>
<td>21</td>
</tr>
<tr>
<td>Independent research projects</td>
<td>0.452</td>
<td>0.015</td>
<td>*</td>
<td>23</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.39 shows the Spearman Rho Correlation Test results for the importance of Physical Chemistry as listed in Environmental Science Survey 2.

Figure 7.40
Spearman Rho Correlation Test Results: Communication

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong quantitative skills</td>
<td>-0.369</td>
<td>0.042</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>English</td>
<td>0.625</td>
<td>0.001</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.466</td>
<td>0.013</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Psychology</td>
<td>0.523</td>
<td>0.006</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Sociology</td>
<td>0.597</td>
<td>0.002</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Social science lab experience</td>
<td>0.463</td>
<td>0.013</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Social science lab experience offered?</td>
<td>-0.595</td>
<td>0.002</td>
<td>**</td>
<td>21</td>
</tr>
<tr>
<td>Social science field experience</td>
<td>0.396</td>
<td>0.034</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Social science field experience offered?</td>
<td>-0.479</td>
<td>0.014</td>
<td>*</td>
<td>21</td>
</tr>
<tr>
<td>Internships offered?</td>
<td>-0.420</td>
<td>0.026</td>
<td>*</td>
<td>22</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.40 shows the Spearman Rho Correlation Test results for the importance of Communication as listed in Environmental Science Survey 2.
Figure 7.41

Spearman Rho Correlation Test Results: Computer Science

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective writing</td>
<td>-0.475</td>
<td>0.009</td>
<td>**</td>
</tr>
<tr>
<td>Chemistry analytical</td>
<td>0.447</td>
<td>0.014</td>
<td>*</td>
</tr>
<tr>
<td>English</td>
<td>0.463</td>
<td>0.011</td>
<td>*</td>
</tr>
<tr>
<td>Geography</td>
<td>0.356</td>
<td>0.047</td>
<td>*</td>
</tr>
<tr>
<td>History</td>
<td>0.505</td>
<td>0.006</td>
<td>**</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0.398</td>
<td>0.029</td>
<td>*</td>
</tr>
<tr>
<td>Philosophy</td>
<td>0.389</td>
<td>0.033</td>
<td>*</td>
</tr>
<tr>
<td>Physics</td>
<td>0.480</td>
<td>0.010</td>
<td>**</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.393</td>
<td>0.031</td>
<td>*</td>
</tr>
<tr>
<td>Psychology</td>
<td>0.585</td>
<td>0.002</td>
<td>**</td>
</tr>
<tr>
<td>Sociology</td>
<td>0.590</td>
<td>0.001</td>
<td>**</td>
</tr>
<tr>
<td>Environmental field experience</td>
<td>0.405</td>
<td>0.024</td>
<td>*</td>
</tr>
<tr>
<td>Environmental field experience offered?</td>
<td>-0.398</td>
<td>0.033</td>
<td>*</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.41 shows the Spearman Rho Correlation Test results for the importance of Computer Science as listed in Environmental Science Survey 2.

Figure 7.42

Spearman Rho Correlation Test Results: Earth Science

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry physical</td>
<td>0.407</td>
<td>0.026</td>
<td>*</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0.403</td>
<td>0.031</td>
<td>*</td>
</tr>
<tr>
<td>Independent research projects</td>
<td>0.377</td>
<td>0.037</td>
<td>*</td>
</tr>
<tr>
<td># of courses offered in DL format?</td>
<td>0.441</td>
<td>0.017</td>
<td>*</td>
</tr>
<tr>
<td>Receive external advice?</td>
<td>0.432</td>
<td>0.019</td>
<td>*</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.42 shows the Spearman Rho Correlation Test results for the importance of Earth Science as listed in Environmental Science Survey 2.
**Figure 7.43**

**Spearman Rho Correlation Test Results: Ecology**

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem-solving</td>
<td>0.486</td>
<td>0.009</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Biology</td>
<td>0.411</td>
<td>0.022</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>Geography</td>
<td>0.407</td>
<td>0.026</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>History</td>
<td>0.449</td>
<td>0.015</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Philosophy</td>
<td>0.480</td>
<td>0.010</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Basic science offered?</td>
<td>-0.449</td>
<td>0.017</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Environmental lab experience</td>
<td>0.487</td>
<td>0.007</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Environmental field experience</td>
<td>0.560</td>
<td>0.002</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Social science field experience</td>
<td>0.398</td>
<td>0.033</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Independent research offered?</td>
<td>-0.690</td>
<td>0.0002</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Capstone course (graduate)?</td>
<td>-0.362</td>
<td>0.048</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Formal thesis required (graduate)</td>
<td>-0.530</td>
<td>0.004</td>
<td>**</td>
<td>23</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.43 shows the Spearman Rho Correlation Test results for the importance of Ecology as listed in Environmental Science Survey 2.

**Figure 7.44**

**Spearman Rho Correlation Test Results: Economics**

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geography</td>
<td>0.519</td>
<td>0.005</td>
<td>**</td>
<td>23</td>
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<tr>
<td>History</td>
<td>0.523</td>
<td>0.005</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Management</td>
<td>0.612</td>
<td>0.001</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.536</td>
<td>0.004</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Psychology</td>
<td>0.363</td>
<td>0.048</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Sociology</td>
<td>0.466</td>
<td>0.014</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Social science lab experience</td>
<td>0.414</td>
<td>0.024</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Social science field experience</td>
<td>0.501</td>
<td>0.008</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Internships</td>
<td>0.354</td>
<td>0.044</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>Internships offered?</td>
<td>-0.378</td>
<td>0.041</td>
<td>*</td>
<td>22</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.44 shows the Spearman Rho Correlation Test results for the importance of Economics as listed in Environmental Science Survey 2.
Figure 7.45
Spearman Rho Correlation Test Results: English

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective writing</td>
<td>-0.465</td>
<td>0.011</td>
<td>*</td>
</tr>
<tr>
<td>Chemistry analytical</td>
<td>0.466</td>
<td>0.011</td>
<td>*</td>
</tr>
<tr>
<td>Communications</td>
<td>0.624</td>
<td>0.0005</td>
<td>**</td>
</tr>
<tr>
<td>Computer science</td>
<td>0.463</td>
<td>0.011</td>
<td>*</td>
</tr>
<tr>
<td>Geography</td>
<td>0.351</td>
<td>0.049</td>
<td>*</td>
</tr>
<tr>
<td>Geology</td>
<td>0.371</td>
<td>0.040</td>
<td>*</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0.385</td>
<td>0.034</td>
<td>*</td>
</tr>
<tr>
<td>Physics</td>
<td>0.559</td>
<td>0.002</td>
<td>**</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.488</td>
<td>0.008</td>
<td>**</td>
</tr>
<tr>
<td>Sociology</td>
<td>0.504</td>
<td>0.008</td>
<td>**</td>
</tr>
<tr>
<td>Social science lab experience</td>
<td>0.375</td>
<td>0.038</td>
<td>*</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.45 shows the Spearman Rho Correlation Test results for the importance of English as listed in Environmental Science Survey 2.

Figure 7.46
Spearman Rho Correlation Test Results: Geography

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective writing</td>
<td>-0.560</td>
<td>0.002</td>
<td>**</td>
</tr>
<tr>
<td>Chemistry physical</td>
<td>0.439</td>
<td>0.017</td>
<td>*</td>
</tr>
<tr>
<td>Computer science</td>
<td>0.356</td>
<td>0.047</td>
<td>*</td>
</tr>
<tr>
<td>Ecology</td>
<td>0.407</td>
<td>0.026</td>
<td>*</td>
</tr>
<tr>
<td>Economics</td>
<td>0.519</td>
<td>0.005</td>
<td>**</td>
</tr>
<tr>
<td>English</td>
<td>0.351</td>
<td>0.049</td>
<td>*</td>
</tr>
<tr>
<td>Geology</td>
<td>0.466</td>
<td>0.012</td>
<td>*</td>
</tr>
<tr>
<td>History</td>
<td>0.584</td>
<td>0.001</td>
<td>**</td>
</tr>
<tr>
<td>Management</td>
<td>0.588</td>
<td>0.001</td>
<td>**</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.514</td>
<td>0.007</td>
<td>**</td>
</tr>
<tr>
<td>Psychology</td>
<td>0.456</td>
<td>0.016</td>
<td>*</td>
</tr>
<tr>
<td>Sociology</td>
<td>0.611</td>
<td>0.001</td>
<td>**</td>
</tr>
<tr>
<td>Basic science field experience</td>
<td>0.502</td>
<td>0.007</td>
<td>**</td>
</tr>
<tr>
<td>Environmental field experience</td>
<td>0.402</td>
<td>0.028</td>
<td>*</td>
</tr>
<tr>
<td>Social science lab experience</td>
<td>0.605</td>
<td>0.001</td>
<td>**</td>
</tr>
<tr>
<td>Social science field experience</td>
<td>0.633</td>
<td>0.0007</td>
<td>**</td>
</tr>
<tr>
<td>Internships</td>
<td>0.357</td>
<td>0.046</td>
<td>*</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.46 shows the Spearman Rho Correlation Test results for the importance of Geography as listed in Environmental Science Survey 2.
### Figure 7.47
**Spearman Rho Correlation Test Results: Geology**

<table>
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<td>Effective writing</td>
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<tr>
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<td>0.542</td>
<td>0.003</td>
<td>**</td>
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<td>0.371</td>
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<td>History</td>
<td>0.593</td>
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<td>0.416</td>
<td>0.026</td>
<td>*</td>
<td>22</td>
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<tr>
<td>Philosophy</td>
<td>0.402</td>
<td>0.031</td>
<td>*</td>
<td>22</td>
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<td>Physics</td>
<td>0.573</td>
<td>0.002</td>
<td>**</td>
<td>22</td>
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<td>0.565</td>
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<td>0.006</td>
<td>**</td>
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<tr>
<td>Sociology</td>
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<td>0.433</td>
<td>0.019</td>
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<tr>
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<td>0.362</td>
<td>0.044</td>
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<tr>
<td>Social science field experience</td>
<td>0.484</td>
<td>0.011</td>
<td>*</td>
<td>22</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.47 shows the Spearman Rho Correlation Test results for the importance of Geology as listed in Environmental Science Survey 2.

### Figure 7.48
**Spearman Rho Correlation Test Results: History**

<table>
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<td>0.505</td>
<td>0.006</td>
<td>**</td>
<td>23</td>
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<tr>
<td>Ecology</td>
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<td>0.015</td>
<td>*</td>
<td>23</td>
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<td>Economics</td>
<td>0.523</td>
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<td>**</td>
<td>23</td>
</tr>
<tr>
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<td>Geology</td>
<td>0.593</td>
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<td>23</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.648</td>
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<td>22</td>
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<tr>
<td>Psychology</td>
<td>0.873</td>
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<td>Sociology</td>
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<td>Basic science field experience</td>
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<td>Environmental lab experience</td>
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<tr>
<td>Environmental field experience</td>
<td>0.540</td>
<td>0.003</td>
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<td>23</td>
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<tr>
<td>Social science lab experience</td>
<td>0.675</td>
<td>0.0002</td>
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<td>23</td>
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<tr>
<td>Internships</td>
<td>0.383</td>
<td>0.035</td>
<td>*</td>
<td>23</td>
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</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.48 shows the Spearman Rho Correlation Test results for the importance of History as listed in Environmental Science Survey 2.
### Figure 7.49
Spearman Rho Correlation Test Results: Management

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Chemistry physical</td>
<td>0.513</td>
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<td>22</td>
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<td>Economics</td>
<td>0.612</td>
<td>0.001</td>
<td>**</td>
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<tr>
<td>Geography</td>
<td>0.588</td>
<td>0.001</td>
<td>**</td>
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<tr>
<td>Geology</td>
<td>0.392</td>
<td>0.035</td>
<td>*</td>
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</tr>
<tr>
<td>History</td>
<td>0.765 &lt;0.0001</td>
<td>**</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Microbiology</td>
<td>0.467</td>
<td>0.016</td>
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<tr>
<td>Philosophy</td>
<td>0.458</td>
<td>0.018</td>
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<td>21</td>
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<td>0.033</td>
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<tr>
<td>Psychology</td>
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<td>Sociology</td>
<td>0.688</td>
<td>0.0003</td>
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<td>Social science lab experience</td>
<td>0.553</td>
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<td>**</td>
<td>21</td>
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<tr>
<td>Social science field experience</td>
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<td>&lt;0.0001</td>
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<tr>
<td>Internships</td>
<td>0.621</td>
<td>0.001</td>
<td>**</td>
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</table>

* = Correlation is significant at the 0.05 level.
** = Correlation is significant at the 0.01 level.

Figure 7.49 shows the Spearman Rho Correlation Test results for the importance of Management as listed in Environmental Science Survey 2.

### Figure 7.50
Spearman Rho Correlation Test Results: Mathematics

<table>
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<tr>
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<td>Chemistry physical</td>
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<td>0.029</td>
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<td>Earth science</td>
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<tr>
<td>English</td>
<td>0.385</td>
<td>0.034</td>
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<td>23</td>
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<tr>
<td>Geology</td>
<td>0.513</td>
<td>0.007</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Microbiology</td>
<td>0.637</td>
<td>0.0007</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Physics</td>
<td>0.668</td>
<td>0.0002</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.360</td>
<td>0.045</td>
<td>*</td>
<td>23</td>
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<tr>
<td>Psychology</td>
<td>0.376</td>
<td>0.042</td>
<td>*</td>
<td>22</td>
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</table>

* = Correlation is significant at the 0.05 level.
** = Correlation is significant at the 0.01 level.

Figure 7.50 shows the Spearman Rho Correlation Test results for the importance of Mathematics as listed in Environmental Science Survey 2.
**Figure 7.51**

**Spearman Rho Correlation Test Results: Microbiology**

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<td>Chemistry analytical</td>
<td>0.520</td>
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<tr>
<td>Geology</td>
<td>0.416</td>
<td>0.027</td>
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<tr>
<td>Management</td>
<td>0.467</td>
<td>0.016</td>
<td>*</td>
</tr>
<tr>
<td>Mathematics</td>
<td>0.637</td>
<td>0.0007</td>
<td>**</td>
</tr>
<tr>
<td>Physics</td>
<td>0.380</td>
<td>0.040</td>
<td>*</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.365</td>
<td>0.047</td>
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<tr>
<td>Sociology</td>
<td>0.391</td>
<td>0.035</td>
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<tr>
<td>Receive external advice?</td>
<td>0.402</td>
<td>0.031</td>
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</table>

* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.51 shows the Spearman Rho Correlation Test results for the importance of Microbiology as listed in Environmental Science Survey 2.

**Figure 7.52**

**Spearman Rho Correlation Test Results: Philosophy**

<table>
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<tr>
<td>Chemistry physical</td>
<td>0.530</td>
<td>0.005</td>
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<tr>
<td>Computer science</td>
<td>0.389</td>
<td>0.033</td>
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<tr>
<td>Ecology</td>
<td>0.480</td>
<td>0.010</td>
<td>**</td>
</tr>
<tr>
<td>Geology</td>
<td>0.402</td>
<td>0.031</td>
<td>*</td>
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<tr>
<td>History</td>
<td>0.717</td>
<td>&lt;0.0001</td>
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<td>0.523</td>
<td>0.005</td>
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<tr>
<td>Psychology</td>
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<td>Sociology</td>
<td>0.586</td>
<td>0.002</td>
<td>**</td>
</tr>
<tr>
<td>Basic science offered?</td>
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<td>0.018</td>
<td>*</td>
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<td>Environmental lab experience</td>
<td>0.374</td>
<td>0.039</td>
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<td>Environmental field experience</td>
<td>0.521</td>
<td>0.005</td>
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<tr>
<td>Environmental field experience offered?</td>
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<td>0.045</td>
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<td>Social science lab experience</td>
<td>0.376</td>
<td>0.042</td>
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<td>Social science field experience</td>
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<td>Social science field experience offered?</td>
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<tr>
<td>Formal thesis required (graduate)</td>
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<td>0.016</td>
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* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.52 shows the Spearman Rho Correlation Test results for the importance of Philosophy as listed in Environmental Science Survey 2.
Figure 7.53

Spearman Rho Correlation Test Results: Physics

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<tr>
<td>Computer science</td>
<td>0.480</td>
<td>0.010</td>
<td>**</td>
<td>23</td>
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<tr>
<td>English</td>
<td>0.559</td>
<td>0.002</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Geology</td>
<td>0.573</td>
<td>0.002</td>
<td>**</td>
<td>23</td>
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<tr>
<td>Mathematics</td>
<td>0.668</td>
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<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Microbiology</td>
<td>0.380</td>
<td>0.040</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.356</td>
<td>0.047</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Psychology</td>
<td>0.391</td>
<td>0.035</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Basic science lab experience</td>
<td>0.394</td>
<td>0.031</td>
<td>*</td>
<td>23</td>
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</tbody>
</table>

* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.53 shows the Spearman Rho Correlation Test results for the importance of Physics as listed in Environmental Science Survey 2.

Figure 7.54

Spearman Rho Correlation Test Results: Political science - law

<table>
<thead>
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<th>N</th>
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</thead>
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<tr>
<td>Chemistry physical</td>
<td>0.458</td>
<td>0.015</td>
<td>*</td>
<td>23</td>
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<tr>
<td>Communications</td>
<td>0.465</td>
<td>0.012</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Computer science</td>
<td>0.393</td>
<td>0.031</td>
<td>*</td>
<td>23</td>
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<td>Economics</td>
<td>0.536</td>
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<td>23</td>
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<tr>
<td>English</td>
<td>0.488</td>
<td>0.008</td>
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<td>23</td>
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<td>0.514</td>
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<td>Geology</td>
<td>0.565</td>
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<td>22</td>
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<tr>
<td>History</td>
<td>0.648</td>
<td>0.0005</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Management</td>
<td>0.567</td>
<td>0.003</td>
<td>**</td>
<td>21</td>
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<tr>
<td>Mathematics</td>
<td>0.360</td>
<td>0.045</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Microbiology</td>
<td>0.365</td>
<td>0.047</td>
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<td>Philosophy</td>
<td>0.523</td>
<td>0.005</td>
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<tr>
<td>Physics</td>
<td>0.356</td>
<td>0.047</td>
<td>*</td>
<td>23</td>
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<tr>
<td>Psychology</td>
<td>0.622</td>
<td>0.001</td>
<td>**</td>
<td>22</td>
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<tr>
<td>Sociology</td>
<td>0.598</td>
<td>0.001</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Basic science field experience</td>
<td>0.377</td>
<td>0.037</td>
<td>*</td>
<td>23</td>
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<tr>
<td>Environmental field experience</td>
<td>0.481</td>
<td>0.010</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Social science lab experience</td>
<td>0.642</td>
<td>0.0006</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Social science field experience</td>
<td>0.661</td>
<td>0.0005</td>
<td>**</td>
<td>21</td>
</tr>
<tr>
<td>Internships</td>
<td>0.377</td>
<td>0.038</td>
<td>*</td>
<td>23</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.54 shows the Spearman Rho Correlation Test results for the importance of Political Science—Law as listed in Environmental Science Survey 2.
Figure 7.55 shows the Spearman Rho Correlation Test results for the importance of Psychology as listed in Environmental Science Survey 2.

<table>
<thead>
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<th>Coefficient</th>
<th>Significance</th>
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<th>N</th>
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</thead>
<tbody>
<tr>
<td>Biology</td>
<td>0.452</td>
<td>0.017</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Chemistry physical</td>
<td>0.452</td>
<td>0.017</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Communications</td>
<td>0.523</td>
<td>0.006</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Computer science</td>
<td>0.585</td>
<td>0.002</td>
<td>**</td>
<td>22</td>
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* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.
Figure 7.56

Spearman Rho Correlation Test Results: Sociology

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<td>Social science field experience</td>
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</table>

* = Correlation is significant at the 0.05 level. ** = Correlation is significant at the 0.01 level.

Figure 7.56 shows the Spearman Rho Correlation Test results for the importance of Sociology as listed in Environmental Science Survey 2.

Having listed all the correlations above, it is more helpful to see how these variables are correlated with one another in a side-by-side manner. Figure 7.57 below gives a matrix of the twenty-one courses compared with themselves. The number 1 denotes a significance at the 0.05 level and a 2 denotes a significance at the 0.01 level. The X denotes the variable correlated with itself.
Figure 7.57
Spearman Rho Correlation Test Results:
Course Matrix

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1 = Correlation is significant at the 0.05 level. 2 = Correlation is significant at the 0.01 level.

Figure 7.57 provides a matrix of the Spearman Rho Correlation Test results for all the significant correlations for the courses listed above in figures 7.36 -7.56. All correlations are positive. ‘X’ denotes a variable correlated with itself.

The chart is only half full because the variables are being compared to themselves so the scores are redundant. Reading across to the X and then reading down will allow the reader to see all the correlations for each variable. The highlighted set of variables is given as an example.

By looking at the distribution of correlated scores, it can be seen that the less technical courses, such as Sociology or History, are related to one another. Also, the chart reveals other correlations. Most important is the idea that all of these are positively correlated so that as one is more highly ranked the others are as well. Again, as with the
other parts of this section, the means listed earlier may provide more information, but the correlations can reveal trends that might otherwise not be seen.

7.4.3.5 Hands-on Experience

The next set of questions that will be examined relate to hands-on experiences. This includes laboratory and field experiences as well as research projects with faculty members and internships or other off-campus work experiences. Figures 7.58 through 7.66 report the correlations that exists for the variables examined. Figure 7.67 contains a matrix similar to that listed above in 7.57 to assist in seeing the connection between and among these variables.

**Figure 7.58**
Spearman Rho Correlation Test Results:
Basic Science Lab Experience

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* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

*Figure 7.58 shows the Spearman Rho Correlation Test results for importance of Basic Science laboratory experience as listed in Environmental Science Survey 2.*
Figure 7.59
Spearman Rho Correlation Test Results:
Basic Science Field Experience

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* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.59 shows the Spearman Rho Correlation Test results for the importance of Basic Science field experience as listed in Environmental Science Survey 2.

Figure 7.60
Spearman Rho Correlation Test Results:
Environmental Lab Experience

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<td>Physics</td>
<td>0.350</td>
<td>0.050</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Basic science lab experience</td>
<td>0.643</td>
<td>0.0003</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Environmental lab experience offered?</td>
<td>-0.434</td>
<td>0.021</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Environmental field experience</td>
<td>0.902</td>
<td>&lt; 0.0001</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Independent research projects</td>
<td>0.501</td>
<td>0.006</td>
<td>**</td>
<td>24</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.60 shows the Spearman Rho Correlation Test results for the importance of Environmental laboratory experience as listed in Environmental Science Survey 2.
**Figure 7.61**  
Spearman Rho Correlation Test Results:  
Environmental Field Experience

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>0.530</td>
<td>0.004</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Chemistry physical</td>
<td>0.562</td>
<td>0.003</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Computer science</td>
<td>0.405</td>
<td>0.025</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>Ecology</td>
<td>0.560</td>
<td>0.002</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Geography</td>
<td>0.402</td>
<td>0.028</td>
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<td>23</td>
</tr>
<tr>
<td>Geology</td>
<td>0.433</td>
<td>0.019</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>History</td>
<td>0.540</td>
<td>0.004</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Philosophy</td>
<td>0.521</td>
<td>0.005</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Political science - law</td>
<td>0.481</td>
<td>0.010</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Psychology</td>
<td>0.421</td>
<td>0.025</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Basic science lab experience</td>
<td>0.461</td>
<td>0.012</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>Basic science field experience</td>
<td>0.407</td>
<td>0.024</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>Environmental lab experience</td>
<td>0.902</td>
<td>&lt;0.0001</td>
<td>**</td>
<td>24</td>
</tr>
<tr>
<td>Social science lab experience</td>
<td>0.481</td>
<td>0.010</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Social science field experience</td>
<td>0.389</td>
<td>0.036</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Independent research projects</td>
<td>0.458</td>
<td>0.012</td>
<td>*</td>
<td>24</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.61 shows the Spearman Rho Correlation Test results for the importance of environmental field experience as listed in Environmental Science Survey 2.
### Figure 7.62
Spearman Rho Correlation Test Results:
Social Science Lab Experience

<table>
<thead>
<tr>
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<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong quantitative skills</td>
<td>-0.399</td>
<td>0.032</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Effective writing</td>
<td>-0.594</td>
<td>0.001</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Biology</td>
<td>0.557</td>
<td>0.002</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Chemistry physical</td>
<td>0.636</td>
<td>0.0006</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Communications</td>
<td>0.463</td>
<td>0.013</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Economics</td>
<td>0.414</td>
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<td>English</td>
<td>0.375</td>
<td>0.038</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Geography</td>
<td>0.605</td>
<td>0.001</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Geology</td>
<td>0.362</td>
<td>0.044</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>History</td>
<td>0.675</td>
<td>0.0002</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Management</td>
<td>0.553</td>
<td>0.003</td>
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<tr>
<td>Philosophy</td>
<td>0.376</td>
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<td>Political science - law</td>
<td>0.642</td>
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<tr>
<td>Psychology</td>
<td>0.615</td>
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<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Sociology</td>
<td>0.704</td>
<td>0.0001</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Basic science field experience</td>
<td>0.579</td>
<td>0.001</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Environmental field experience</td>
<td>0.481</td>
<td>0.010</td>
<td>**</td>
<td>23</td>
</tr>
<tr>
<td>Social science field experience</td>
<td>0.882</td>
<td>&lt;0.0001</td>
<td>**</td>
<td>22</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.62 shows the Spearman Rho Correlation Test results for the importance of Social Science laboratory experience as listed in Environmental Science Survey 2.
Figure 7.63
Spearman Rho Correlation Test Results:
Social Science Field Experience

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective writing</td>
<td>-0.580</td>
<td>0.002</td>
<td>**</td>
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</tr>
<tr>
<td>Biology</td>
<td>0.550</td>
<td>0.003</td>
<td>**</td>
<td>22</td>
</tr>
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<td>Chemistry physical</td>
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</tr>
<tr>
<td>Communications</td>
<td>0.395</td>
<td>0.034</td>
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<tr>
<td>Computer science</td>
<td>0.471</td>
<td>0.013</td>
<td>*</td>
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</tr>
<tr>
<td>Ecology</td>
<td>0.398</td>
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<td>Economics</td>
<td>0.501</td>
<td>0.008</td>
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<td>22</td>
</tr>
<tr>
<td>Geography</td>
<td>0.633</td>
<td>0.0008</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Geology</td>
<td>0.484</td>
<td>0.011</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>History</td>
<td>0.786</td>
<td>&lt;0.0001</td>
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<td>22</td>
</tr>
<tr>
<td>Management</td>
<td>0.730</td>
<td>&lt;0.0001</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Philosophy</td>
<td>0.587</td>
<td>0.003</td>
<td>**</td>
<td>21</td>
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<tr>
<td>Political science - law</td>
<td>0.661</td>
<td>0.0005</td>
<td>**</td>
<td>21</td>
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<tr>
<td>Psychology</td>
<td>0.746</td>
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<td>**</td>
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<td>Sociology</td>
<td>0.733</td>
<td>&lt;0.0001</td>
<td>**</td>
<td>21</td>
</tr>
<tr>
<td>Basic science field experience</td>
<td>0.477</td>
<td>0.012</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Environmental field experience</td>
<td>0.389</td>
<td>0.036</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Social science lab experience</td>
<td>0.882</td>
<td>&lt;0.0001</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Independent research projects</td>
<td>0.391</td>
<td>0.036</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Internships</td>
<td>0.441</td>
<td>0.02</td>
<td>*</td>
<td>22</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.63 shows the Spearman Rho Correlation Test results for the importance of Social Science field experience as listed in Environmental Science Survey 2.

Figure 7.64
Spearman Rho Correlation Test Results:
Independent Research Projects With Faculty Members

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Significance</th>
<th>@</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry physical</td>
<td>0.452</td>
<td>0.015</td>
<td>*</td>
<td>23</td>
</tr>
<tr>
<td>Earth science</td>
<td>0.377</td>
<td>0.037</td>
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<td>23</td>
</tr>
<tr>
<td>Basic science field experience</td>
<td>0.401</td>
<td>0.026</td>
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<tr>
<td>Environmental lab experience</td>
<td>0.501</td>
<td>0.0063</td>
<td>**</td>
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</tr>
<tr>
<td>Environmental field experience</td>
<td>0.458</td>
<td>0.012</td>
<td>*</td>
<td>24</td>
</tr>
<tr>
<td>Environmental field experience offered?</td>
<td>-0.590</td>
<td>0.002</td>
<td>**</td>
<td>22</td>
</tr>
<tr>
<td>Social science field experience</td>
<td>0.391</td>
<td>0.035</td>
<td>*</td>
<td>22</td>
</tr>
<tr>
<td>Receive external advice?</td>
<td>0.385</td>
<td>0.031</td>
<td>*</td>
<td>24</td>
</tr>
</tbody>
</table>

* = Correlation is significant at the 0.05 level.  ** = Correlation is significant at the 0.01 level.

Figure 7.64 shows the Spearman Rho Correlation Test results for the importance of independent research projects with faculty members as listed in Environmental Science Survey 2.
Having listed all the correlations above, it is more helpful to see how these variables are correlated with one another in a side-by-side manner. Figure 7.75 below gives a matrix of the eight variables related to hands-on experiences compared with themselves similar to the matrix above.

**Figure 7.65**
**Spearman Rho Correlation Test Results:**
**Hands-on Experience Matrix**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Basic science lab experience</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Basic science field experience</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Environmental lab experience</td>
<td>2</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Environmental field experience</td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Social science lab experience</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Social science field experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td>X</td>
</tr>
<tr>
<td>7. Independent research projects with faculty members</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>8. Internships or other off-campus work experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

1 = Correlation is significant at the 0.05 level.  
2 = Correlation is significant at the 0.01 level.

Figure 7.65 provides a matrix of the Spearman Rho Correlation Test results for all the significant correlations for the hands-on experiences listed above in figures 7.58 - 7.66. All correlations are positive. ‘X’ denotes a variable correlated with itself.

This matrix shows that the items that are ranked more highly are related to laboratory experience. In addition, independent studies correlates with all but basic science laboratory experience. Once again, the means for these subjects are more informative than the correlations; however, these relationships are useful for understanding the trends that can be seen in the data.

### 7.5 Free Responses

To assist the researcher, the survey contained open-ended questions that allowed the respondents to provide further details or more information about the topics being discussed. Following each of the questions in section two of the survey were additional
questions that asked about how these skills were transferred to the student. In general all of the answers related to course work or classes that give students the skills desired. For question 13, concerning problem solving skills, several respondents suggested classes dealing in the preparation of an Environmental Impact Statement (EIS) or completion of Pollution Prevention evaluations could be used to teach students about problem solving methodologies.

In section three, an open-ended question asked for additional courses that should be included with the ones listed in the chart. Survey participants listed specific classes such as toxicology or environmental chemistry. Also, general areas such as classes dealing with soil, atmosphere, or other general aspects of the environment were suggested.

In section four, an open-ended question asked for additional courses or comments about the field and laboratory experiences beyond those listed in the chart. The responses given by participants were clarifications for their program. Some respondents indicated that courses such as the ones in this section were not handled within the department but farmed out to other disciplines such as Chemistry or Biology.

7.6 Data Analysis

Having listed the results, it is important to discuss these findings in relation to the institutions’ surveys. The following section explains how the survey results led to the outcomes listed in the remaining sections of the dissertation. It is important to note that the outcomes are based on both the literature and models listed in earlier chapters along with the results of the surveys.
There are several major insights provided by the charts listed above and the results from Survey 2 in general. In addition, the follow-up phone conversations echoed these findings and provided even more insight into programs.

The first outcome was the verification of the premise that certain student abilities are important to EVSC students. As can be seen in Figure 18, all of the listed abilities received an average score above 5.6 out of a possible 6. When asked about this in the interviews, all respondents agreed that these skills are vital to students and should be taught. Also, the way these skills are taught seem to be mainly incorporated in general university courses outside the EVSC program. Other survey participants suggested that capstone or thesis preparation courses give students the ability to learn these skills and hone them.

The second outcome relates to the classes listed in Figure 22. The classes Biology, Basic Chemistry, and Ecology, all received scores of above 5. These classes were seen as providing a basic foundation for EVSC education. Other courses were less clearly defined. Several respondents left answers blank explaining that they were not sure what was meant by a class title. For example, Earth Science scored almost five but it was stated that it could have many meanings and include aspects of Ecology, Soil Science, Atmospheric Science or many other topics. However, in other courses it may only be a cursory introduction to Geology. As a result, several subjects had blanks illustrating that EVSC has many interpretations and the classes that comprise it are not easily defined. In general, the traditional, “hard” sciences such as Mathematics, Analytical Chemistry or Geology received scores in the 4 to 5 range; the social sciences such as sociology and psychology were a full point or more lower, scoring in the high 2 to middle 3 range. However, classes
that may be seen as useful in the marketplace such as Communication, English, Economics and Computer Science all ranked much higher despite their lack of connection directly with a hard science or the field of EVSC.

An important point to bring up here is the varying nature of both institutions and programs. Institutions that house undergraduate and/or graduate programs may differ greatly from one another. One major outcome of the survey process is the understanding that every school is unique. It is difficult to say that the importance of a course at the undergraduate level is the same at the graduate level. Nonetheless, all agree that graduate students need to have certain skills and undergraduate programs need to provide students with these skills. In many cases, EVSC programs need to rely upon the university curriculum to provide students with skills outside of the EVSC core. In particular, the interdisciplinary nature of EVSC makes the undergraduate degree far more complex and the offerings more difficult. In the next chapter, this idea will be discussed further and then used to suggest ways that the problem can be addressed.

At this point, it is important to share an insight provided by the phone interviews that was suggested in the numerical and free-responses of the course evaluation section. EVSC can be seen to have two major sections of education. One section provides students with a basic skill set provided by the core courses in science and general education. These classes include Biology, Ecology, Chemistry, Physics, English, Mathematics, as well as other courses needed to provide the student with the tools to understand and research problems of the environment. Beyond this, EVSC programs help students to apply the learned skills and tools to problems of the environment so that solutions can be found, understood, and implemented. Some programs even have mission statements that reflect
this exact idea. If the program is for undergraduate, the emphasis is more heavily on the basic courses with some time given to helping the student experience how those learned skills are applied. At the graduate level, these basic skills are assumed to be provided by an undergraduate degree or bridge course and a greater emphasis is placed upon the application of the skills. In addition, more specific skill transfer classes related more directly to EVSC are also given. Classes such as toxicology, microbiology, or area specific sciences such as atmospheric, soil or marine science can be offered.

Related to the courses offered is the idea of a capstone. A capstone or thesis class was brought up repeatedly throughout the survey. It is cited as a place to teach problem-solving, a way to accomplish hands-on training and as a necessary part of the program in general. At either the undergraduate or graduate level, a capstone, or thesis class pulls the basic and applied portions of the program together. It allows students to demonstrate the ability to approach, analyze and solve problems related to the environment. This idea will be discussed further in the upcoming chapters.

The third major outcome of the survey relates to the hand-on experiences to which students are exposed. Figure 14 shows that all of the areas of hands-on experience have scored well with the exception of the social sciences. Additional comments made by respondents as well as phone interviews state that hands-on experience, both laboratory and field work, is an essential part of the EVSC educational process. In particular, the faculty research work and internships are seen as vital to good work. Unfortunately, not all institutions and programs have a large enough faculty to allow students to work with faculty on research. Even so, having external input from government agencies, private industry and other organizations related to the field of EVSC can give students
opportunities to work on real-world problems, have research projects and be mentored by professionals in the field they have chosen. The laboratory and field work can prepare the student to understand what is going to be asked of them, but only these research projects and internships will allow them to put this knowledge into practice as they apply the skills and tools they have learned. In some cases, capstone classes and thesis work has been included as a hands-on topic by some respondents as well.

The idea of an experience that ties the entire EVSC program together, assists the student in learning how to apply their knowledge and solve problems, as well as demonstrates the students’ abilities is key to programs. Moreover, when trying to evaluate how well a student has achieved the goals of a program as set out in the mission statement, a capstone class provides a valuable opportunity to administrators and external evaluators. Almost all the programs surveyed had some sort of external review or input. Unfortunately, not all of these were regular reviews intended to both assess the program and provide assistance to the students in the program. Once again, individual variation in faculty, curriculum, institutional involvement and various other factors contribute to the vast differences in programs.

Beyond the direct outcomes of the survey results that were necessary for the remainder of the dissertation, other information was gathered. All of the programs surveyed were created after 1962 though some were created in the last few years. Some programs evolved from existing programs while others are combined with programs in varied fields such as management or policy giving them a different and at times more focused view of EVSC. Regardless the background of the program or its particular focus,
all of these programs do share the common aspects described in Figure 2. These aspects can thus be used to assist in the creation, evaluation and improvement of programs.

After reviewing the literature, consulting hundreds of program web pages and conducting the two rounds of surveys, the author can now move on to the outcomes chapter of the dissertation. Though there is a tremendous variation in programs, institution, faculty and students, there are common threads that run throughout all of EVSC and all of education in general. It is these threads that will be highlighted and tied together to make a coherent program of EVSC education at all levels.
CHAPTER 8

CONCLUSIONS

8.1 Introduction

The insights that come from all the surveys' responses and other research is the most vital outcome of this dissertation. The intention of this dissertation is to develop a model that could be followed as well as some specifics that are needed to put the model into use. It is now time to give the final details that underlie the model and support its implementation. In addition, some other important aspects of the EVSC educational process and all of education more generally have also come to light in this research.

One major idea that has come to light is that there is no one perfect program or ultimate end to be attained. After having examined the programs, it is obvious that each is unique. Moreover, education cannot be a guarantee at any point because of the vast array of variables that comprise it. Even with the most well described and implemented aspects of the program and with fully devoted faculty and staff, a program may not succeed in educating all students. At the same time, even the poorest of programs can educate the most excellent of students because that student can find the underlying message of EVSC despite the poor execution of the educational process. However, by conducting the research contained in this dissertation, it is possible to see what makes a program more or less effective. Moreover, the research provided a series of things that can help improve a program so that it does a more effective and an overall better job of educating students in EVSC. By identifying clear goals for EVSC education, as well as areas of potential problems along with some solutions, programs can examine themselves and seek to
improve. In addition, students can look at the programs they intend to attend and evaluate them more effectively.

Whether at the undergraduate or graduate level, the basic components of EVSC programs remain the same. Though the focus and content might change, the need to transfer skills in the areas remains constant. The knowledge skills and expertise to be taught should be identified as the goals of the program in the mission as well as covered by the various classes in the program. The program itself relies upon the areas identified by the model shown in Figure 3.1 to accomplish the goals set in the mission statement.

Figure 3.1 has specified four major outcomes that should be accomplished by programs along with four areas within programs that are typically used as methods by which these outcomes are accomplished. Each outcome—content knowledge, problem-solving, communication, and interdisciplinarity—have ways of being taught and methods for assisting students in this learning. The tools to do this—curriculum, faculty, extracurricular activities, and external advisement—provide a program the ways to transfer knowledge to students in order to achieve the outcomes. Though each of these areas will be discussed, some other aspects of the process must be examined and explained first. One aspect that must be looked at first is the actual definition of Environmental Science. Along with the definition are the goals and objectives of the programs. Once these things have been understood, then the improvements to programs can commence. Without clearly defined subjects, goals, and objectives, it is difficult to specify the program and assess its effectiveness. Once all this is completed, then the program can be described. Finally, an additional step that is sometimes overlooked—assessment—will be discussed.
is important to maintain and improve the program. Only through this system of a preset
mission and mechanisms to achieve it will the program be ultimately effective and
successful. To assist those interested in seeing examples of all that described below,
Appendix 2 contains a list of sample programs as well as the web page addresses (URL)
for pages related to the material presented that might be of interest to readers.

8.2 Mission Statements—Goals and Objectives

Before delving into EVSC program specifics, it is important to define what is meant by
environmental science. As a result of its complexity and wide ranging nature, programs in
EVSC have a wide range of mission statements and expressed or implied goals. Due to the
particular focus and size of an institution, the composition of faculty, as well as many other
factors, mission statements are uniquely designed for each program. Some are short and
give a broad overarching intent to the program while others are lengthy and provide
specific goals for the students in the program to achieve. Even so, certain common aspects
can be seen in each. Below are some of these mission statements.

<table>
<thead>
<tr>
<th>Institution</th>
<th>Mission Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of California at Santa Barbara</td>
<td>To play a leading role in training professionals and research scientists, discovering new knowledge about environmental issues, and identifying and solving environmental problems.</td>
</tr>
<tr>
<td>University of Illinois</td>
<td>The Department of Natural Resources and Environmental Sciences endeavors to establish and implement research and educational programs that enhance environmental stewardship in the management and use of natural, agricultural and urban systems in a socially acceptable manner.</td>
</tr>
<tr>
<td>University of Massachusetts at Amherst</td>
<td>The Environmental Sciences Program prepares students to contribute to the development of solutions to critical environmental problems. Graduates of the program can pursue career opportunities in government agencies, industry, international organizations, consulting firms, analytical laboratories, and educational institutions.</td>
</tr>
<tr>
<td>Southern Illinois University, Evanston</td>
<td>The mission of the Environmental Sciences Program is to cultivate the students' perspectives of environmental issues and provide students with refined knowledge of environmental issues at the local, regional, and global scale. The program will increase the student's technical competence in addressing these issues, their origins, ramifications, and resolutions. The Environmental Sciences Program at SIUE is interdisciplinary, and is designed to enhance and promote professional education and career opportunities in a wide area of interests.</td>
</tr>
</tbody>
</table>
The Department of Environmental Sciences is an academic department in the College of Arts and Sciences, offering instruction and conducting research in the areas of Ecology, Geosciences, Hydrology, and Atmospheric Sciences. This unique juxtaposition of several sciences in one Department fosters cooperation and exchange among traditional disciplines that share similar methodological and philosophical problems. The research endeavors of both faculty and graduate students, whether disciplinary or interdisciplinary, deal largely with problems of fundamental scientific interest and to a lesser extent with applied science, management or policy making.

Environmental Sciences is an interdisciplinary field concerned with the interaction of processes that shape our natural environment. The Environmental Sciences major provides strong preparation for (1) employment in natural resource fields through liberal arts science training; (2) professional schools through a focus on the reasoning, analysis and management skills that involve natural processes; and (3) graduate school in one of the disciplines through its in-depth training in theory and method.

The Environmental Science program at UNT emphasizes water and land resources and environmental policy. The curriculum is designed to produce environmental scientists who have problem-solving skills and a balanced understanding of the roles of natural, physical and social sciences in addressing environmental problems. The philosophy of environmental education at UNT involves both the curriculum and the "experience" of being involved in environmental problem-solving research.

Educational objectives of the program are:
- Develop skills to define problems, formulate hypotheses, design and carry out experiments and interpret and evaluate environmental data;
- Develop an understanding of fundamental ecological processes applicable to environmental resources management;
- Develop environmental monitoring, measurement, analysis and data management skills;
- Understand the fate and effects of contaminants and other stressors in the environment;
- Develop an understanding of environmental law, policy regulations and institutions;
- Develop a strong environmental ethic;
- Develop skills necessary to work effectively as an interdisciplinary team member;
- Conduct integrated risk assessments and be effective in risk communication.

Figure 8.1 lists the mission statements from several EVSC programs. These statements were taken directly from Survey 2 or from web pages referenced by the respondents on that survey.

In other institutions, the department does not have a mission statement but rather follows a guiding principle and attempts to achieve the mission of the larger institution.

For example, the EVSC department of Queens College, part of the City University of New York system (CUNY), responded with the following answer about the mission statement.

We (the EVSC program) also quoted from a report of the Nathan Cummings Foundation: "Identifying the causes of and possible remedies for the environmental crisis will require in every sector a skilled army of people whose careers are dedicated to protecting and restoring the environment. Yet, it is even more critical for the development of a sustainable future that people whose job titles do not include the word 'environmental' come to exercise a strong environmental awareness and competence in their lives and work."
Environmental concerns can not be compartmentalized. The environmental ethic must extend contractor who selects building materials to the executive who chooses whether and what to build, to the legislator who drafts pertinent laws, to the public who elect the legislator.”

This fits with parts of the mission of Queens College: The mission of Queens college is to prepare students to become leading citizens of an increasingly global society. Its goal is that students learn to think critically, address complex problems, explore various cultures, and use effectively the full array of available technologies and information resources.

In addition, ”[Queens College] is a source of information in the public interest. Through its graduates' contributions to an educated workforce and through the leading roles they assume in their local communities, the College is vested in the economic future and vitality of New York.

Since there are many different definitions, it was necessary to find one that encompassed all the possible aspects of EVSC. To that end, a broader definition was created after reviewing the existing definitions given earlier.

**Environmental Science (EVSC)** is the study of interactions between humans and their surroundings, particularly, the impact that people have on their environment. The goal of EVSC is to describe and understand existing and potential problems with the environment, as well as develop solutions to remediate and prevent those problems. To accomplish these goals, those studying EVSC must have a depth of disciplinary knowledge complemented by broad interdisciplinary experiences. Environmental scientists need to understand how to solve a variety of problems and communicate with experts and lay persons from a wide range of disciplines in order to gather research and disseminate findings. All Environmental Scientists should be interdisciplinary problem-solvers and decision-makers with the ability to communicate clearly and effectively.

As shown above in Figure 8.1, the mission statement can be very broad like those listed first or extremely specific like that presented by the University of North Texas.

However, no matter the length or specificity of the mission statement, having an
understanding of what the program intends to do, showing how students are to be taught and knowing what the eventual outcome of the program is to be, is vital to a good working program that can improve itself as well as educate students.

The next phase of discussion is to present a sample mission statement and discuss how it can be put into practice. Unfortunately, it is not an easy thing to give a universal statement of purpose for all programs. Many EVSC programs exist in conjunction with other existing programs. Some are housed in Agronomy, Oceanography, Geology or other physical science programs. At the same time, programs exist that contain a policy, management, or other social science components. There is no one mission statement that can be used for all of these and still provide the student with useful knowledge. This does not mean that nothing can be said about the mission of programs.

In addition to this general definition is the understanding that has come from the surveys that have been conducted. From this research, it can be seen that EVSC courses provide students with two different areas of learning. There are fundamental theoretical concepts that are given to students so they can understand how things work and why problems arise as well as how solutions can be developed. There are also the applications of these skills to existing and potential problems that students are taught to address. These applications rely upon and bridge many disciplines.

Every program needs to meet the overarching educational goals of education that the institution they are part of try to attain. These include those listed in Figure 3.1—awareness, enlightenment and vocation, as well as the others of citizenship, sociability and many other. However, these ends are often assumed as part of a university-level education. In addition, the objectives specified in the model can also be included in the mission.
Teaching students so they can acquire the skills, knowledge and expertise to function as an EVSC professional are also important. Content knowledge, problem-solving, communications, and interdisciplinarity are intended to be provided to students as outcomes of the program. To simply say that the program would do this is insufficient other than as an overall guiding principle. This is similar to a coach saying we are going to win or a general saying the army will fight. A mission statement this broad says that students will learn so they can become aware, deepen their knowledge of a subject, or acquire a job. Though true, a mission statement of this type is not particularly helpful.

Each program must decide to set goals and objectives for itself. The creators of the program can decide what they wish to teach. Sometimes, this is done by reviewing existing curriculum and developing a program from that point. At other times, an idea for a new program is formulated and then faculty and courses are sought to help make the idea a reality. In either case, there needs to be a vision for the overall program for it to be successful in accomplishing the mission of good education. In any case, knowing what the program wants to accomplish will allow for a better outcome than a program that lacks this direction.

Even so, there is something that must also be considered when developing a program or refining one that already exists. Many programs state that they are teaching students through their courses to attain many things. In addition, when asked about basic student skills, the respondents listed course work, often from outside the department, as the source of the knowledge transfer. Though education is the main mission of the program, it seems to assume that students will accomplish many fundamentals on their own. In our world today, fundamental education is being questioned in our secondary schools but once
within a university, it is often taken for granted. It is this assumption that must be dealt with first before other specifics of EVSC educational programs can be addressed.

8.3 Educating Students

8.3.1 General Overview

To begin the discussion of educating students it is helpful to imagine a professor at an American University teaching a course in the EVSC curriculum. If the professor was presented the problem of teaching a set of students who each came from a foreign country and spoke a foreign language, it might seem obvious that a first step might be to find a common language with which to instruct them. However, if they were admitted to an institution of higher learning, it might be assumed that it was the students' responsibility to learn the language of the professor first. In the same way, when this professor teaches a higher level course in the curriculum, the students are expected to have mastered the fundamental skills necessary to complete the course work. To ensure this, many courses require prerequisites. All of this seems quite obvious, but at the same time highlights a momentous problem that must be addressed especially when speaking about EVSC education because of its complexity and interdisciplinarity.

The problem is the assumptions made by administrators and faculty regarding the general education of post-secondary level students. These assumptions are numerous and varied. In many instances the assumptions relate to the lack of time and interest by faculty to deal with educational problems outside the specified purview of the course they are teaching. This is complicated by the need for many classes especially at large universities to be taught outside of a department. Often a name and a description of a course provide the only information to a program about what the course provides. Then too, there are
assumptions by administrators that students can learn all the varied skills necessary to be well-rounded while learning content, without putting into effect any means of accomplishing this lofty goal. Moreover, the problem itself is exacerbated by the system of rankings put forth as models for comparison. All of these complexly intertwined problems lead to a problem that exists outside of any one program and which is difficult to be solved by any one program. Even so, it is vital to EVSC that these problems be addressed and an attempt made to rectify the situation so that the students can be given a higher quality education and a better opportunity to acquire the skills, knowledge and expertise needed to solve the problems facing the environment.

The first assumption to be addressed regards the ranking of universities. From the research presented at the outset of the dissertation, it can be seen that the rankings provide two views of the institution being ranked. One of these is the quality of the infrastructure the institution provides. Things such as facilities, libraries and, to some extend, even faculty assessments give a view of the passive educational setting. If a student is driven to learn, a highly ranked institution gives the student the ability to use these facilities more readily than a lower ranked institution might and can expose the student to a different learning atmosphere. The second aspect of the rankings is to categorize the quality of students at the institution. By factoring in GPA, test scores and other academic measures, the rankings actually assess how well a university can screen incoming students rather than show how well the institution can educate any type of student. A highly ranked institution removes poor students from their roles while a lower ranked institution might accept a group of students that have not shown they can perform at the higher level. In this scenario, better students make a better university rather than the reverse. This in no way
ensures that an institution does anything to improve a student’s ability to learn or think for themselves but rather shows that the assumptions of those in the institution may be flawed.

Moving to some of the other assumptions raises other concerns. How much can be assumed about the ability of a student entering college. They are not yet fully mature nor able to clearly think about all the issues being presented. However, there are some things that can be done. Rather than assume the quality of students is a responsibility of the student, an active part should be taken in improving the raw material. Many universities provide tutors and other learning aids to students who wish to take advantage of them but few require a course that provides them with the basic training needed to function at a college level. Too often, professors assign a research paper or an oral report without first knowing if the student understands what that entails. Some uniformity of these types of skills is needed. In addition, with the awareness and uniformity that a basic training course would bring, there needs to be an agreement by faculty throughout a program to work with one another to comply with the accepted norms of the system. In science, there are accepted standards of measurement, such as SI, and methodologies for completing tasks, such as the EPA methods. Yet in many cases, when it comes to research papers, oral reports, and other class-related tasks, no such standards are adopted across curricula to help the students learn a proper way of conducting themselves.

More necessary than all these other skills is a need for a general problem-solving methodology to be taught to students early in their academic career. By giving students a blueprint for approaching all problems in any discipline will help them speak a common language with one another and their professors. Beyond just providing uniformity, the general problem-solving process listed earlier can give a common language to all students
so they can interact with various disciplines and see them in a similar way. This will allow
students to communicate more readily, will hone their thinking, and allow them to
approach complex problems throughout their academic career. By having problem-solving
introduced early in a student’s learning, they can carry and reinforce the skill while
learning content. However, if they are asked to find the methodology for themselves from
a wide variety of classes. and are only shown it at the end of their academic life; the skills
they learn will not be nearly as sharp, and their critical thinking, problem-solving and
decision-making ability will be far less developed. Though there may be many different
ways to teach students how to solve problems, each follows a similar methodology to
identify, research, analyze and solve the problems facing all of us. The ways the research
is done and decisions are made may vary, but the overall steps taken to work from the
awareness of a problem to its solution are very similar. It is this process that will aid
students to becoming better at learning and communicating.

Though a basic training course may be important to all programs, the focus of this
dissertation is EVSC. To that end, the basic training course is even more important when
discussing an interdisciplinary and often interdepartmental program. A classic program
housed within a department can more easily adopt and maintain a standard or identify
students that may be experiencing problems with subject areas. When the focus is spread
across disciplines and the program relies upon outside courses to accomplish its mission,
this internal oversight may lessen or totally disappear. EVSC students must learn to
identify the goals of many disciplines and apply the tools of those disciplines to
appropriately and effectively solve problems. Early on in their academic lives, they need
to have a transcendent methodology that does not rest within one discipline. Rather, they
must use a process that can be applied to a variety of disciplinary situations and provide a basis for comparison. The general problem-solving process can be the multidisciplinary process to do just that. Beyond the ability to understand is the ability to balance the many different disciplines and weigh the solutions that each provides. Though often an engineering solution may be the easiest or a political solution the least expensive or an economic solution the most acceptable, it is the responsibility of the environmental scientist to evaluate all solutions and select the best rather than defer to the disciplinary mandate of a doctrine learned in school.

It is also important to show that EVSC relies upon clear and effective communication skills as part of the learning process. Due to the interdisciplinary nature of the subject matter, the ability of the EVSC student to write and speak about the varied fields is directly connected to success. Unlike some engineering or science problems, all environmental problems have some human component, requiring effective communication.

Whether or not the student has been able to take a basic training course, problem-solving and communication are also important within EVSC curricula. These need to be taught throughout the entire process. In addition, both undergraduate and graduate students can benefit from these types of courses discussed earlier. Hopefully, a basic skills course could be offered as a one-credit refresher course or workshop for graduates, but this makes it no less necessary. Whatever the case is to be with a baseline set of skills being established, once inside the curriculum, the skills discussed here must be reinforced and a uniform set of ideas put forth to save time and confusion for the students. However, having said this, it is now time to delve into what should be contained in the program itself according to the research regarding the model.
All of the topics to be discussed in the following sections are easily seen as part of an interconnected process, though some are more easily accomplished than others. The more easily integrated skills will be discussed first.

8.3.2 What Students Should Obtain

Though mission statements may vary and what each student learns may not be exactly the same, there are several basic ideas that remain constant. Each program may focus on one more than another as missions, classes, and intents change, but in the end, the student will be seen to have acquired varying levels of competency in the same basic areas no matter what program has been attended. These areas are problem-solving, communications, content knowledge, and interdisciplinarity.

This section will discuss the four outcomes of education by seeing how these different aspects can be transferred to students and why they are important. Though other aspects may also be present, these four were identified as the characteristic areas that should be learned. Deficiencies in these areas does not mean that the student cannot practice EVSC, but rather shows that the program has not been able to transfer the knowledge successfully. Having none of these skills does denote a lack of knowledge and skills by the student and would most likely lead to failure as a professional. In turn, a student who is highly accomplished in all of these specified areas will be seen as an accomplished EVSC professional.

8.3.2.1 Problem-solving

Though this topic has been discussed several times, it is important to highlight certain things with regard to the model for EVSC. Problem solving, as defined in this dissertation,
is essential to the success of all environmental scientists. It acts as a means to uncover, research, understand, analyze, and develop solutions for problems facing the environment today and into the future. At its root, EVSC is centered around this process of finding solutions to problems. Students armed with a clear and effective strategy for approaching and solving problems will succeed if they can implement it effectively.

Problem-solving contains many other related topics that are vital to understanding the process and making it effective. Helping students to become aware of the impact of their actions and the actions of others is a vital step in EVSC education. Moreover, EVSC programs must assist students to become aware of how various disciplines can help them as they work through a problem. In addition, by giving students a common language of problem-solving to speak, they can see where different students were able to make different choices along the same path. This is incredibly important when discussing issues of environmental protection because so many different disciplines can be involved and so much of the material can deal with human choices or decisions without clear causes rooted in a hard science foundation.

Then too, many other methods presented in an EVSC curriculum are more specialized cases of the more general process. Topics such as Environmental Impact Statement (EIS) completion and pollution prevention analysis are specific ways of analyzing a situation. They both highlight a broader problem-solving process that the students are using to determine the impact of an action or proper alteration of a process. As EVSC students move through every class, they will be given methods for research or problem-solving that are used by the discipline. Economics, Chemistry, and English classes all have methods for completing tasks. Though they are not the same
methods, they all share a decision-making process that can be assisted by a clear rational approach like that described by the general problem-solving process. If EVSC students are aware how these methods can be used to assist them when facing problems not strictly within the discipline, they may be able to use them as graduates when facing yet unknown environmental problems.

Whether at the undergraduate or graduate level, some underlying methodology needs to be used as a common platform for understanding and discourse. As students attain higher levels of academic achievement, too often this becomes disciplinary jargon and entrenched methodology. For EVSC, these types of things are either borrowed from other preexisting disciplines or created within a program and given to the students to carry with them. No overarching methodology has been adopted nor suggested to unify EVSC and give it continuity. Though programs may be well developed and consistent within themselves, there is still a need for communication and interdepartmental and EVSC-wide consistency.

8.3.2.2 Communication

Communication is another area of general education that has particular impact on EVSC. This too is a vital part of the EVSC program but can be accomplished effectively only if it is integrated into the entire program in a consistent way. Students of EVSC will, in many cases, be required to comment more effectively than other science students. Since many environmental problems have social aspects, a well-rounded and properly prepared student should be able to communicate not only with members of the EVSC community but with policy makers and ordinary citizens as well.
One difficulty facing programs with relation to communication skills is that these skills are often more readily taught by other departments such as the English Department of an institution. What is needed within the EVSC program is a connection to these departments so the professors understand the needs of an environmental professional. Also, a concerted effort must be made within the program to encourage students to develop these same skills. It is important to have some consistent standard that is used throughout the program and, if possible, by all EVSC programs. In the same way that most research papers need to use a specified format for presenting a paper such as the Modern Language Association (MLA) or American Psychological Association (APA) guidelines, EVSC students need to have some standard method for presenting material in both a written and oral form.

8.3.2.3 Content Knowledge

Perhaps the most obvious of all programmatic topics is content knowledge. This is, of course, at the heart of every program and helps define the types, and in many cases, the value of the degree being offered. At the same time, it is one of the most difficult topics to discuss with regard to EVSC education. The variety of classes and the scope of the material to be taught is vast. Each program must determine what classes it can offer and how they are to be brought together to create a degree in EVSC at either the undergraduate or graduate level. However, there are several things that can be discussed about what types of information are to be taught and what level of understanding needs to be attained by those institutions offering degrees in EVSC.

As stated above, the content knowledge transferred to students can be discussed in two major parts. The first is theoretical basic knowledge needed to understand the systems
of the environment as well as the human interaction with it. The second deals with the knowledge of applied sciences that allow students to conduct research and solve problems utilizing the basic knowledge learned. This dichotomy is not split along the undergraduate and graduate lines as many advanced graduate classes may deal with more in-depth methods of research necessary to have a better understanding of some applied methodology. However, in general, undergraduate education in EVSC must begin with the basic courses to lay the groundwork for applied classes in the junior and certainly senior years. In a similar way, an undergraduate degree should lay the groundwork for courses in the graduate years. This will be discussed further in the Curriculum section below.

From the material gathered in Survey 2 and from subsequent interviews, some clear ideas about what content needs to be taught was gathered. Basic science classes seem to be the most important at early stages. Biology, Chemistry, Ecology, and Mathematics can provide fundamental information necessary to students as part of their EVSC education. At the same time, classes intended to give the students marketability and diverse knowledge are also important. English, Economics and Computer Science were cited as important for both future success within EVSC classes as well as in the work place. Since many tasks in EVSC rely upon the ability to communicate and make decisions, general classes can assist the students to hone these vital skills.

Beyond this cursory examination of content, lies the need for course content that provides usable skills and prepares students to function as environmental scientists. At the undergraduate level these courses may contain information intended to inform students about general environmental issues such as overpopulation, pollution, and deforestation or specific issues such as global warming, and ozone depletion. Long lists of issues similar to
these can be constructed and may be used to illustrate the tools used to solve them. The key is to make the students aware of the problems and issues as well as how they are being approached and solved.

At the graduate level, the focus of content shifts to more specific methodologies for research and problem-solving. Advanced classes in particular media provide students with content knowledge that is intended to give them more refined expertise. Though undergraduate students are exposed to some of this expert knowledge, the scope of what is to be learned is so great that much of the content is only a review that points students to the deeper understanding. At the graduate level, students can choose an aspect of EVSC to explore more deeply and the content knowledge taught can more closely reflect the set of skills needed to properly deal with the issues or problems in that field.

Most, if not all, graduate level programs have a core of courses that contain similar content. This curriculum will be discussed below. However, with regard to content knowledge, these advanced classes mirror the basic classes but are given far more depth and related strictly to the study of the environment. Classes such as Environmental Chemistry, Biology, Research Methods, Problem-solving, and Law give students a baseline understanding of the topic. Other specialized classes such as Toxicology appear in many programs so that cause-and-effect relations can be seen. Toxicology relies upon many basic sciences as well as social sciences to understand the route of disease and other environmental problems. Even a course in environmental laws moves beyond science into social science as it explains the motivation for the regulations as well as their enforcement and interpretations.
Whatever the level of education or intent of the program, the content knowledge is used to achieve the goals set forth by the mission statement. The content can also be a vehicle to hone problem-solving and communication skills. However, it must remain clear that content is not something separate from these other skills. Content of courses is more than just the facts and processes related to a field. Though it is easiest to teach or in some cases simply have students memorize these types of materials, content is the mechanism for educating students in the interconnected nature of the environment. EVSC must rely upon the content of classes to create well-rounded and fully educated individual thinkers armed with the knowledge, skills, and expertise to deal with environmental problems. The tools of the EVSC students are more than just the factual content of classes. Some of these additional tools are listed in the following sections.

8.3.2.4 Interdisciplinarity

The fourth area of EVSC education to be discussed is Interdisciplinarity. Though not easily taught, interdisciplinarity is vital to EVSC students and ties the various aspects of content knowledge, communication, and problem-solving together. EVSC is accepted as a course of study that relies upon a variety of disciplines to prepare students to deal with the problems of the environment. This does not mean that EVSC students become truly interdisciplinary, but rather have knowledge from a group of disciplines that they may choose to use at different times. Simply having a set of texts and case studies when illustrating the ideas of interdisciplinarity is helpful, but it is not enough to fully accomplish this objective. True interdisciplinarity is accomplished when the student can understand a variety of disciplines, use the tools from each of them when appropriate and,
most importantly, synthesize the many different perspectives offered by the disciplines into a coherent whole to solve a problem or resolve an issue most effectively.

The problems facing EVSC students have many constraints on them that are often at odds and best understood by a diverse group of people. A single environmental problem can have social, legal, economic and/or other impacts beyond the strictly scientific and engineering concerns. If the EVSC student is to be more than just a technician providing data, he/she must understand and be able to work across these various disciplines. To be the problem-solver and not just the symptom-reliever, EVSC students must be interdisciplinary.

In order to help bring together a team of disciplinary experts and focus their efforts, the EVSC student, armed with good communication skills, can be the mediator and leader. In addition, the general problem-solving methodology and a depth and breadth of content knowledge of the various disciplines allows the EVSC student to understand as well as communicate and work effectively with each disciplinary expert. Also, an interdisciplinary person can help the other experts understand one another as the problem is being worked through.

It is necessary to discuss how interdisciplinarity is transferred to the students so they can appreciate how to be interdisciplinary themselves. The first step is to make students aware that interdisciplinarity is important to their studies and that each class is connected to others. It is the interconnection that many students fail to grasp. A major idea that must be stressed is that balance must exist in and among the many classes that are taught. Many students, especially undergraduates, see education as a race in which the degree is the finish-line and classes are hurdles to be passed along the way. Often graduate
students bring some of this attitude with them as well. When required classes not directly related to a major or in an area of expertise consume a student’s time, they see it as interfering with their narrow interest of graduation and successful employment. However, a successful EVSC student must be interdisciplinary. Unfortunately, this narrowed focus works against interdisciplinarity and is fostered by many bad habits that exist from the earliest days of a student’s educational life. By tying classes together, showing how different disciplines can work together and having students work in interdisciplinary teams, this problem can be alleviated.

Each institution, program and class can do many things to promote interdisciplinary learning by students. EVSC in particular has several methods for incorporating this concept into classes. One method is to bring in guest speakers to speak about related disciplines. Also, by utilizing interdisciplinary case studies and texts, students can be exposed to the idea that more than one discipline can assist them when approaching problems and deriving solutions. In some classes, team-teaching can allow a single subject to be addressed from a variety of viewpoints providing the students with an easy-to-follow example of interdisciplinary thinking being created. Along these same lines, asking students to attend workshops and panel discussions that deal with issues being handled in an interdisciplinary way can provide a real-world demonstration of the in-class discussions.

No matter how it is handled, interdisciplinarity is vital to the success of EVSC students. If they do not acquire the ability to think in this way, they may not achieve the goals of the program and be as successful in the profession because of the limits that one or several disciplines place upon them. Environmental problem-solving needs experts as consultants but must have generalists as the leaders.
8.4 Attaining Program Goals and Objectives

8.4.1 Introduction

The linchpin holding the goals of a program to their execution is faculty. No matter how well the program is designed, its execution rests in the hands of the faculty charged with teaching the students. It is the faculty and, by extension, the staff and administration, that must design curricula, organize extracurricular activities and solicit external advisement. At the heart of any good program are a group of capable, diligent, hard-working faculty.

This section will discuss how faculty, curriculum, extracurricular activities and external advisement can be used to attain program goals and objectives.

8.4.2 Faculty and the Use of Management Tools

The phrase, "publish or perish" is often associated with university professors. The drive to acquire grants, publish articles and books, as well as garner acclaim in one's chosen field often consume much of a professor's time. The idea that a member of the university staff is charged with both teaching and research is not a new one. However, many times the way in which these roles are executed are not well-defined or even thought-out. Moreover, at times, the ability to research and garner grants may become more important to the success of the teacher than the ability to actually teach and motivate students to learn. This constant pressure forces faculty to divide their valuable time and make choices about how to expend their efforts. Often times, less emphasis is placed upon teaching as less time is devoted to it by professors. It would be a horrible example to set if a classroom became a place where both the student and the faculty members agreed that there were better ways of spending time than learning the material. If this happens, the class becomes a task to be
accomplished and does not serve to educate but rather simply validate as one might a parking stub.

To assist professors with teaching and improve their skills, the author suggests that all professors view themselves as more than lecturers or even teachers. Each professor should be a manager and a leader of the classroom team so the goals of the program and education in general can be accomplished.

Before going any further, it is vital to point out that it is not being suggested that a rigid management scheme like that found in industry should be adopted by post-secondary educational institutions. If this was to come about, the bottom-line, performance evaluations, and restrictive cost-benefit analyses might become the main means of determining what is best for higher education, which would be an undesirable outcome.

Nevertheless, it is important to examine the role of faculty in a university. After reviewing hundreds of university web pages, and programs as part of this work, the author has seen that many universities have put forth at least four main goals as part of their mission statements—fundamental or ‘pure’ research, applied research, an improved community, and knowledgeable and capable students. Pure research takes the form of ideas, concepts, theories and other incremental advancements in the body of knowledge that is taught to and used by others. Applied research comes in the form of technological advances that have a direct impact on human activity. An improved community is the result of direct university investment and community service, as well as the indirect benefit of better-educated citizens. The fourth product is knowledgeable and capable students.

Too often this aspect of the university may not be given the proper weight by the distracted professor fighting for tenure, a grant, or even a job. However, students should
be one of the main products of the higher education system. The better the quality of the finished product, the higher the renown of the university. In turn, as these students continue through their careers, they will, hopefully, remember their education and be more likely to reinvest time, money, and influence in their university. To this end, teachers and their university should embrace a new vision of how to educate students and guide these products through the process of learning. Students should be shown that education is a process not a trial or an end. It is vital to shift classrooms from places where information is dispensed like a huge vending machine or shown like a film in a movie theater, to a place where the students can experience learning first hand.

By shifting from factual-based to process-based learning, students are prepared for a diverse set of career options. Universities can build problem-solvers and thinkers rather than disciplinary-focused copies of the professors teaching particular courses. In the new age of diversity, educational institutions should shift away from an apprenticesing system to a comprehensive interdisciplinary system that views students as a part of a team that has the professor as its manager and leader. Whether students are striving towards a goal of completing a task, a course, a major, or their entire education, at all times they are members of a team. This team is inherently tied with one or more professors.

Both as classroom leaders and as academic or extracurricular advisors, professors head teams of students working towards goals throughout the educational world whether they are aware of it or not. To facilitate these teams, programs should identify related courses and have their professor collaborate and discuss what can be done do to improve the learning process. Learning teams such as these are useful in many ways but not readily formed and maintained without guidance and structure.
The author suggests looking towards Organizational Behavior (OB) and management research for ways to improve teaching by utilizing management models and techniques. Many researchers in the field of management and OB (Robbins, 1998) had different ideas of what a manager should or could do to motivate workers, make them more productive, and help them attain goals. They suggest a manager should endeavor to do the following 10 tasks in order to be a good manager: Planning, Organizing, Leading, Directing, Staffing, Controlling, Coordinating, Representing, Innovating, and Motivating (Himelstein, 1998).

- **Planning** is defining the short-range and long-range goals the manager has for the team, the company and the employees.
- **Organizing** is the method by which the manager brings together teams, to address these goals.
- **Leading** is the role that the manager plays on the team and for the workers.
- **Directing** relates to the delagatory and assigning nature of a manager.
- **Staffing** is concerned with finding the right person for the right job on the team. This involves interviewing, promoting, rewarding, and removing personnel.
- **Controlling** is concerned with the power and position of the manager. The manager must remain calm and composed when making decisions and be prepared to make those decisions.
- **Coordinating** refers to the inherent interlacing that the manager must do to keep the office running, the team working effectively and the goals from being lost in the mix.
- **Representing** is the management role to bring the issues of the workers in the team to upper management, and the upper management’s ideas to the staff.
- **Innovating** simply means being creative and always trying to develop new things and cultivate new ideas.
- **Motivating** stands for the need of a manager to inspire workers to be more productive and keep them from just being maintenance seekers.

If one replaces the word worker with student, office with classroom, and manager with professor, these ten ideas seem to apply well to teaching. Some of these roles translate clearly into teaching while others seem somewhat less clearly and directly transferable. Of the ten, the two important ones to discuss further are motivating and leading followed closely by coordinating and innovating.
According to OB and management systems, there are five approaches to motivating and managing workers or, in this case, students. (Himelstein, 1998)

1) The “be good” approach.
2) The “be strong” approach.
3) Implicit bargaining.
4) Competition.
5) Internalized motivation.

The first two approaches most nearly mirror many high school experiences. The first says that good treatment gets people to participate but not produce. If you ask students to attend and to quietly listen, they may do so, but not really learn much at all. The second is more like a drill sergeant or coach. Shouting and screaming commands obedience but not understanding. This is only good in the short-term and leads to a fear of question-asking or free-thinking and thus stifles learning. Though in small doses and at appropriate times, both of these methods may be useful or even necessary, when used as the only means of motivation for learning, they will not produce the desired results.

Moving on to the third method brings us to a tool of motivation used, perhaps, from birth by parents to sway children. A bargain that exchanges a wanted commodity like money or freedom to use the television or the car for good grades, attendance, or other desired goods has been employed for years to motivate students. In a classroom, good grades are traded like commodities for hard work, good attendance, and participation. However, these bargains do not assure that students will learn. In addition, sometimes bargains can be abused or taken too far. This can also tie into the fourth method, competition. If the instructor sets up different groups in class to motivate students, learning can be enhanced. However, sometimes the competition is for a single grade rather than for healthy internal debate and competition. Though some competition is always
present in a class graded upon a curve or set up along a team project system, if not watched
carefully and used to benefit the student learning process, any competition can quickly
devolve into cut-throat grade-seeking and conflict if left unmonitored.

Finally, we have internal motivation. When a student wants to learn and come to
class, they are more likely to be motivated to learn. Their minds are open to possibilities
and can be moved more easily to the goal of the educator. Though most effective, this is
the hardest to implement in a classroom and asks the teacher to build and create a class
where an individual can get responsibility and through the work itself see satisfaction and
success. Internal motivation begins with student self-awareness of personal goals. Making
students aware of their self-responsibility and own wishes helps to have them be motivated
from within. Without this awareness, internal motivation becomes less attainable except
by those exceptional students who have inner drive independent of professorial
inducements.

All five of these management styles can be seen in the classroom at different times
and places. The main purpose of each is to help motivate the students to participate in the
learning process. Along with motivation, the teacher is a leader. Here also, OB provides a
model of a good leader that can be brought into the classroom. The research identifies
three types of leaders: directional, transitional, and transformational. As with the
motivational techniques, these three leadership styles can be seen in the classroom.

The directional leader is one that points to goals and tells the team members to go
towards it. This can be seen in the classical lecture method. By telling students what to
learn and how others have been able to accomplish goals, a lecturer helps the student learn
the specified material.
A **transitional leader** takes this one step further by actually moving through the process with the student. Rather than just pointing the way, a transitional leader actually works through the task with the team members or students and helps them to understand the thinking involved. Many times case studies, multimedia presentations, and guest speakers can be used to instruct the student and then be reworked through feedback from those students.

Finally, there is the **transformational leader**. This style of leadership not only moves the students from one point to another but also tries to change the student during the journey. Not only is the teacher trying to dispense knowledge and show how things apply, but the teacher is working to create new ways of thinking. As students are made more mature, responsible, and better equipped to solve problems, the transformational leader continually assesses the progress of students and taps into the skills of the other two leaders to help attain a goal. It is vital to note that this goal is more than a fixed point in space or quantity of knowledge. The goal of a transitional leader is a change in the student. By effecting this change, the transformational leader can internally motivate students to learn while, at the same time, providing the student the tools necessary to learn on their own.

In the end, the goal of any educational system should be to create a self-sufficient, self-motivated, mature, and responsible learner. However, a teacher does not have sole responsibility for the success of a student. The teacher is given the control of the educational process, but the student must be part of the team. Students, administration, class size, subject matter and many other factors influence the way a class is conducted. By keeping in mind these styles of management, a teacher can be a better "leader" of the class team and help the student "workers" accomplish the goal of education. Not all
management or OB research applies to education; however, in this case, students are
workers and part of a team that is trying to attain a vital and hard to reach goal—
knowledge, experience, and enlightenment.

Looking toward EVSC in particular, faculty are comprised of a verity of disciplines
and often come together from outside departments to teach courses under the umbrella of
EVSC. If the faculty are brought into EVSC, this may not pose as large a problem as when
EVSC students are sent out to other departments to satisfy requirements. Without some
type of connection to the topic of EVSC, students can be taught disjointed environmental
messages as well as fail to see how the tools of these disciplines apply to EVSC.

Like real environmental change itself, good environmental education occurs at the
interface between faculty and student, whether in classrooms or elsewhere. A student can
read a text and have the facts of a situation without truly understanding the message or
many nuances that exist concerning a particular issue in EVSC. It is here that faculty have
the greatest impact. Anyone can be pointed in the right direction, instructed on what to
learn and lectured to about a subject. Only skilled faculty can transform students as leaders
both inside and outside the classroom. Moreover, faculty members must be able to discuss
the topics they teach with one another to help provide connection between and among
classes. Having consistency within the courses taught as well as continuity between these
classes is an important first step towards a connected program. Faculty are essential to
creating this connection. If all EVSC faculty in a program can adopt similar in-class
protocol for research work, papers, and other pedagogical-type concerns, students will have
more time to devote to the material in the class once they have mastered these ground-
rules. At the same time, faculty will see more consistent work from students. There will
be no questions about how things should appear and how work should be submitted once it has been established in an introductory class.

Faculty can also work with others in the program to coordinate efforts as well as verify that the necessary lessons are being learned. By meeting with other professors that teach classes in a course sequence, contradictory messages and conflicting signals can be eliminated so the student is allowed a clearer view of the topics being discussed.

Another important role of faculty is to become involved in student activities and development. By sharing research interests, attending functions, and participating in advising sessions, faculty members become more closely tied to students. On a similar note, asking fellow faculty members to come to class and present materials from research, join discussions, or watch and listen can broaden the learning experience as well as demonstrate to the students, the interconnectedness of topics, the program faculty and the program in general.

The last topic regarding faculty in EVSC is outreach. Faculty research and publication connects the faculty to outside academic sources. In addition, when research leads to copyrights, patents, technologies and other tangible applications, faculty members become involved with other EVSC professions. These connections can be shared with students and used to enhance the program. Also, by bringing aspects of those outside activities to the classroom and infusing the lessons of EVSC into each class period, the material can provide more tangible case-studies for the students to understand as well as show the direct application of the EVSC principles being taught. Though all research and outside connection may not be appropriate for every class, by making this connection evident students may begin to realize that their academic lives and their professional lives
are tied together. In addition, as students move from the undergraduate to the graduate level, many will be tied to specific projects. Bringing the research into the classroom will allow students participating in projects to have an opportunity to discuss it as well as share their insights. Moreover, as other students hear of the work being done, they can see how their own research is progressing and how it too applies to EVSC class work and projects underway in the program. In this way, students can become more skillful at problem-solving, communication, and interdisciplinarity.

8.4.3 Curriculum

Curriculum is the instrument used to accomplish the missions of the program, as set down in the mission statement. As with content knowledge, the curriculum is most directly related to the classes that need to be taught and the requirements of the program. In the end, students need to be transformed through the process of education such that they have internalized the knowledge and added the tools of the discipline to their daily working lives. The curriculum specifies the minimum set of courses required to accomplish this transformation. Having consistency within the courses taught as well as continuity between these classes will give the program internal structure and cohesion that can assist EVSC students to learn the material and understand the more difficult concepts of interdisciplinarity, environmental communication and problem-solving.

In general, EVSC education may be seen as a continuum moving from undergraduate basic science toward upper division and graduate applications and carried on to the doctoral level in specific areas of interest. Knowing how courses tie together and move from the general to the specific and the theoretical to the more applied should be a clear part of the courses in an EVSC curriculum. In addition, each EVSC student should
be familiar with the tools that each course provides and when it is appropriate to use them.

Even at the graduate level, some courses will be more of a general overview of a discipline while others provide deep insight into the inner-workings of the discipline. It is up to the faculty members teaching the courses, and the course administrators developing and overseeing the program, to determine where this balance lies.

Each student should be able to choose classes that either provide a breadth of knowledge, or depth of knowledge, within EVSC. Too often, students are not given sufficient choices of classes. As a result, they are asked to learn both the breadth and depth of knowledge in one class in too short a time or forego learning some material all-together. As always, time constraints and other competing factors force choices to be made within programs. Too often, the student must sacrifice as they are forced to make a choice.

The first step in developing a curriculum is to define the terms being discussed as well as set out the goals and objectives of the program. For EVSC, many varied definitions can be found as has been shown earlier in this work. In addition, because of this great variety as well as the broad range of focuses that exist for EVSC programs, it is vital that each program clearly determine what is to be taught and how these ideas are to be successfully delivered to the students. Having clearly defined goals and objectives in the mission statement will assist students to understand what is expected of them and being offered by the program as well as allow for easier evaluation of success within the program. With a mission statement established, the curriculum can be developed to accomplish these goals and objectives.

Every curriculum is a balance between the issues of breadth necessary to build a good interdisciplinary EVSC program and the depth necessary to prepare students to
function as environmental scientists. The remainder of this section will discuss some types of courses that should appear in a curriculum. In the end, however, each program is unique and limited by funds, faculty, and other factors making a universal curriculum difficult to define.

Most curriculum contains some type of introductory course to provide students with some baseline knowledge and understanding of the field. Many programs also ask students to complete capstone classes, senior projects, or a thesis course among others, as a way of summarizing the knowledge learned throughout the curriculum and show proficiency in EVSC. Examples of this can be seen in both survey 1 and 2 as well as the sample programs listed in appendix 2.

Introductory courses and capstone classes are two components of programs that can bracket the learning experience, providing a good means of attaining continuity. Beyond this, each curriculum needs to have hands-on experience as part of the curriculum. These experiences may be in the laboratory and/or in the field. In both cases, the experience of gathering, recording and analyzing data as well as drawing conclusions and testing them cannot be underestimated for success in EVSC. In addition, seminars, workshops, and other one credit classes designed to refresh information or expand learning can be offered by a program as part of the curriculum but given only a one credit non-graded status. Internships and faculty research projects also may be given credit and thus be considered as part of the curriculum. These issues, however, will be covered more in the section on extracurricular activities that follows.

A good curriculum should begin with some introductory classes in EVSC, which provide baseline skills to all students so that higher level classes can be taught with some
consistency. Introductory classes can provide students with a problem-solving methodology, as well as improved communication skills, to be used throughout the EVSC curriculum. Case studies should be utilized to emphasize interconnectivity and interdisciplinarity of the field. In addition, an introductory course, especially at the graduate level, can provide an opportunity for students to meet professors and learn more about the research being done at the university. Even if each professor simply provides a short synopsis of the research being conducted and the course taught, students can begin to see the structure of their future educational curriculum. If a seminar series is included with the introductory courses, faculty members can more personally describe their research and create student interest.

Having spoken of the beginning of the program, the end should also be examined. Typically, programs require a capstone class or research project at the completion of the curriculum to serve as a final review of all the lessons learned as part of EVSC. In addition, these classes provide students the opportunity to demonstrate their abilities and accomplishments. These classes are not necessarily part of every undergraduate curriculum, but almost all graduate programs require some type of thesis or project as part of the requirements for graduation.

Between the classes geared towards introduction and conclusion are many others intended on providing the necessary content to students. Among these are laboratory courses. Due to the nature of EVSC research and practice, students must be exposed to and become competent in laboratory and field methods. These hands-on classes give the student a place to apply the theories learned as well as understand the limitations of the tools and processes being taught. The first labs that the EVSC student will be exposed to
at the undergraduate level will most likely be in basic sciences (Chemistry, Physics, and Biology) followed by applied labs and field work in EVSC. When working in the field, the true interdisciplinary nature of EVSC can be brought out along with the need for the variety of problem-solving and research skills required to accomplish the work.

Both the advanced laboratory and field classes for EVSC should incorporate a variety of disciplines and problem-solving techniques to give the student the best experience. Even if the primary focus of an EVSC lab class is within a discipline, such as Environmental Chemistry, the overall process of the class can incorporate skills from a variety of other sciences including, social sciences. When venturing into the field, this becomes even more necessary. When looking at a class such as Toxicology, there are many direct chemical exposures, but at the same time, many social factors, survey skills, and other related skills that are necessary.

As students move through the curriculum and attain higher levels of EVSC education, the hands-on classes become more interdisciplinary and thus rely more heavily on application of a variety of skills. Tools from economics, geography, geology, earth science and many other fields must be considered as EVSC courses delve into complex issues of the environment at these higher levels.

To supplement and enrich the curriculum while reinforcing the sense of continuity, consistency and connection, a series of one-credit classes can also be implemented. These courses can assist the program in accomplishing its mission by providing a wide range of activities including speakers, field trips, workshops, refresher courses, and bridge courses.

The most common of these one credit add-ons are seminars and guest speaker series. It gives students an opportunity to come together and gain exposure to faculty
research as well as outside experts. Similarly, field trips and workshops provide access to otherwise unattainable resources such as industrial plants, testing labs, remediation sites or other EVSC related areas. In some cases, field trips are the extension of a course or a seminar series. In other cases, all of these activities must be arranged through club and other extracurricular organizations.

Another curricular item that is similar to the one-credit courses are refresher courses and bridge courses. Many programs offer post-senior-level classes that bridge the work between undergraduate and graduate. In other cases, graduate students must complete courses to meet the minimum standards for a program. In either case, a series of courses exist to bridge the undergraduate and the graduate curricula. Often it is an ideal method for interesting students in graduate work as well as providing a method for drawing professionals into the program. In other cases, EVSC programs offer certification courses at various levels. These courses are usually intended for EVSC professionals returning to school. These refreshers may be used to fulfill job training requirements or government regulations.

In other cases, specialized skills required by those working in the EVSC field can be provided through the school. In many cases, these classes do not directly relate to a track within the curriculum but are seen as important for those pressing some careers in the fields of EVSC. Examples of these types of classes might be Occupational Safety and Health Administration (OSHA) refresher courses, current EPA regulatory changes, or Environmental Impact Statement (EIS) preparation seminars. In either case, refresher courses and bridge courses are important parts of the curriculum that are often overlooked. As can be seen from the Student Abilities section of Survey 2, ensuring all students have
the necessary basic skills is important. In addition, these courses can be an avenue for more students to learn about EVSC and pursue higher level degrees. Examples of good undergraduate, graduate and combined programs are in Appendix 2.

The last thing that must be discussed with regard to curriculum is the idea of consistency and continuity. All of this has been stated before, but it bears repeating. Each course should have a clearly stated definition available to all students. With that, each course should have a mission statement as does the program. This statement should outline the goals of the class and how those goals are to be attained. If this is done in each class, the overarching mission statement of the program will be more clearly defined and more easily attained. This common thread woven throughout the program will assist students to follow the curriculum to its end and know what to expect as they enter and work through each class.

As was suggested in the beginning of the chapter, students are the key to a successful learning experience. No matter how well all the other aspects of the program are executed, a disinterested and unmotivated student will not be successful. However, if the student wishes to learn, even the poorest program can provide enough to allow the student to learn on their own and succeed. Moreover, since many students do not choose to enter an EVSC program until after having taken many other classes including the basic sciences and other core requirements for graduation, many of the lessons that need to be learned may be lost. As a result, there needs to be a guidebook for EVSC students to be able to examine any class either while enrolled in it or after it has been completed. This book would allow student to identify the lessons needed for success in EVSC. Such a book would include clear definitions and descriptions of the tools related to EVSC, clear
statements of the goals and objectives of each class, and a list of questions that need to be answered when examining each discipline so that clear evaluations of a discipline can be made to determine its merits and shortcomings. An example of this type of guide is given in Appendix 3.

Having discussed the various elements of curriculum, the following example of a generic EVSC curriculum is provided. It begins with the mission statement for the program and then moves through the development of the undergraduate and graduate curriculum. The undergraduate program will be discussed first. It is intended to prepare students to expertly solve any problem concerning the environment. This program prepares students to pursue advanced degrees, work in the public or private sector, or become involved in research projects. To this end, the undergraduate program consists of two major segments, teaching students a wide range of fundamental skills and giving them a depth of knowledge in an area of specialization. Every student begins with the same set of courses. At the end of the second year, students are asked to choose a track of interest in which to specialize. Even though there are still common requirements during the last two years, students entering different tracks will take electives from specific areas of interest related to the area they have chosen. Depending on the track selected, varying courses, field work opportunities, and internships will be presented to the student. In addition, faculty members with expertise in the various tracks will be given advisory roles for the students choosing to specialize in their tracks.

Each area of specialization explores a facet of the overall field of Environmental Science. Students gain more in-depth knowledge while still learning how to relate these content areas to the broader topic of Environmental Science and the other disciplines being
taught within the program. Students are required to select a minimum of five courses related to a particular area of specialization. Though several areas are specified, students may wish to make their own areas of specialization based upon personal interests and career goals. Predetermined areas of specialization include broad topics such as:

- Biological Science
- Chemical Science
- Ecology/Conservation
- Law and Policy Studies
- Multimedia Environmental Problems—Atmosphere, Soil & Water Science
- Natural Resource Studies Project Management
- Social Sciences/Economics

These areas can be made more specialized as students refine their focus. For example, Multimedia Environmental Problems—Atmosphere, Soil & Water Science can be focused on hydrology, water pollution, or other water-related areas. Then, through course selection, this can be made more focused to a topic such as groundwater pollution or made more interdisciplinary by choosing a topic such as watershed planning policy.

At the graduate level, some areas of specialization may be contained within the mission of the program itself. Though the general mission statement presented below may still apply, many graduate programs choose to focus graduate work on a specific area of EVSC such as Environmental Management, Environmental policy, Environmental Biology, Environmental Chemistry, Environmental Agricultural Sciences or any other specialized field. Even so, these graduate level courses still have several things in common. All programs require certain core courses, and then allow students to choose other courses to supplement their learning. Often, these core courses draw on a varied set of disciplines. At least one class concentrates on basic sciences, such as Biology, Chemistry, or other physical sciences. Another course is focused on the social sciences
such as economics, law, management or policy. In many cases, graduate programs have laboratory and/or field work as part of the core courses as well. All of these core courses are intended to provide uniformity to the students.

In addition to course work, many programs allow a thesis or project to be completed as part of the requirements for the degree. Often, this type of project or thesis is required. Along these same lines, many programs allow credit for internships and encourage students to work with faculty on research projects to broaden and deepen their learning experience.

Though graduate students learn a higher level of material, the program construction is similar to that at the undergraduate level. Students learn the fundamentals first to set a common level for all students, and then each student customizes the learning process by taking specialized courses. Though the number of credits is less, the same division can be seen.

Though no one curriculum can be used at every institution for every situation, the sample curriculum listed below in Figure 8.2 has been created from the research in this work. Moreover, the model developed as part of this work supports the sample given. In addition, when the sample is used to examine existing curriculum, most of the EVSC course offerings can be seen to fall into the categories listed. Each program developer and administrator must decide for him/herself what to include based upon available resources, faculty interests and ability, and other factors unique to their situations. This blueprint is not meant as an unchangeable cast but rather as an adaptable and moldable launching point.
Generic Mission Statement

**Mission Statement:** Environmental Science (EVSC) is the study of human interaction with other humans and their surroundings. Particular interest is focused upon the influence of humans and their impact on the ecosystems in which they live. The goal of EVSC is to describe and understand existing and potential problems with the ecosystem as well as develop solutions to remediate and prevent these situations. In addition, EVSC is aimed at providing a better understanding of human interactions with one another and the world so the ecosystemic effects can be foreseen and lessened. To accomplish these goals, those studying EVSC must have a depth of disciplinary knowledge complemented by broad and interdisciplinary experiences so that they can utilize tools and processes from these many disciplines. Also, these scientists need to understand how to solve a variety of problems and communicate with experts and lay persons from a wide range of disciplines in order to gather research and disseminate findings. All Environmental Scientists should be interdisciplinary problem-solvers and decision-makers with the ability to clearly and effectively communicate.

**Undergraduate Curriculum (126-134 Credits)**

**Year 1**

<table>
<thead>
<tr>
<th>1st Semester</th>
<th>Description</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Introduction to Environmental Science</td>
<td>Overview of what is learned by Environmental Scientists.</td>
<td>3</td>
</tr>
<tr>
<td>Physics I</td>
<td>Basic mechanics and fundamentals of Physics.</td>
<td>3</td>
</tr>
<tr>
<td>English Composition</td>
<td>Basic writing, speaking and thinking skills.</td>
<td>3</td>
</tr>
<tr>
<td>Calculus and Analytical Geometry</td>
<td>Fundamentals of Mathematics.</td>
<td>4</td>
</tr>
<tr>
<td>Computer Science</td>
<td>Fundamentals of logic and programming.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Seminar</td>
<td>Faculty and external speakers discuss current issues.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>17</strong></td>
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<th>Description</th>
<th>Credits</th>
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<tbody>
<tr>
<td>Basic Chemistry I (Inorganic)</td>
<td>Fundamentals of Inorganic Chemistry.</td>
<td>3</td>
</tr>
<tr>
<td>Basic Chemistry Laboratory</td>
<td>Introduction to Chemistry Laboratory.</td>
<td>1</td>
</tr>
<tr>
<td>Environmental Issues &amp; Problem-solving</td>
<td>Use of a general problem-solving process to address environmental problems.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Presentations</td>
<td>Public Speaking and presentations.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Biology/Microbiology</td>
<td>Fundamentals of Environmental Biology.</td>
<td>3</td>
</tr>
<tr>
<td>Basic Economics</td>
<td>Fundamentals of Macro/Micro Economics.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Seminar</td>
<td>Speakers discuss current issues.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>
### Year 2

#### 1st Semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Science Research Methods</td>
<td>Designing methodologies for gathering and interpreting data related to environmental issues.</td>
<td>3</td>
</tr>
<tr>
<td>Geology/Earth Science</td>
<td>Understanding Earth systems.</td>
<td>3</td>
</tr>
<tr>
<td>Basic Chemistry II (Organic)</td>
<td>Fundamentals of Organic Chemistry.</td>
<td>3</td>
</tr>
<tr>
<td>Society, Technology, &amp; Environment</td>
<td>Overview of Humanities and Social science (STS).</td>
<td>3</td>
</tr>
<tr>
<td>Introduction to Management</td>
<td>Fundamentals of Management and group dynamics.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Seminar</td>
<td>Speakers discuss current issues.</td>
<td>1</td>
</tr>
<tr>
<td>Physical Education Requirement</td>
<td>University required course in Physical Education.</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total** 17

#### 2nd Semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Science Analysis Methods</td>
<td>Fundamental environmental analytical methods.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Science Laboratory</td>
<td>Environmental laboratory experience.</td>
<td>1</td>
</tr>
<tr>
<td>Statistics and Probability</td>
<td>Advanced Mathematics—probability and statistics.</td>
<td>3</td>
</tr>
<tr>
<td>Technical Writing</td>
<td>Advanced environmental writing and presentation.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Ethics and Decision-making</td>
<td>Explores environmental dilemmas and decisions.</td>
<td>3</td>
</tr>
<tr>
<td>General University Requirement(Core or Elective)</td>
<td>Any course that fulfills university requirements.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Field Activity</td>
<td>Environmentally related trips/community projects.</td>
<td>1</td>
</tr>
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</table>

**Total** 17

### Year 3

#### 1st Semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Systems/Ecology</td>
<td>Advanced study of ecosystem dynamics.</td>
<td>3</td>
</tr>
<tr>
<td>Advanced Technical Elective</td>
<td>Any upper division technical course.</td>
<td>3</td>
</tr>
<tr>
<td>Specialization Elective</td>
<td>Specialized track of study course.</td>
<td>3</td>
</tr>
<tr>
<td>Specialization Elective</td>
<td>Specialized track of study course.</td>
<td>3</td>
</tr>
<tr>
<td>General University Requirement(Core or Elective)</td>
<td>Any course that fulfills university requirements.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Field Work (Community Activity)</td>
<td>Environmental community service projects.</td>
<td>1</td>
</tr>
<tr>
<td>Physical Education Requirement</td>
<td>University required course in Physical Education.</td>
<td>1</td>
</tr>
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</table>

**Total** 17

#### 2nd Semester

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Case Analysis</td>
<td>Discussion and development of environmental case studies.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Research Field Experience</td>
<td>Faculty overseen field projects.</td>
<td>3</td>
</tr>
<tr>
<td>Specialization Elective</td>
<td>Specialized track of study course.</td>
<td>3</td>
</tr>
<tr>
<td>Specialization Elective</td>
<td>Specialized track of study course.</td>
<td>3</td>
</tr>
<tr>
<td>General University Requirement</td>
<td>Any course that fulfills university requirements.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Field Work</td>
<td>Environmental field projects.</td>
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**Total** 16
Year 4

<table>
<thead>
<tr>
<th>1st Semester</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Thesis Proposal</td>
<td>Proposal for synthesizing project in specialization.</td>
<td>3</td>
</tr>
<tr>
<td>Specialization Elective</td>
<td>Specialized track of study course.</td>
<td>3</td>
</tr>
<tr>
<td>Practical Problem-solving</td>
<td>Examines the application of Environmental Science lessons learned.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Field Work</td>
<td>Project outside of the university related to areas of specialization.</td>
<td>1-3</td>
</tr>
<tr>
<td>Free elective</td>
<td>Any course the student wishes to take.</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>13-15</strong></td>
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<table>
<thead>
<tr>
<th>2nd Semester</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Thesis</td>
<td>Completion and presentation of findings for specialized senior project.</td>
<td>3</td>
</tr>
<tr>
<td>Field Work/Internship</td>
<td>Cooperative project, internship, or other hands-on experience.</td>
<td>3-9</td>
</tr>
<tr>
<td>Free elective</td>
<td>Any course the student wishes to take.</td>
<td>3</td>
</tr>
<tr>
<td>Free elective</td>
<td>Any course the student wishes to take.</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
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<td><strong>12-18</strong></td>
</tr>
</tbody>
</table>

Sample Graduate Curriculum (36 Credits)

Year 1

<table>
<thead>
<tr>
<th>1st Semester</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Environmental Science</td>
<td>Overview of what is learned by Environmental Scientists in the program and skills needed.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Chemistry/Biology/Toxicology</td>
<td>Course in fundamental sciences used in the program. Some programs may wish to have more credits in these areas as deemed necessary.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Science Research Methods</td>
<td>Designing methodologies for gathering and interpreting data related to environmental issues.</td>
<td>3</td>
</tr>
<tr>
<td>Specialization Elective</td>
<td>Specialized track of study course.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Seminar</td>
<td>Faculty and external speakers discuss current issues.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>13</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2nd Semester</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Science Laboratory</td>
<td>Explains Environmental laboratory methods and procedures</td>
<td>3</td>
</tr>
<tr>
<td>Quantitative/Qualitative Analysis</td>
<td>Environmental analysis methods used by Social Sciences including Law, Management or Economics.</td>
<td>3</td>
</tr>
<tr>
<td>Specialization Elective</td>
<td>Specialized track of study course.</td>
<td>3</td>
</tr>
<tr>
<td>Specialization Elective</td>
<td>Specialized track of study course.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Seminar</td>
<td>Speakers discuss current issues.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>13</strong></td>
</tr>
</tbody>
</table>


### Year 2

<table>
<thead>
<tr>
<th>1st Semester</th>
<th>Description</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masters Thesis/Project</td>
<td>Synthesizing thesis/project in specialization. The project is usually only 3 credits while the thesis can be more.</td>
<td>3-6</td>
</tr>
<tr>
<td>Practical Problem-solving</td>
<td>Examines the application of Environmental Science lessons learned.</td>
<td>3</td>
</tr>
<tr>
<td>Specialization Elective</td>
<td>Specialized track of study course.</td>
<td>3</td>
</tr>
<tr>
<td>Environmental Field Work</td>
<td>Project related to areas of specialization. This can be research, community service, or an internship.</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>12-15</strong></td>
</tr>
</tbody>
</table>

Figure 8.2 is a sample curriculum for undergraduate and graduate EVSC programs.

### 8.4.4 Extracurricular Activities

Though the title may be misleading, it is meant to encompass all those things that are not awarded credit and registered for as part of the curriculum. The types and number of these activities is large and varied. Workshops, seminars, clubs, trips, competitions, newsletters, professional societies, internships, research projects, and community service may qualify as extracurricular activities along with many other things that can enrich the students' lives as well as deepen their understanding of EVSC. All of these things provide a valuable addition to the curriculum and allow students to discuss what they learn in the classroom as well as see how it can be practiced.

Both aware and involved students and faculty are needed for extracurricular activities to be more than just something to attend or a social outlet. Without student involvement, extracurricular events do not serve their purpose and, in many cases, reflect poorly on the program. At the same time, without faculty support and guidance, student efforts to hold these events may be difficult and may fail.

As a young field, EVSC needs extracurricular activities to assist students in many ways. First, these activities help the students form a community to examine and practice the various ideas comprising EVSC. Within an institution, workshops, seminars, and other such events allow for area-specific ideas to be brought to the students that might otherwise
be missed due to the time constraints on classroom learning. Also, these same events can bring EVSC professionals from outside the department or institution to the student so they can network and be given the opportunity to increase their interdisciplinarity. Professionals especially can bring cutting-edge material and problems to the students as well as give them a feel for how these issues are dealt with outside of the classroom.

Besides being able to experience different views of EVSC, these events also serve as a gateway for students to meet others with similar interests at other institutions and in the working world. These experiences cannot be underestimated as both valuable learning experiences and as motivation for students to become involved.

Internships and research projects sponsored by but not part of the curriculum serve many useful purposes. Of course, the experience itself can bring together all of the learning of the curriculum as well as assist students in determining the type of area within EVSC they might wish to delve deeper into as they work through the curriculum. Participation in internship programs and research projects can provide motivation for students as well. By working with professors on their projects, students can see how the classroom material and cases apply to and are derived from the class work. All the skills learned in class can be honed by close work with professors interested in sharing their expertise as the team moves towards finding new additions to the body of EVSC knowledge. In a similar way, working as an intern provides students with this same sense of how theories are applied. For those students not intending to move into a research oriented career, internships can be a place to network, refine skills, prove themselves, and become comfortable working with the everyday demands of EVSC. Both the interns and
research assistants can report back about their work enriching the classroom experience while improving presentation skills and making the entire class more interdisciplinary.

Another important aspect of extracurricular activities is community involvement. This helps to show the students the benefits of their work as well as fulfill one of the major roles of the university—investment back into the community to enrich it. Through clubs and outreach programs, students can tackle large issues that they might face once they graduate. Advocating for environmental issues, or working in the field to protect and revitalize a wilderness area, clean a river or local park or any of the myriad of other activities sponsored locally, nationally, or internationally can provide a sense of accomplishment and connection to the student. By doing rather than just learning to do, the students are able to better themselves as well as improve their skills.

All the extracurricular activities listed here are but a sample of what can be done to enrich the student experience. All of these things help students become better at EVSC by giving them practice with the four major objectives listed above. None of this is easy, but all is worthwhile and rewarding for the students and faculty involved as well as the program, the institution and the community as a whole. Many national clubs and preservation organizations provide free material for students interested in organizing a club related to the environment. Each program can decide for itself which, if any, of these is appropriate and accessible. In addition, national competitions, conferences and workshops are held that can be attended to gather more information.

**8.4.5 External Advisement**

Perhaps the least utilized but extremely effective methods of accomplishing the goals of the program is to ask for the input of professionals from outside the program itself working
in private industry, consulting companies, government agencies at all levels (local, state, federal, and international), non-governmental agencies, or as environmental activists. When the value of external input is seen, and it is realized that students look for the opportunity to have “real-world” experience to see what lies ahead for them, the external input can become a highly integrated part of a program and an accepted norm. Of course, as with all the other areas in this section, these things all tie together. Advisory boards, external panel reviews, mentoring programs, scholarships, fellowships, internships, contests, guest lecturers, real-world problem-solving, outside speakers, and other such external input helps the students and faculty stay current and in-touch with the market that will be accepting many of the graduates.

Then too, many of the ideas suggested earlier as improvements rely upon individuals from outside the program giving of their time to share knowledge and expertise. Without this participation, the task is daunting at the least and, perhaps, too great for any one program to tackle on its own. However, soliciting input and participation is not an easy task either but one that can be accomplished and show immediate dividends.

Advisory boards and external panel reviews are common means of bringing outside people into a program. In some cases, these reviewers are still from within the institution, but not the particular department or program. More often, industry professionals, government officials, or other outsiders are asked to come together once a year and give insight into how the program can be improved. Members of the advisory board can also serve as contacts for their organizations as the program and the students reach out to them.

Another way these types of boards or panels can assist the program is as an independent review committee for senior projects, or thesis and dissertation defenses.
Programs can have students present findings in front of a panel of persons with expertise in the area being discussed. Moreover, many doctoral candidates are required to have at least one person from outside their department on their committee. If there is a good working relationship with several persons outside the program, this will be a useful tool for the students as they work through and present their dissertation.

Along the same lines, many outside organizations sponsor scholarships, fellowships, and contests. Having sponsorship to enter these types of things or being recommended by an individual familiar with a candidate is extremely beneficial. Though not necessary, a good working relationship can assist a program to find and place students in internships, as well as garner scholarships and fellowships. In other cases, a particular company will provide funds and materials to assist a student with research or so that students can enter a competition. If not for this type of support, many research projects may never be worked on or completed.

One of the most useful ways outside input can be taken advantage of is through guest lecturing. Bringing an outside expert into the classroom ties all the aspects of learning together. Having god ties to persons willing to come speak at a school can inform and enrich the learning experience. Whether the expert is giving a short speech at a seminar or workshop, teaching a class for a day, or being used as an adjunct to address a highly specialized need in the program, having outside input allows the program to function more effectively.

Once in the classroom setting, whether for an hour or a semester, outside persons bring much with them. First, they can present the students with firsthand knowledge of real-world problem-solving methods as well as examples from their working lives. In
addition, these classes may be able to visit the professional or work through a problem being discussed currently by the speaker. In any case, having outside contact inside the classroom opens many avenues for the student and the program in general.

One of these avenues and something that can be very helpful to students in all programs, especially EVSC, is mentoring. Though some EVSC programs use faculty members to mentor students, often this is not possible or appropriate. By having a pool of professionals in various areas of EVSC, a mentoring program can team a student with a professional whose interests match closely. The professional can then assist the student in becoming aware of opportunities, improving skills, finding jobs, and, in general, becoming better at EVSC. The mentor can lend continuity to the learning experience as well as work with student advisors to ensure the student moves through the educational program. Good mentors like good faculty advisors provide the student with a resource from which they can draw years of expert knowledge as well as a place to ask questions and seek advice.
CHAPTER 9

TESTING THE MODEL

9.1 Introduction

Though many good ideas for improving programs have been identified, this is not enough. Just saying something should be done is not sufficient to accomplish the goal of improvement. Just by outlining the areas that need to be improved cannot ensure, that when put into practice, they will be successful. Since EVSC is so complex and each program is unique, it is important to include one other step in the process of defining good programs. Now that the specifics of an EVSC program have been described, it is necessary to comment on how some of the aforementioned items can be integrated into a program and assessed.

Evaluation is necessary to determine if a program is successful as well as find ways to improve upon existing practices. As long as a goal has been specified, mechanisms can be put into effect to assess the attainment of these goals. If each class in a program is able to define its goals, and if the overall program has a goal, the methodology listed in this chapter can be used to assist program administrators in tracking progress and identifying areas of need so that the program can continue to grow, improve, and become more effective.

9.2 Curriculum Assessment and Refinement

In order to assess a curriculum, it is vital to gather information about its effectiveness with the intention of improving the program by making changes resulting from the information gathered during the assessment process. Any examination must come full-circle and not simply gather information about goal attainment. Assessments must provide a means for
utilizing the data to improve the program being assessed or they serve little purpose beyond self-affirmation.

The other areas of the program can also be assessed. Unfortunately, assessing faculty is difficult without knowing specifics of institutions. In a similar way, assessment of extracurricular activities and external advisement must be done on a case-by-case basis. Each of these is important but beyond the scope and expertise of the researcher at this point in time. Nonetheless, similar mechanisms for assessing these other areas can be implemented once the curriculum assessment has been instituted. Some of the same types of evaluation methods listed below can be employed in part when looking at the other aspects of a program.

9.3 Accomplishing Goals and Objectives

Every program must have an overall goal or set of goals to be clear about what it intends to accomplish. In order to attain those goals, objectives are set as milestones along a road toward the ultimate end. In turn, each of these objectives becomes a goal for a smaller set of objectives. Their process of goals and objectives is iterated so that a set of circles within circles is replicated until small easily attainable objectives are left and the larger goal is on a higher more global level. At the minimum, assessment of a program must look at the ultimate intention or goal of the program. If this is not seen as appropriate and if it is not attained, any other accomplishments are all but inconsequential. Once these overarching goals are assessed, a more in-depth review can be undertaken to understand if the program is successful. Also, assessment tools can be put in place to see how to improve and refine the objectives, tools, and processes used to attain a larger goal.
Having said all this, assessment is not a simple task. Each process presents a unique challenge for assessment. Then too, the specific goals prescribed for the process demand a set of appropriate assessment tools. The methods for assessing the quality of a manufactured item will be different from those used to test the purity of chemicals or the knowledge of workers after a training program. Nonetheless, all of these different processes share many common traits and have similar methods for assessment available to them. All assessment of processes can look at the end results to determine if the product specifications have been met. In the same way, an educational process can be assessed to determine if it has accomplished its goals.

If the processes were manufacturing computers, the end product would be expected to function properly and would be dependent on the intended applications. The tests would look to determine the ability to gather and process data and follow a specified program or algorithm. Once an answer to the given problem has been found, the computer would be expected to report it in some way such as a written or spoken response. Extending the analogy to a school curriculum, the students are like the computer and the systematic course work set forth in the curriculum is the manufacturing processes. Just as the computer is given programs and algorithms to gather and process, students are taught tools and methods they are to use once they graduate. Whatever the raw material of students might be, the educational process, as specified in the curriculum, has a desired outcome. The process transforms the raw material through a series of unit operations—courses—until each has become a finished product. In this particular case, the curriculum seeks to create environmental scientists who understand, communicate with and utilize the tools of the professionals in that field. Broader goals of the total educational process, from the
institution, are also present. Each student is given knowledge outside the discipline and expected to be able to understand and communicate with the various disciplines they will encounter in life. In the end, every school experience has an overarching goal of preparing students for a life of critical-thinking, decision-making and problem-solving as they live as productive citizens.

9.4 Assessing a Specific Program

Looking at all educational processes, and EVSC in particular, in this way allows for a clear assessment of goal attainment and thus the program. Each student, upon graduation, should understand and be able to utilize the processes, tools, and methods of the major. In addition, these students should be able to solve the problems typically faced by the discipline as well as communicate their solutions to others.

Though there are many ways of testing student knowledge and accomplishment within a class, not all of these work as well to help with assessment of goal attainment and effectiveness of curriculum. Quizzes, midterms, papers and oral exams can show us about a particular student but may not reveal the effectiveness of groups of classes or an entire curriculum. Trends throughout, patterns within, and a more global perspective of the entire educational system is needed to truly assess and improve a curriculum.

One of the easiest way to assess the attainment of goals such as these is through a capstone or thesis course completed at the end of a course of study within a specific curriculum that is intended to expose students to complex real-world problems. By reviewing the solutions students produce and having it reviewed by a panel of experts, the ability of the program to produce effective environmental scientist can be determined. A list of specified goals and objectives can be given to the panel along with some sample
answers produced by faculty or other experts. If the goals of the program have been met, experts from industry, academia, and government should be able to see the clear demonstration of the specified skills knowledge and expertise in the work that is produced. The quality and refinement of the work along with the completeness of the examination can be seen to represent the successful completion of the project. Also a ranked comparison can be made between the benchmark solutions and the students’ solutions. A discrepancy between expected and actual outcomes can be addressed with alteration of objectives or corrections within curriculum. In this way, the assessment is not just a tool for grading but a way of improving the curriculum and so the students as well.

Though this method of assessment is highly effective, it is also time consuming and requires time to be implemented and executed properly. As a result, some type of simple objective exam that has questions highlighting the specific objectives and overall goals of the program can be developed. This test can be given at various points in the curriculum to determine milestones that students have reached. In an introductory course, the test can be administered to determine a baseline for all students interested in a program or for all students at a particular institution. The same test can be administered at the beginning of the capstone or thesis class to assess the value added by the curriculum to that point as well as any points particular students may not have grasped to assist them with their weak areas. Though not intended to be an entrance or exit exam, this comparison between the baseline and endpoint can provide valuable feedback on what areas of the curriculum are being understood and retained. The test can also be given at the beginning of a junior level class that is required for all majors. In this way, those who are moving towards a degree can be reassessed as a more representative baseline sample. These skill-tests are intended to be
general and easy to complete. The questions are meant to determine whether the student is aware and conversant with the terminology, concepts, and general content of the major as opposed to specific content information from any one class. In addition, in every version the test must be tied to the goals and objectives of the overall program.

In the same ways that an entire program can be assessed, smaller divisions can be made within a program. Upper and lower division is a typical distinction that is often made. Taken a step further, this type of testing can be extended down to the course level to give a better understanding of what is understood in each class. Encapsulating exams, end-product tests, and other reviews of work to test goal and objective attainment can be conducted at the course level. The iterative nature of these types of exams build on and link together with the tests and other evaluations at other points along the way in the curriculum. Though time consuming these types of assessment can provide the most detailed and useful feedback that is also the most objective.

Besides those methods listed above, others do exist. Surveying students, alumni, and faculty during and after class can be useful to determine goal attainment. In class evaluation by internal or external reviewers can also provide a means of assessment. However, these tools are not effective at giving more than a general view of successes and problems within classes and produce a voluminous amount of data without a large quantity of useful outcomes. When used in conjunction with other methods or in certain special cases they can provide in-depth information about a particular goal. As a rule, however, as the larger sample answers a more standardized set of questions the program can obtain better and more applicable feedback.
9.5 Implementation

No matter what the intent of the assessment, it is necessary to have the various aspects of the program in place first. It is impossible to use a capstone class if one does not exist. If faculty do not participate in surveying and testing, no test results can be generated. Accreditation boards are moving to this new outcomes-based way of assessing and accrediting programs. Rather than just list credit hours, it is now required that programs determine if students are learning concepts. By integrating tests such as these into a program, the program not only can assess itself while satisfying the boards, but also find problem areas that can be improved and determine how to better educate the students.

Beyond knowing how to evaluate a program and what tools should be used, these tools must be created, tested, and put into effect within the program. As a result, a methodology and implementation plan must be devised for the assessment of the programs. Most likely, the easier to develop will be put into effect first and the other more difficult tools can be brought on-line later. Toward that end, the senior project evaluation would be the most likely to be implemented first. A small panel could be chosen from professors, alumni, and working professionals in the field from private and public organizations. The set of criteria will reflect the existing program goals and objectives. The samples can be written or taken from previously written projects.

The baseline tests might be next to be implemented. The questions would need to be developed and tested to determine if they truly determine knowledge and effective learning by students as well as reflect the other goals of the program. A good test of this might be to have the program administrator develop the test in conjunction with outside experts. Then the test could be administered to faculty as a way of evaluating its fairness,
completeness, and effectiveness. Once the test is deemed acceptable, a group of upper division students could be given the test along with a follow-up questionnaire as a field test. The results could then be used to refine the instrument to ensure the information gathered reflects the intent of the test.

Finally, the particular single-class tests could be created from existing exam sets in conjunction with in-class reviews. Demonstrated student weaknesses from the earlier tests could be highlighted in particular test questions.

In the end, any assessment tool is only as good as the group creating it and the use it is intended to serve. Each tool must be chosen for the task and used properly. If this is done, a clear direction for improvement can be drawn from the results of the many-tiered system of checks so that the program most effectively educates students. Assessment and implementation of tools, like the setting of goals and objectives, is an iterative process that forms closed loops of circles within circles that reinforce one another. It is this iteration and reinforcement that ensures the highest quality results and, thus, the highest quality education for the students.
CHAPTER 10
WHAT'S NEXT

10.1 Introduction

Though this dissertation covers a large amount of material, there are some areas that it does not. In other cases, because a particular vantage point had to be chosen, the examination may not be as complete as might be wished. This chapter will examine the limitations of this dissertation.

Furthermore, much more research on this topic still remains to be done. Some of these topics will be identified and discussed briefly.

10.2 Limitations

Though not always easily identifiable, most works have limitations. This dissertation is no exception. Many of the limitations relate to the assumptions made and the constraints on time and resources. Perhaps the greatest limitation of the work was the number of EVSC programs examined and the actual responses received. Unfortunately, there is no way to avoid the practical problem of sample size, program complexity and cost in both effort and money. All of these factors had to be overcome by limiting the scope of the research.

Another major limitation of the work relates to the diversity of the sample that was taken. No one model can be all-inclusive. Nonetheless, trying to define EVSC for both undergraduate and graduate level programs may have been too large a task yielding too great a diversity of sample. Though the findings are valid for EVSC, the sheer variety and uniqueness of programs makes some of the generalizations necessary and less useful in certain specific cases. There is no universal ‘right’ or ‘best’ that can be found. Each
The program must look to itself and see how the recommendations put forth here can be best applied to produce improvements within the program.

Another limitation of the work is its exclusive reliance on programmatic information. In the same way that the program administrator and faculty were surveyed, students and those employing the students or accepting them into other educational programs could have also been surveyed. The complexity and sheer size of a project attempting to do all that is far too great for this dissertation. The limiting of the work to just program surveys was necessary to allow its completion in a reasonable amount of time. In addition, correlating these types of surveys and having them provide useful results would be far more difficult.

Finally, the last limit is related to the balancing of the many different disciplines and desires involved in EVSC. Though the author has tried to be as fair as possible, the interest of the student was often put first. In addition, when a choice between breadth and depth had to be made, the author focused more upon balance and breadth than depth of knowledge. As a result, certain aspects of programs may not have been as well defined as might otherwise have been possible. Rather than determine what class is offered by every program, it was thought more important to determine what innovative ideas and practices were being used at the schools ranking highest in terms of the identified areas of excellence. More general skills were assessed and overall attitudes determined rather than specific instances of recurring characteristics. Each program was seen as having particular needs that are fulfilled by programmatic course offerings. It was the other aspects of the program that had to be identified and shared with the readers of the work. This, of course,
is a choice that had to be made, but one that limits the results in some ways by not fully describing all programs.

In the end, these limitations are all taken into consideration by the stated parameters and assumptions of the original premise of the dissertation. Highlighting them here is important so that these ideas are not lost when the results are examined and evaluated. Moreover, if the results of the work are put into practice to improve a program, the limitations must be kept in mind. Then too, each limitation of this research project can then become a topic for further research. There is always room for improvement and self-awareness and self-examination is a necessary part of the improvement process.

10.3 Future Research

The most obvious place to start with topics for further research is the limitations listed above. Each can be a new topic. Some of the general concepts presented can be combined to provide a new way of looking at the topic of this dissertation.

One of the easiest areas to expand the research project is by altering the number of programs examined and the actual responses received. By limiting the research to only undergraduate, graduate, or combined programs, the number of any one type surveyed may be increased. Similarly, if the type of program surveyed is expanded from strictly EVSC to other larger classifications such as Environmental Studies or Environmental Engineering, the sample will be changed and so might the results. Taken to the logical end, the general model for education can be used to examine any type of educational program. Though the dissertation was intended to examine EVSC programs, any educational program could be examined in a similar way. The end result of the analysis would be a description of what
exists and how existing programs can improve by self-analysis and new programs can learn from what is generated from the analysis.

The second area for further research concerns those people interested in the outcome of the educational process. The students and the employers both have vested interest in how EVSC programs prepare students. The students are pursuing their own ends—employment, knowledge, preparation for further education, or something else. Employers are looking for well-trained competent workers with useful skill sets. In either case, these two sets of respondents were not sampled in the dissertation. Both can provide valuable information about what should be in a program. Students from various levels of the program can be surveyed as well as before entering the institution and after graduation. Though not a simple task, the responses could be highly enlightening and provide a great deal of insight. Similarly, by surveying those organizations that hire or accept students after graduation from an EVSC program, the types of skills and expertise these groups seek could be determined. Both employers and admission officers from programs of higher education, could be surveyed to determine what aspects are highly sought by these professionals. Incorporating these desired skills could also improve an EVSC program by tying it more closely to the areas that students perceive as important.

Another data analysis step that could have been done would have been to correlate the types of classes offered by each program. By examining curriculum, trends could be found and a sample curriculum based upon percentages could be developed. This is not necessarily the best way to develop a curriculum or even possible considering the demands of faculty and program continuity. However, having the knowledge of what are the most common courses taught and the level that each of these courses is taught at would prove
useful for curriculum revision committees and those interested in creating or revising a program in EVSC.

Finally, the last area for future research directly related to EVSC education at four year institutions is the testing of the outcomes listed in Chapter Eight. By taking the results and turning them into a survey for program faculty and administrators, the results can be assessed for various levels of acceptance and willingness to be implemented. Similarly, if the various aspects are implemented in a program, the program can be examined to see how the implementation regimen works and how the improvements are perceived to be working. In either case, the suggested improvements can be seen as goals that need to be evaluated by a researcher as worthwhile and effective.

Beyond EVSC educational program evaluation, other research projects may also be pursued in relation to the work. First, the ideas listed herein can be used to develop high school environmental curricula so that the continuity suggested in Chapter Eight can be expanded beyond an individual school. In addition, the community outreach aspects of EVSC programs at the university level can be facilitated by working with high school students beginning the learning process.

Another area of research relates to the general evaluation methodology developed for this dissertation. Other non-educational environmental programs can be evaluated for effectiveness. By clearly defining goals and objectives, identifying involved parties, conducting survey research and evaluating responses, the effectiveness of many types of programs can be determined. For example, the effectiveness of pollution prevention initiatives, community recycling programs, and other such programs could be examined.
In the end, the work has provided a series of guidelines and methods for understanding, evaluating, and ultimately improving EVSC programs. At the least, the material presented can be seen as another means of ranking educational programs by their ability to effectively educate and improve students' knowledge and expertise in EVSC. However, it can be used for much more than that. The sample programs, evaluation methodologies, as well as tools and examples presented in this work are intended to provide a blueprint for EVSC administrators, curriculum developers, and others. It is the author's hope that individuals will use these materials to research how their programs can be improved and how their students can benefit from what has been researched and presented in this dissertation.
Appendix 1 contains sample survey responses from the two rounds of surveys. Three survey responses are presented for Environmental Program Survey 1. Two survey responses are presented Environmental Program Survey 2.
Figure A1.1
Sample Results for Survey 1 of University of Scranton

Name: Michael C. Cann
Title: Professor of Chemistry, Co-Director of Environmental Science
Institution: University of Scranton

Environmental Science Program Survey 1 (Undergraduate)

1) What degrees does your program offer? (BA, BS, and/or Others) BS

2) Does your program have a mission statement outlining the goals and objectives of the program in Environmental Science?
   ___X___YES     ______NO

3) Does your program curriculum contain a course in which the students demonstrate mastery of the skills, knowledge, and expertise outlined in the mission statement such as a capstone, senior project, or senior thesis?
   ______YES     ___X___NO

4) Does your program contain a course which teaches a systematic problem-solving methodology for real-world problems and their solutions?
   ______YES     ___X___NO

5) Do courses in your program utilize real-world case studies to assist in the teaching process?
   ___X___YES     ______NO

6) Does your program encourage students to participate in extracurricular activities related to the field of Environmental Science? Do these activities encourage students to discuss current problems and solutions in the field? Do these activities include seminars, workshops, academic societies, and field trips?
   ___X___YES     ______NO

7) Does your program or department offer internships or other workplace experiences to students?
   ___X___YES     ______NO

8) Does your program or department have an external advisory board? (i.e. individuals from industry or government to give direction and aid to the program)

Program:     ___X___YES
             ___X___NO

Department:     ___X___YES
                ___X___NO
9) Do the faculty in the program publish articles each year?

_ X__YES   _____NO

10) Upon graduation, what types of companies or educational programs do your graduates enter? Industrial (many in chemistry related areas), National Park Service, private consulting companies, Americorp, MS and Ph.D. programs in environmental science and studies

11) Is there a unique or innovative part of your program you wish to explain or discuss? Program emphasizes the biological and chemical aspects of the environmental. The strong emphasis in chemistry we believe is unusual.

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Figure A1.1 is the completed survey response from the University of Scranton for Environmental Science Program Survey 1

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**Figure A1.2**

Sample Results for Survey 1 of University of Colorado at Denver

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Name: Rosemary Wormington
Title: Coordinator
Institution: University of Colorado at Denver

Environmental Science Program Survey 1 (Graduate)

1) What degrees does your program offer? (please list all including MA, MS, Ph.D., and/or others)  MS

2) Does your program have a mission statement outlining the goals and objectives of the program in Environmental Science?

_ X__YES   _____NO

3) Does your program curriculum contain a course in which the students demonstrate mastery of the skills, knowledge, and expertise outlined in the mission statement such as a Master's project or thesis?

_ X__YES   _____NO

4) Does your program contain a course which teaches a systematic problem-solving methodology for real-world problems and their solutions?

_ X__YES   _____NO

5) Do courses in your program utilize real-world case studies to assist in the teaching process?

_ X__YES   _____NO
6) Does your program encourage students to participate in extracurricular activities related to the field of Environmental Science? Do these activities encourage students to discuss current problems and solutions in the field? Do these activities include seminars, workshops, academic societies, and filed trips?

____X____YES ______NO

7) Does your program or department offer internships or other workplace experiences to students?

____X____YES ______NO

8) Does your program or department have an external advisory board? (i.e. individuals from industry or government to give direction and aid to the program)

Program: ______X____YES ______NO
Department: NA ______X____YES ______NO

9) Do the faculty in the program publish articles each year?

____X____YES ______NO

10) Upon graduation, what types of companies or educational programs do your graduates enter?

Government agencies (U.S. EPA, USGS, NOAA, State Dept. of Public Health and Environment, etc.), Consulting firms (Foster Wheeler, Parsons Brinkerhoff, Dames & Moore, Jacobs Engr., etc.)

11) Is there a unique or innovative part of your program you wish to explain or discuss?

The M.S. in Environmental Sciences program at the University of Colorado at Denver (CU-Denver) is designed for the student with a science or engineering background. CU-Denver is a commuter campus and many of the students are working professionals, so courses are offered in the late afternoon and early evening. Having students who are already working in the environmental field are an added benefit for the younger graduate students. The 'older' students bring real world knowledge to the classroom as well as information on possible internships or jobs. The masters program and the Office of Internships and Cooperative Education are also available to help students find internships.

Figure A1.2 is the completed survey response from the University of Colorado at Denver for Environmental Science Program Survey 1

Figure A1.3
Sample Results for Survey 1 of Florida International University

Dear Mr. Lipuma,

On behalf of the Environmental Studies Department at Florida International University, I would like to submit to you the survey responses for your dissertation research. The
surveys were completed by our Department Chair, David Bray, and I am relaying the responses to you. We have both an undergraduate and graduate program so I will be sending both survey responses in this email. Also, please note that we are an Environmental Studies Dept, not an Environmental Science Dept.

Good Luck,

Ingrid Sotelo
Internship Coordinator, Environmental Studies

Name: David Bray
Title: Chair
Institution: Florida International University

Environmental Science Program Survey 1 (Undergraduate)

1) What degrees does your program offer? BA & BS

2) Does your program have a mission statement outlining the goals and objectives of the program in Environmental Science? Yes

3) Does your program curriculum contain a course in which the students demonstrate mastery of the skills, knowledge, and expertise outlined in the mission statement such as a capstone, senior project, or senior thesis? No

4) Does your program contain a course which teaches a systematic problem-solving methodology for real-world problems and their solutions? Yes

5) Do courses in your program utilize real-world case studies to assist in the teaching process? Yes

6) Does your program encourage students to participate in extracurricular activities related to the field of Environmental Science? Do these activities encourage students to discuss current problems and solutions in the field? Do these activities include seminars, workshops, academic societies, and field trips? Yes

7) Does your program or department offer internships or other workplace experiences to students? Yes

8) Does your program or department have an external advisory board? (i.e. individuals from industry or government to give direction and aid to the program) Department: No

9) Do the faculty in the program publish articles each year? Yes

10) Upon graduation, what types of companies or educational programs do your graduates enter? County government, Federal government, Non-government organizations
Name: David Bray
Title: Chair
Institution: Florida International University

Environmental Science Program Survey 1 (Graduate)

1) What degrees does your program offer? MS

2) Does your program have a mission statement outlining the goals and objectives of the program in Environmental Science? Yes

3) Does your program curriculum contain a course in which the students demonstrate mastery of the skills, knowledge, and expertise outlined in the mission statement such as a Master’s project or thesis? Yes

4) Does your program contain a course which teaches a systematic problem-solving methodology for real-world problems and their solutions? Yes

5) Do courses in your program utilize real-world case studies to assist in the teaching process? Yes

6) Does your program encourage students to participate in extracurricular activities related to the field of Environmental Science? Do these activities encourage students to discuss current problems and solutions in the field? Do these activities include seminars, workshops, academic societies, and field trips? Yes

7) Does your program or department offer internships or other workplace experiences to students? Yes

8) Does your program or department have an external advisory board? (i.e. individuals from industry or government to give direction and aid to the program) Department: No

9) Do the faculty in the program publish articles each year? Yes

10) Upon graduation, what types of companies or educational programs do your graduates enter? Non-government organizations, Federal government

Figure A1.3 is the completed survey response from Florida International University Environmental Science Program Survey 1
ENVIRONMENTAL SCIENCE PROGRAM SURVEY 2

Section 1. Background Information

The first section of this survey asks you to describe your program in Environmental Science to give us a sense of the program. If you find the questions too narrow, please annotate any of your answers.

1. What degrees do you offer in Environmental Science?

<table>
<thead>
<tr>
<th>Degree Type</th>
<th>Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor of Arts</td>
<td>☐</td>
</tr>
<tr>
<td>Bachelor of Science</td>
<td>☒</td>
</tr>
<tr>
<td>Master of Arts</td>
<td>☐</td>
</tr>
<tr>
<td>Master of Science</td>
<td>☐</td>
</tr>
<tr>
<td>Doctor of Philosophy</td>
<td>☐</td>
</tr>
</tbody>
</table>

If you offer another degree not included in this list, please provide the degree awarded.

2. Which of the following statements best describes the administrative location of your Program?

<table>
<thead>
<tr>
<th>Location Description</th>
<th>Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Environmental Science program is located within a specific academic department.</td>
<td>☒</td>
</tr>
<tr>
<td>The Environmental Science program is located within a specific campus research center.</td>
<td>☐</td>
</tr>
<tr>
<td>The Environmental Science program is interdepartmental.</td>
<td>☐</td>
</tr>
</tbody>
</table>

If the administrative location of your Program is not included in the list above, please provide the location.

Administered by the Department of Oceanography but interdepartmental within the School of Ocean and Earth Science and Technology

3. Please tell us about your Program’s history and admissions criteria.

A. For Undergraduate Degrees

   a. When was your Program begun (i.e., approved to be offered by the institution)?
a. before 1950
b. 1951-1961
c. 1962-1972
d. 1973-1993
☑ e. 1994-present

b. Are standardized scores (i.e. SAT or ACT) required for acceptance to the Program?

YES ☑ NO ☐

If so, what is the minimum standardized score? ___ on the ____ (name examination)

c. Is a minimum high school grade point average(GPA) required?

YES ☑ NO ☐

If so, what is the minimum grade point average? ____ out of ____ (total GPA)

d. Are letters of recommendation required?

YES ☑ NO ☐

e. How many students enter the Program in one calendar year (fall through summer semesters)?

☑ a. fewer than 10 students
☐ b. 11-21 students
☐ c. 22-32 students
☐ d. 33-43 students
☐ e. more than 44 students

B. For Graduate Degrees

a. When was your Program begun (i.e., approved to be offered by the institution)?

☐ a. before 1950
☐ b. 1951-1961
☐ c. 1962-1972
☐ d. 1973-1993
☐ e. 1994-present

b. Is a minimum grade point average required for admission into the graduate program?

YES ☑ NO ☐
If yes, what is the minimum grade point average? ____ out of ____ (total grade point average)

c. What type of bachelor’s degree does a student need to gain admission to the graduate Environmental Science program?

☐ a. A degree in Environmental Science is required.
☐ b. A degree in a field related to Environmental Science is required.
☐ c. A degree in a field unrelated to Environmental Science is acceptable.

d. Are standardized scores (i.e. GRE) required for admission to the graduate program?

[ ] YES [ ] NO

If yes, what is the minimum standardized score? ____ on the ____ (name examination)

e. Are letters of recommendation required?

[ ] YES [ ] NO

f. How many students enter the Program in one calendar year (fall through summer semesters)?

☐ a. fewer than 10 students
☐ b. 11-21 students
☐ c. 22-32 students
☐ d. 33-43 students
☐ e. more than 44 students

4a. How many full-time faculty (i.e. tenured, full-time non-tenured, and tenure-track) teach in the Program?

☐ a. 5 or fewer faculty
☐ b. 6 to 11 faculty
☐ c. 12 to 17 faculty
☐ d. 18 to 22 faculty
☒ e. more than 22 faculty

4b. How many part-time faculty (i.e., adjuncts, special lecturers, and visiting lectures) teach in the Program?

☒ a. fewer than 5 faculty
☐ b. 6 to 11 faculty
☐ c. 12 to 17 faculty
☐ d. 17 to 21 faculty
5. Of those faculty who teach in the Program, what percent of their time is committed to working with the Environmental Science Programs?

- a. less than one-quarter time
- b. one-quarter time
- c. half time
- d. three quarters time
- e. full time

6. Which of the following statements applies best to the use of part-time faculty in your Program?

- a. Part-time faculty are rarely used to teach courses in the Environmental Science.
- b. Part-time faculty are occasionally used to teach courses in Environmental Science.
- c. Part-time faculty are frequently used to teach courses in Environmental Science.

7. Which of the following statements best describes the fields of your faculty?

- a. The majority of the faculty hold degrees in Environmental Science.
- b. The majority of the faculty hold degrees in areas related to Environmental Science (i.e. Environmental Studies, Environmental Biology, or Environmental Management).
- c. The majority of the faculty hold degrees in fields unrelated to areas of the environment.

8. What is the mission statement for your Program. If you wish, you may simply include the URL for the program web page that contains the statement or send a copy of it via fax or US mail.

   See website for the GES program

Section II. Student Abilities

With this background information, we would like you to consider the outcomes of the Program. That is, what abilities do you believe students should master by graduation? Please mark the answer that best describes your assessment of that skill and explain how the program teaches the students these skills.

9a. Students should have strong quantitative skills.

<table>
<thead>
<tr>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
</table>
9b. How do you teach students to have strong quantitative skills.
   e.g. basic courses in math and science; emphasis on problem solving in the
   GES curriculum; application of computer modeling to large-scale environmental
   databases; hands-on field or laboratory research for senior thesis

10a. Students should be able to convey ideas and communicate effectively with the written
   word.

<table>
<thead>
<tr>
<th></th>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10b. How do you teach students to convey ideas and communicate effectively with the
   written word?
   Most courses in the GES curriculum require oral and written communication
   skills; the senior thesis obviously is important in terms of writing skills and also oral
   presentation

11a. The students should be able to convey ideas and communicate effectively by means of
   oral presentations.

<table>
<thead>
<tr>
<th></th>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11b. How do you teach students to convey ideas and communicate effectively by means of
   oral presentations?
   Lots of oral presentations, including that of the senior thesis

12a. Students should be able to evaluate literature in the field critically.

<table>
<thead>
<tr>
<th></th>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12b. How do you teach students in your program to evaluate literature in the field
   critically.
   Through the senior thesis and literature research assignments in classes and
   presentation of findings

13a. Students should be able to utilize a process to approach, research, analyze, and solve
   problems.

<table>
<thead>
<tr>
<th></th>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>☑</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13b. What process for approaching, researching, analyzing, and solving problem does your program
   teach to its students?
   See above
Section III. Subject Areas
The next series of questions asks you to evaluate content areas of Environmental Science programs. Please rank the importance of each of the selected disciplines listed below to an effective Environmental Science program according to the following scale:

6=very important 3=somewhat unimportant
5=moderately important 2=moderately unimportant
4=somewhat important 1=very unimportant

14a. Here are the selected disciplines of study:

<table>
<thead>
<tr>
<th>Discipline</th>
<th>RANK (6-1)</th>
<th>RANK (6-1)</th>
<th>RANK (6-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>6</td>
<td>Ecology</td>
<td>6</td>
</tr>
<tr>
<td>Chemistry-analytical</td>
<td>4</td>
<td>Economics</td>
<td>4</td>
</tr>
<tr>
<td>Chemistry-basic</td>
<td>6</td>
<td>English</td>
<td>6</td>
</tr>
<tr>
<td>Chemistry-physical</td>
<td>4</td>
<td>Geography</td>
<td>5</td>
</tr>
<tr>
<td>Communications</td>
<td>6</td>
<td>Geology</td>
<td>6</td>
</tr>
<tr>
<td>Computer Science</td>
<td>5</td>
<td>History</td>
<td>4</td>
</tr>
<tr>
<td>Earth Science</td>
<td>6</td>
<td>Management</td>
<td>3</td>
</tr>
</tbody>
</table>

14b. Are there subject areas that are not listed above which you think should be included? Are there any comments that you would like to make about these subject areas or your ratings?

Oceanography and Atmospheric Sciences rate 6 in our curriculum, along with the other Earth Sciences.

Section IV. Laboratory and Field Experiences
Beyond the didactic world of the classroom, many programs offer opportunities for laboratory experiences and fieldwork. Please evaluate each of these opportunities for applied experiences in Environmental Science according to the following scale:

6=very important 3=somewhat unimportant
5=moderately important 2=moderately unimportant
4=somewhat important 1=very unimportant

15a. Here are the areas for laboratory and field work experiences:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Score (6-1)</th>
<th>Offered in the EVSC Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Science (biology/chemistry/physics) laboratory experience.</td>
<td>6</td>
<td>YES ☑ NO ☐</td>
</tr>
<tr>
<td>Basic Science (biology/chemistry/physics) field experience.</td>
<td>6</td>
<td>YES ☑ NO ☐</td>
</tr>
<tr>
<td>Environmental laboratory experience.</td>
<td>6</td>
<td>YES ☑ NO ☐</td>
</tr>
<tr>
<td>Environmental field experience.</td>
<td>6</td>
<td>YES ☑ NO ☐</td>
</tr>
<tr>
<td>Social science laboratory experience.</td>
<td>4</td>
<td>YES ☑ NO ☐</td>
</tr>
<tr>
<td>Social science field experience.</td>
<td>4</td>
<td>YES ☑ NO ☐</td>
</tr>
<tr>
<td>Independent research projects with faculty members.</td>
<td>6</td>
<td>YES ☑ NO ☐</td>
</tr>
<tr>
<td>Internships or other off-campus work experience.</td>
<td>5</td>
<td>YES ☑ NO ☐</td>
</tr>
</tbody>
</table>
15b. Are there any subjects that are not listed above which you think should be included? Are there any comments that you would like to make about these subjects or your ratings?

Section V. Capstone and Thesis Requirements

In addition to field experiences, graduate programs may require capstone courses and submission of a formal thesis. Please answer each of the following questions regarding these program requirements.

16. The graduate Program requires a capstone or other synthesizing experience in which the student brings together aspects of his/her work in the program culminating in the investigation of a single topic.

YES ☐ NO ☐ Not Applicable ☐

17. The Program requires a formal thesis that is reviewed, approved, and retained by the department or institution.

YES ☒ NO ☐ Not Applicable ☐

Section VI. Distance Learning

The next set of questions deal with any learning handled in a format that does not require face-to-face contact between students and teachers.

18. How many courses in the Environmental Science program are offered in a distance learning format?

☐ a. No courses are offered in this format
☐ b. 1-3 courses
☐ c. 4-6 courses
☐ d. 7-9
☐ e. more than 10 courses are offered in this format

19. May a student take all the course work required for the degree in a distance learning format?

YES ☐ NO ☒

Section VII. External Advisement

20a. How often does your program receive external advisement and input concerning your Environmental Science Program? In this case, the input can be meeting with an advisory
board, external reviewers, outside consultants or others who are intending to improve the program through oversight and guidance.

☐ a. Fewer than once a year
☐ b. Yearly
☐ c. Semiannually
☐ d. Quarterly
☐ e. Monthly

20b. What groups or individuals provide the external advisement guidance for your program?

Only internal evaluation of the program so far

21. Are there any areas of Environmental Science that you feel the survey did not cover or any other information about your program that you would like to include to help understand what you feel would make a good Environmental Science program?

As mentioned above, I and my faculty feel that environmental science must include a healthy dose of mathematics, cognate basic science, and interdisciplinary science, including earth science, oceanography, and atmospheric science. Environmental science of the future must not only be interdisciplinary but the individual must be able to work at the interfaces of the derivative sciences and to understand and appreciate the human dimensions problems of the environment, i.e. economics, politics, etc.

Figure A1.4 is the completed survey response from the University of Hawaii Environmental Science Program Survey 2

Figure A1.5
Sample Results for Survey 2 of University of Virginia

Your Name: James N. Galloway
Your Title: Professor and Chair
Institution Name: Environmental Sciences Department, University of Virginia

If you would be willing to discuss your answers during a phone interview, please list a telephone number where you can be reached as well as a convenient time to call.

Phone #: 804-924-1303
Convenient time to call: 

ENVIRONMENTAL SCIENCE PROGRAM SURVEY 2

Section 1. Background Information

The first section of this survey asks you to describe your program in Environmental Science to give us a sense of the program. If you find the questions too narrow, please annotate any of your answers.

1. What degrees do you offer in Environmental Science?
2. Which of the following statements best describes the administrative location of your Program?

- ☑ The Environmental Science program is located within a specific academic department.
- ☐ The Environmental Science program is located within a specific campus research center.
- ☐ The Environmental Science program is interdepartmental.

If the administrative location of your Program is not included in the list above, please provide the location.

3. Please tell us about your Program's history and admissions criteria.

A. For Undergraduate Degrees

a. When was your Program begun (i.e., approved to be offered by the institution)?
   - ☐ a. before 1950
   - ☑ b. 1951-1961
   - ☐ c. 1962-1972
   - ☐ d. 1973-1993
   - ☐ e. 1994-present

b. Are standardized scores (i.e. SAT or ACT) required for acceptance to the Program?
   - YES ☑ NO ☐

   If so, what is the minimum standardized score? n/a on the n/a(name examination)

c. Is a minimum high school grade point average(GPA) required?
   - YES ☑ NO ☐

   If so, what is the minimum grade point average? n/a out of n/a (total GPA)

d. Are letters of recommendation required?
e. How many students enter the Program in one calendar year (fall through summer semesters)?

- a. fewer than 10 students
- b. 11-21 students
- c. 22-32 students
- d. 33-43 students
- e. more than 44 students

B. For Graduate Degrees

a. When was your Program begun (i.e., approved to be offered by the institution)?

- a. before 1950
- b. 1951-1961
- c. 1962-1972
- d. 1973-1993
- e. 1994-present

b. Is a minimum grade point average required for admission into the graduate program?

- YES X NO 

If yes, what is the minimum grade point average? ____ out of ____ (total grade point average)

c. What type of bachelor’s degree does a student need to gain admission to the graduate Environmental Science program?

- a. A degree in Environmental Science is required.
- b. A degree in a field related to Environmental Science is required.
- c. A degree in a field unrelated to Environmental Science is acceptable.

d. Are standardized scores (i.e. GRE) required for admission to the graduate program?

- YES X NO 

If yes, what is the minimum standardized score? 1000 on the v+q (name examination)

e. Are letters of recommendation required?
YES □ NO □

f. How many students enter the Program in one calendar year (fall through summer semesters)?

□ a. fewer than 10 students
☒ b. 11-21 students
□ c. 22-32 students
□ d. 33-43 students
□ e. more than 44 students

4a. How many full-time faculty (i.e. tenured, full-time non-tenured, and tenure-track) teach in the Program?

□ a. 5 or fewer faculty
□ b. 6 to 11 faculty
□ c. 12 to 17 faculty
□ d. 18 to 22 faculty
☒ e. more than 22 faculty

4b. How many part-time faculty (i.e., adjuncts, special lecturers, and visiting lectures) teach in the Program?

☒ a. fewer than 5 faculty
□ b. 6 to 11 faculty
□ c. 12 to 17 faculty
□ d. 17 to 21 faculty
□ e. more than 21 faculty

5. Of those faculty who teach in the Program, what percent of their time is committed to working with the Environmental Science Programs?

□ a. less than one-quarter time
□ b. one-quarter time
□ c. half time
□ d. three quarters time
☒ e. full time

6. Which of the following statements applies best to the use of part-time faculty in your Program?

☒ a. Part-time faculty are rarely used to teach courses in the Environmental Science.
□ b. Part-time faculty are occasionally used to teach courses in Environmental Science.
c. Part-time faculty are frequently used to teach courses in Environmental Science.

7. Which of the following statements best describes the fields of your faculty?
   - [X] a. The majority of the faculty hold degrees in Environmental Science.
   - [ ] b. The majority of the faculty hold degrees in areas related to Environmental Science (i.e. Environmental Studies, Environmental Biology, or Environmental Management).
   - [ ] c. The majority of the faculty hold degrees in fields unrelated to areas of the environment.

8. What is the mission statement for your Program. If you wish, you may simply include the URL for the program web page that contains the statement or send a copy of it via fax or US mail.
   http://www.evsc.virginia.edu/

Section II. Student Abilities

With this background information, we would like you to consider the outcomes of the Program. That is, what abilities do you believe students should master by graduation? Please mark the answer that best describes your assessment of that skill and explain how the program teaches the students these skills.

9a. Students should have strong quantitative skills.

<table>
<thead>
<tr>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
</table>

9b. How do you teach students to have strong quantitative skills.
   - rigorous classes; modeling exercises, math through DE

10a. Students should be able to convey ideas and communicate effectively with the written word.

<table>
<thead>
<tr>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
</table>

10b. How do you teach students to convey ideas and communicate effectively with the written word?
   - substantial writing, draft proposals, papers

11a. The students should be able to convey ideas and communicate effectively by means of oral presentations.

<table>
<thead>
<tr>
<th>Very important</th>
<th>Moderately important</th>
<th>Somewhat important</th>
<th>Somewhat unimportant</th>
<th>Moderately unimportant</th>
<th>Very unimportant</th>
</tr>
</thead>
</table>
11b. How do you teach students to convey ideas and communicate effectively by means of oral presentations?

seminars–long and short

12a. Students should be able to evaluate literature in the field critically.

12b. How do you teach students in your program to evaluate literature in the field critically.

classes, research projects, etc.

13a. Students should be able to utilize a process to approach, research, analyze, and solve problems.

13b. What process for approaching, researching, analyzing, and solving problem does your program teach to its students?

independent research activities, proposal writing, critical reviews

Section III. Subject Areas

The next series of questions asks you to evaluate content areas of Environmental Science programs. Please rank the importance of each of the selected disciplines listed below to an effective Environmental Science program according to the following scale:

6=very important  3=somewhat unimportant
5=moderately important  2=moderately unimportant
4=somewhat important  1=very unimportant

14a. Here are the selected disciplines of study:

<table>
<thead>
<tr>
<th></th>
<th>RANK (6-1)</th>
<th>RANK (6-1)</th>
<th>RANK (6-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>6</td>
<td>Ecology</td>
<td>6</td>
</tr>
<tr>
<td>Chemistry-analytical</td>
<td>4</td>
<td>Economics</td>
<td>2</td>
</tr>
<tr>
<td>Chemistry-basic</td>
<td>6</td>
<td>English</td>
<td>4</td>
</tr>
<tr>
<td>Chemistry-physical</td>
<td>4</td>
<td>Geography</td>
<td>4</td>
</tr>
<tr>
<td>Communications</td>
<td>3</td>
<td>Geology</td>
<td>6</td>
</tr>
<tr>
<td>Computer Science</td>
<td>4</td>
<td>History</td>
<td>3</td>
</tr>
<tr>
<td>Earth Science</td>
<td>6</td>
<td>Management</td>
<td>3</td>
</tr>
</tbody>
</table>

14b. Are there subject areas that are not listed above which you think should be included? Are there any comments that you would like to make about these subject areas or your ratings?
Section IV. Laboratory and Field Experiences

Beyond the didactic world of the classroom, many programs offer opportunities for laboratory experiences and fieldwork. Please evaluate each of these opportunities for applied experiences in Environmental Science according to the following scale:

6 = very important  
5 = moderately important  
4 = somewhat important  
3 = somewhat unimportant  
2 = moderately unimportant  
1 = very unimportant

15a. Here are the areas for laboratory and field work experiences:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Score (6-1)</th>
<th>Offered in the EVSC Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Science (biology/chemistry/physics) laboratory experience.</td>
<td>6</td>
<td>YES x NO</td>
</tr>
<tr>
<td>Basic Science (biology/chemistry/physics) field experience.</td>
<td>6</td>
<td>YES x NO</td>
</tr>
<tr>
<td>Environmental laboratory experience.</td>
<td>6</td>
<td>YES x NO</td>
</tr>
<tr>
<td>Environmental field experience.</td>
<td>6</td>
<td>YES x NO</td>
</tr>
<tr>
<td>Social science laboratory experience.</td>
<td>3</td>
<td>YES x NO</td>
</tr>
<tr>
<td>Social science field experience.</td>
<td>3</td>
<td>YES x NO</td>
</tr>
<tr>
<td>Independent research projects with faculty members.</td>
<td>6</td>
<td>YES x NO</td>
</tr>
<tr>
<td>Internships or other off-campus work experience.</td>
<td>6</td>
<td>YES x NO</td>
</tr>
</tbody>
</table>

15b. Are there any subjects that are not listed above which you think should be included? Are there any comments that you would like to make about these subjects or your ratings?

Section V. Capstone and Thesis Requirements

In addition to field experiences, graduate programs may require capstone courses and submission of a formal thesis. Please answer each of the following questions regarding these program requirements.

16. The graduate Program requires a capstone or other synthesizing experience in which the student brings together aspects of his/her work in the program culminating in the investigation of a single topic.

YES x NO □ Not Applicable □

17. The Program requires a formal thesis that is reviewed, approved, and retained by the department or institution.

YES x NO □ Not Applicable □
Section VI. Distance Learning

The next set of questions deal with any learning handled in a format that does not require face-to-face contact between students and teachers.

18. How many courses in the Environmental Science program are offered in a distance learning format?

- a. No courses are offered in this format
- b. 1-3 courses
- c. 4-6 courses
- d. 7-9
- e. more than 10 courses are offered in this format

19. May a student take all the course work required for the degree in a distance learning format?

- YES
- NO

Section VII. External Advisement

20a. How often does your program receive external advisement and input concerning your Environmental Science Program? In this case, the input can be meeting with an advisory board, external reviewers, outside consultants or others who are intending to improve the program through oversight and guidance.

- a. Fewer than once a year
- b. Yearly
- c. Semiannually
- d. Quarterly
- e. Monthly

20b. What groups or individuals provide the external advisement guidance for your program?

- DEAN EVERY YEAR, OUTSIDE REVIEWERS EVERY FIVE YEARS

21. Are there any areas of Environmental Science that you feel the survey did not cover or any other information about your program that you would like to include to help understand what you feel would make a good Environmental Science program?

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

Figure A1.5 is the completed survey response from the University of Virginia Environmental Science Program Survey 2
APPENDIX 2

SAMPLE PROGRAM MATERIALS AND URLs

This chapter contains sample programs for six different Environmental Science programs that were shown to be good examples. The programs selected represent undergraduate, graduate and combined undergraduate and graduate programs. The programs are:

University of Illinois, Urbana (BS, MS, PhD); University of Massachusetts, Amherst (BS);

Duquesne University (MS); University of California, Los Angeles (PhD); Washington State University (BS, MS, PhD); and University of Virginia (BS, MS, PhD) The materials presented were taken from the web pages of each program.
**Mission Statement**
Department of Natural Resources and Environmental Sciences endeavors to establish and implement research and educational programs that enhance environmental stewardship in the management and use of natural, agricultural and urban systems in a socially responsible manner.

**Undergraduate:**
The Natural Resources and Environmental Sciences faculty provides personalized education for students. Although we are the largest department in the College of Agricultural, Consumer and Environmental Sciences, we take a strong interest in individual student advising. Our current enrollment is 340 undergraduate and 150 graduate students. An average-size NRES class may range from 25 to 30 students.

NRES students are introduced to a "big-picture" view of the environment that helps them understand societal issues. Undergraduates specialize in a specific discipline, yet have the capability of putting that knowledge to use in solving real-world problems.

**Bachelor of Science in NRES**
This curriculum prepares students for careers in management and protection of natural resources; the study of environmental sciences; teaching, research, or other related professional activity; business or government agencies providing services related to environmental and natural resource management; and as preparation for graduate studies or for advanced professional training. Examples of careers for graduates include environmental consultants, educators, communicators, plant physiologists, researchers, social and environmental impact analysts, resource planners, naturalists, ecologists, biologists, environmentalists, managers of wildlife, parks, forests and rangelands, conservation officers, nature center directors, aquatic ecologists, resource policy analysts, forest economists, water shed managers, soil conservationists, soil scientists, soil test analysts, land use specialists, plant and animal quarantine officers, lobbyists, plant nutrient consultants, and technical sales representatives.

The biological science option best serves students with an interest in the fundamental properties and management of natural resource systems, including interactions among plants, other soil biota, soil, water, wildlife and humans. Students may choose the social science option in which they will study agricultural policies and programs, environmental sociology, land use planning, environmental management, natural resource allocation, social impacts and environmental law. Students with an interest in soil conservation, soil and water interactions with plants and other organisms, water quality, environmental chemistry, land use assessment, soil nutrient analysis and related sales would choose the environmental soil and water science option. Students interested in studying fish or wildlife management, ecology, behavior or conservation would choose the new fish and
wildlife conservation option. Preparation for graduate studies in natural resources and environmental sciences and related areas can be accomplished in any of the options through appropriate selection of course work.

Additional Information
- Curriculum - the first two years (required of all options)
- Biological Science Option
- Environmental Soil and Water Science Option
- Fish and Wildlife Conservation Option
- Social Science Option

Bachelor of Science in NRES

Curriculum
Year 1
First Semester
ACES 100, Contemp. Issues in Agric., Consumer and Env. Sci.
NRES 102, Intro. Forestry, or NRES 104, Introduction to Environmental Science
RHET 105, Composition
MATH 120, Calculus and Analytic Geometry, or Math 134, Calculus for Social Scientists

Second Semester
PLBIO 100, Plant Biology
SPCOM 101, Prin. of Effective Speaking
CHEM 101, Gen. Chemistry
CHEM 105, Gen. Chemistry Lab
Cultural Studies
d Humanities Course
g

Year 2
First Semester
Social Science - ACE 100, Economics of Resources, Ag. and Food, or ECON 102, Microeconomic Principles
GEOL 107, General Geology I or GEOG 103, Earth's Physical Systems
Cultural Studies
CHEM 102, Gen. Chemistry
CHEM 106, Gen. Chemistry Lab

Second Semester
Social Science (non economic course)f
STAT 100, Statistics
ACE 210, Economics of the Environment or NRES 310, Natural Resource Economics or NRES 311,
Forest Resource Economics
Advanced Composition
Humanities Course
Years 3 & 4
Courses are required in one of the four options:
Environmental Soil and Water Science Option
Additional Requirements

ATMOS 140 Climate and Global Change
CHEM 122 Elementary Quantitative Analysis
CHEM 231 Elementary Organic Chemistry
MATH 130 Calculus and Analytic Geometry, II
MCBIO 100 Introductory Microbiology
MCBIO 101 Introductory Experimental Microbiology
NRES 101 Introductory Soils
NRES 251 Environmental Chemistry
NRES 390 or NRES 388 Chemistry of Surface Water Systems or The Physics of the Plant Environment
PHYCS 111
General Physics (Mechanics)
PLBIO 330 or BIOCH 350 Plant Physiology or Introductory Biochemistry
Restricted Electives
A minimum of 15 hours are required, at least 6 must be from the atmospheric/aquatic group and 6 from the soil group.
Soil Group
NRES 279 Soil Ecology
NRES 368 Soil Fertility & Fertilizers
NRES 371 Pedology
NRES 372 Soil Testing
NRES 374 Soil Conservation & Management
NRES 375 Soil Microbiology
NRES 376 Field Pedology
NRES 381 Laboratory Methods for Soils Research
NRES 383 Soil Mineralogy
NRES 384 Introduction to Soil Physical Chemistry
NRES 387 Soil Chemistry
NRES 388 The Physics of the Plant Environment Atmospheric/Aquatic group
ATMOS 301 Principles of Atmospheric Physics
CEE 347 Stream Ecology
CEE 348 Atmospheric Chemistry
GEOL 370 Oceanography

NRES 301 or GEOL 355 or CE 357 Watershed Hydrology or Introductory Groundwater Hydrogeology or Groundwater
NRES 330 Aquatic Ecosystems Conservation
NRES 351 Environmental Organic Chemistry
NRES 390 Chemistry of Surface Water Systems

Figure A2.1 is the program description for the University of Illinois, Urbana accessible at http://www.siue.edu/ENVS/.
The Mission of the Environmental Sciences Program

The Environmental Sciences Program prepares students to contribute to the development of solutions to critical environmental problems. Graduates of the program can pursue career opportunities in government agencies, industry, international organizations, consulting firms, analytical laboratories, and educational institutions.

Curriculum

All majors take required courses which provide a background in natural sciences, mathematics, and environmental studies. First-year students attend a required seminar to discuss critical environmental issues with faculty and outside speakers. A core curriculum of four courses and a junior-year writing course are also required by all majors. These core requirements provide a solid foundation in the social and scientific aspects of environmental problems. Students learn how to apply scientific data to solve complex environmental problems and to establish coherent environmental policy options to protect and sustain environmental resource systems. This knowledge is essential to the assessment and containment of environmental hazards on a local and global scale.

A diverse selection of upper-level courses allows students to work with their Faculty Advisor to design a unique curriculum tailored to their individual interests and needs. Students combine related courses in a General Track of study, or select a specific concentration in: Biology, Health Sciences, Toxicology and Chemistry, Policy, and Integrated Pest Management. Independent Studies and Internships offer students the opportunity to integrate laboratory and field work into their curriculum. Students in the program often pursue a second major or a minor to prepare for a more specific area of environmental study.

A degree in Environmental Sciences may lead to a variety of careers in private industry and governmental agencies concerned with environmental quality assessment, community environmental programs, and interagency coordination in environmental quality maintenance.

Environmental Sciences Core Courses

Math and Science
BIOL 100/101 Introductory Biology
CHEM 111/112 General Chemistry
CHEM 250/252 Organic Chemistry (1 semester)
CHEM 261/262/290A Organic Chemistry w/ Lab (2 semesters)
MATH 127/128 Calculus
RES EC 211 Introductory Statistics
RES EC 262 Environmental Economics
ENVSCI 191/194 Introductory Seminar
ENVSCI 112 Fundamentals of the Environment (Fall)
ENVSCI 213 Introduction to Environmental Policy (Fall)
ENVSCI 214 Principles of Environmental Biology (Spring)
ENVSCI 315 Principles of Environmental Toxicology and Chemistry (Spring)
ENVSCI 380 Writing in the Environmental Sciences

Upper Level Course Requirements
Four additional courses in the environmental sciences area must be taken at the 300 level or above. Students electing the General Track of study are encouraged to take courses that emphasize a specific area of interest within the field. Students selecting a specific concentration should refer to the specific concentration page for a listing of courses.

Note: CHEM 261/262/290A and PHYSIC 131/33 and 132/34 are strongly recommended for students planning to enter graduate school.

Areas of Specialization

Environmental Biology
The Environmental Biology concentration is ecological in perspective and is designed to develop competency in understanding the inter-dependence of all living organisms (microorganisms, plants, animals, humans) in aquatic and terrestrial habitats. Emphasis is placed on qualitative and quantitative definition of natural and managed ecosystems and determination of their normal function and degree of dysfunction when environmental pollutants are introduced into air, water, and soil. Environmental Biology students learn methods used to detect and monitor environmental pollutants and assess their biological effects and potential risks.

Upper-Level Course Selections

Environmental Microbiology Group

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVSCI 515</td>
<td>Microbiology of Soils and Sediments (basic biology and chemistry, same as PLSOIL 515)</td>
</tr>
<tr>
<td>MICBIO 310/312</td>
<td>General Microbiology (CHEM 261)</td>
</tr>
<tr>
<td>MICBIO 391B</td>
<td>Microbial Ecology (MICBIO 310)</td>
</tr>
</tbody>
</table>

Environmental Ecology Group

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL 283</td>
<td>General Genetics (BIOL 100, 101)</td>
</tr>
<tr>
<td>BIOL 421</td>
<td>Plant Ecology (BIOL 100)</td>
</tr>
<tr>
<td>BIOL 524</td>
<td>Coastal Plant Ecology (BIOL 100 or 103 or 104, plus BIOL 221 or 421)</td>
</tr>
<tr>
<td>BIOL 528</td>
<td>Principles of Evolution (BIOL 283)</td>
</tr>
<tr>
<td>BIOL 537</td>
<td>Ecology (A life science course beyond the introductory level)</td>
</tr>
<tr>
<td>ENVSCI 97D</td>
<td>Ecology (ENVSCI 112 or BIOL 100/101)</td>
</tr>
</tbody>
</table>
W&FCON 563 Wetland Wildlife Ecology and Management (W&FCON 261 or basic ecology)
W&FCON 564 Forest Wildlife Ecology and Management (W&FCON 261)
W&FCON 565 Dynamics and Management of Animal Populations (RES EC 211 or Intro. Statistics)
W&FCON 569 Biodiversity Conservation (W&FCON 261 or basic ecology)

Environmental Pollution Group
CEE 575 Hazardous Waste Management (CEE 370) - corequisite CEE 371
ENVSCI 303 Methods of Pollution Measurement (CHEM 111, 112)
ENVSCI 504 Air Pollution Biology (BIOL 100, 101, CHEM 111)
ENVSCI 530 Aquatic Toxicology (ENVSCI 315, RES EC 211)
GEO 354 Climatology (GEO 100 or ASTRON 105)

Aquatic Environmental Group
BIOL 485 Aquatic Vascular Plants (BIOL 226)
BIOL 534 Biological Limnology (BIOL 100)
BIOL 535 Limnology (BIOL 100, CHEM 112)
BIOL 542 Ichthyology (BIOL 521)
ENVSCI 416 Aquatic Microbiology (ENVSCI 112)
ENVSCI 576 Aquatic Invertebrates (same as ENT 576)
W&FCON 470 Ecology of Fish (BIOL 542)
W&FCON 550 Freshwater Fisheries Biology and Management (W&FCON 297B)

Note:
CHEM 261/262/290A and PHYSIC 131/33 and 132/34 are strongly recommended for students planning to enter graduate school.

Environmental Health Sciences
The Environmental Health Sciences concentration examines the effects of environmental degradation on human health. Students learn about current regulations designed to protect the environment and human health, and become familiar with the technology used to detect, monitor, and control environmental contaminants. The curriculum emphasizes a broad knowledge of environmental health problems and also allows an opportunity to acquire more specialized information in the areas of occupational health, institutional hygiene, air pollution, food sanitation, solid and hazardous materials management, and radiological health.

Upper-Level Course Selections
Chemistry, Biology, Microbiology and Physics Group (required)
CHEM 261 Organic Chemistry I (CHEM 112 or 122)
CHEM 262/290A Organic Chemistry II and Lab (CHEM 261 or 265)
BIOL 339 Human Anatomy and Physiology (BIOL 100 or CHEM 111)
MICBIO 310/312 General Microbiology (CHEM 261)
PHYSIC 131/133 Introductory Physics I and Lab
PHYSIC 132/134 Introductory Physics II and Lab

Environmental Health Group (required)
ENV HL 565 Environmental Health Practices

Concentration Electives
BIOEPI 540 Introductory Biostatistics
ENV HL 562 Air Quality Assessment
ENV HL 563 Biological Effects of Ionizing Radiation (ENV HL 571)
ENV HL 564 Principles of Industrial Hygiene
ENV HL 566 Radiation Instrumentation (ENV HL 563)
ENV HL 571 Calculation Methods (one year: mathematics, chemistry and physics)
ENV HL 590J Environmental Compliance Regulations
BIOEPI 630 Principles of Epidemiology
ENV HL 660 Issues in Environmental Health Policy and Law
ENVSCI 515 Microbiology of Soils and Sediments (basic biology and organic chemistry, same as PLSOIL 515)

Note:
CHEM 261/262/290A and PHYSIC 131/33 and 132/34 are strongly recommended for students planning to enter graduate school.

*********************************************************************
Integrated Pest Management
The Integrated Pest Management concentration combines course work in Environmental Science with specialized courses in Entomology, Plant Pathology, and Plant Production. In the senior year, a "capstone" course integrates the elements of insect, weed, nematode and disease management, Climatology, computer modeling and information delivery, and the economics and regulations of pesticide use. Trained students will be capable of making complex pest management decisions.

Upper-Level Course Selection

Required Courses
CMPSCI 105 (both) Computer Literacy (replaces MATH 127 and 128)
ENVSCI 390S (fall) Principles and Applications of IPM (junior year) (BIOL 100, 101, ENVSCI 112, 213, 214)
ENVSCI 490S (spring) Capstone Course in IPM (senior year) (ENVSCI 390S or ENT 581) OR
ENT 581 (fall) Integrated Pest Management, may be taken in place of ENVSCI 390S and 490S(ENT 526)

Select two courses from the following:

ENT 526 (fall) Insect Biology (BIOL 100)
MICBIO 530 General Plant Pathology (Botany)
PLSOIL 310 (fall) Principles of Weed Management
Select one course from the following

PLSOIL 230 (fall)  Introductory Turfgrass Management (botany, soils)
PLSOIL 300 (fall, odd years)  Deciduous Orchard Science
PLSOIL 305 (fall, even yrs)  Small Fruit Production
PLSOIL 315 (fall)  Greenhouse Management (BIOL 103)
PLSOIL 325 (fall)  Vegetable Production (PLSOIL 100 102 BIOL 101 or 103)
PLSOIL 350 (spring)  Sustainable Crop Production (BIOL 103, PLSOIL 100)
FOREST 110 (spring)  Introduction to Forestry
FOREST 225 (fall)  The Forest Environment (FOREST 150)
FOREST 332 (fall)  Principles of Arboriculture
W&FCON 260 (fall)  Fisheries Conservation (BIOL 100)
W&FCON 261 (spring)  Wildlife Conservation (BIOL 100)

Recommended Courses (Not Required)

ENT 342  Pesticides, the Environment and Public Policy
FOREST 310 (spring)  Urban Forestry
LARP 335 (fall)  Plant Materials
MICBIO 535  Plant Disease Diagnostics (MICBIO 530)
PLSOIL 105 (spring)  Soils (knowledge of chemistry)
PLSOIL 297A (spring)  Sustainable Agriculture (knowledge of basic agriculture principles helpful)
PLSOIL 540 (fall)  Plant Breeding (BIOL 400 or course in genetics)

Environmental Policy

The Environmental Policy concentration is intended for students who wish to use their scientific background to address public policy questions including economic analysis, regulation, administration, enforcement, and law. Society has a need for analysis and expert testimony from people qualified to discuss both the natural science of environmental problems and the complex social issues relevant to finding solutions. The Environmental Policy concentration is for students who are interested ultimately in bridging the science and policy of the environment. Analytical tools such as environmental impact analyses, risk assessment, and benefit-cost analysis are utilized to examine how society can best approach the resolution of environmental problems.

Upper-Level Course Selections

Environmental Public Policy Group

ENVSCI 342  Pesticides, the Environment, and Public Policy
NAREST 409  Natural Resources Policy and Administration
POLSCI 382  Environmental Policy
POLSCI 397  International Environmental Politics
REG PL 553  Resource Policy and Planning
REG PL 558  Issues in Environmental Management

Environmental Economics Group
Political Economy of the Environment (Two of the following: ECON 103, 105, 203, 305)
Natural Resource and Energy Economics
Land Economics
Benefit-Cost Analysis of Natural Resource Programs (RES EC 305 or ECON 203)

Additional Public Policy Courses
NAREST 390A Wilderness Conservation
NAREST 397B Human Dimensions of Natural Resources
W&FCON 550 Freshwater Fisheries Biology and Management (W&FCON 297B)
W&FCON 563 Wetland Wildlife Ecology and Management (W&FCON 261 or basic ecology)
W&FCON 564 Forest Wildlife Ecology and Management (W&FCON 261)
W&FCON 569 Biodiversity Conservation (W&FCON 261 or basic ecology)
W&FCON 571 Marine Fisheries Science and Management (W&FCON 565)

Note:
CHEM 261/262/290A and PHYSIC 131/33 and 132/34 are strongly recommended for students planning to enter graduate school.

Environmental Toxicology and Chemistry
The Environmental Toxicology and Chemistry concentration focuses on the impact of contaminants on ecosystems and related biological processes in air, soil, sediment, and ground and surface waters. The quantity and variety of toxic inorganic and organic compounds released into the environment by industrial and other human activities frequently constitute a potential threat to the health of both society and the environment. Both the industries that produce and the governmental agencies that regulate toxic compounds are in need of expertise regarding the environmental fates and mechanisms of toxicity of organic and inorganic contaminants. Environmental Toxicology and Chemistry students study the chemistry, toxicology, microbiology, and physics of toxicant mobility and degradation in the environment. Analytical determinations of the types and concentrations of toxicants in the environment are essential for the determination of hazards and for the assessment of safety.

Upper-Level Course Selections

General Toxicology Group
BIOCHM 420 Elementary Biochemistry (organic chemistry)
BIOCHM 523 General Biochemistry (one year of organic chemistry, BIOCHM 285)
BIOL 283 General Genetics (BIOL 100 and 101)
BIOTCH 385 Laboratory in Agricultural Biotechnology (BIOL 100, CHEM 111)

General Chemistry Group
CHEM 312 Analytical Chemistry (CHEM 250, 262 or 266)
CHEM 315 Quantitative Analysis (CHEM 262 & lab or 266 & lab)
General Microbiology Group
FD SCI 467 Food Microbiology (MICBIO 310/312)
MICBIO 310 General Microbiology (CHEM 261)
MICBIO 330 Microbial Genetics (MICBIO 310, general biochemistry)
MICBIO 560 Microbial Diversity (MICBIO 310)

Environmental Toxicology Group
ENVSCI 497A Fundamentals of Environmental Risk Assessment (ENVSCI 214)
ENVSCI 530 Aquatic Toxicology (ENVSCI 315, RES EC 211)
ENVSCI 535 Methods in Environmental Toxicology and Chemistry (2 years of college chemistry)
ENVSCI 585 Toxicology of Insecticides (organic chemistry)
ENVSCI 592 Chemicals and the Environment (introductory environmental toxicology)
FD SCI 785 Toxicology (consent)
PLSOIL 555 Environmental Stress & Plant Growth (plant physiology)

Environmental Chemistry Group
ENVSCI 303 Methods of Pollution Measurement (CHEM 111, 112)
ENVSCI 504 Air Pollution Biology (BIOL 100, 101, chemistry)
ENVSCI 535 Methods in Environmental Toxicology and Chemistry (2 years of college chemistry)
ENVSCI 575 Environmental Soil Chemistry (CHEM 111, 112, PLSOIL 105)
GEO 519 Aqueous & Environmental Geochemistry (CHEM 111, 112)

Environmental Microbiology Group
ENVSCI 416 Aquatic Microbiology (MICBIO 310)
ENVSCI 515 Microbiology of Soils and Sediments (basic biology and organic chemistry)
PLSOIL 597 Organic Contaminants in Soils, Waters and Sediments (CHEM 250/252, general biochemistry)
PLSOIL 597 Inorganic Contaminants

Note:
CHEM 261/262/290A and PHYSIC 131/33 and 132/34 are strongly recommended for students planning to enter graduate school.

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Figure A2.2 is the program description for the University of Massachusetts, Amherst Program accessible at http://www.umass.edu/envsci/
The Environmental Science and Management Program, leading to a Master of Science degree, provides the skills required for today's professionals in industry, regulatory agencies, academe, and the public policy arena who must deal with ever more complex environmental issues in an informed, responsible way.

The 42-credit curriculum emphasizes a strong foundation in environmental sciences, the necessary training in business and behavioral science, and an introduction to law and public policy. Practice in writing and related communication skills is integrated throughout the program. The two internships, in industry and in a regulatory agency, will provide valuable practical experience; however, in certain cases students may elect to write a thesis instead.

Classes are offered in the evenings and on Saturdays. Program requirements will be typically taken over a two-year period during four regular semesters and two summer sessions. However, full-time students entering in the summer or fall semester may also take all course requirements in an accelerated "FAST TRACK" sequence over a one year period.

Students must complete a minimum of 42 credit hours of course work from the following curriculum.

Program of study
Environmental Science Segment (Minimum 14 Credits)
Business and Behavioral Science Segment (Minimum 14 Credits)
Public Policy and Law Segment (6 Credits)
Internships or Thesis (6 Credits)

The Curriculum

Environmental Science Segment (Minimum 14 Credits)

Required
ESM 551 Introduction to Environmental Science (3cr.)
ESM 552 Environmental Chemistry (3cr.)
ESM 670 Environmental Toxicology (3cr.)

Electives (Minimum 2 classes)
ESM 539 Air Quality (3cr.)
ESM 566 Terrestrial Field Biology (3cr.)
ESM 591 Environmental Hydrogeology (2cr.)
ESM 594 Environmental Sampling (3cr.)
ESM 595 Environmental Biotechnology (3cr.)
ESM 596 Survey of Environmental Technologies (3cr.)
ESM 597 Environmental Microbiology (3cr.)
ESM 598 Environmental Ecology (3cr.)
ESM 662 Enhanced Microwave Chemistry (3cr.)
ESM 690 Independent Study (1-3 cr.)

Business and Behavioral Science Segment (Minimum 14 Credits)

Required
ESM 531 Environmental Management (3cr.)
ESM 533 Writing for Environmental Professionals (3cr.)
ESM 535 Environmental Public Relations (3cr.)
ESM 537 Conflict Resolution and Problem Solving Skills (3cr.)

Electives
ESM 530 Environmental Regulatory Requirements (3cr.)
ESM 534 Environmental Risk Assessment (3cr.)
ESM 538 Environmental Economics (3cr.)
ESM 542 Sustainable Development (3cr.)
ESM 543 Pollution Prevention (3cr.)
ESM 547 Leadership in Environmental Organizations (3cr.)
GRBUS 524 Organizational Behavior in Management (3 cr.)
GRBUS 616 Leadership (3 cr.)
ESM 690 Independent Study (1-3 cr.)

Public Policy and Law Segment (6 Credits)

Required
ESM 540 National and International Environmental Law (3cr.)
ESM 544 Public Policy and Environmental Politics (3cr.)

Internships or Thesis (6 Credits)

ESM 600 Internship in Regulatory Agency (3cr.)
ESM 601 Internship in Industry (3cr.)
Or:
ESM 700 Thesis (6cr.)

Colloquium (0 Credits)

Required
ESM 691 Colloquium Series (0 cr.)

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Figure A2.3 is the program description for Duquesne University accessible at http://Www.science.duq.edu/.
The UCLA Environmental Science and Engineering (ESE) Interdepartmental Program was founded in 1973 by Nobel Laureate Dr. Willard Libby, who perceived a need to train environmental scientists, engineers, and policy makers in a more interdisciplinary manner than is afforded by traditional Ph.D. programs. Graduate students who have earned the Doctorate in Environmental Science and Engineering now occupy positions of leadership in government agencies, the private sector, the national laboratories, and public interest groups.

**Ese Program Focus**

**Background**

To date, the ESE Program has awarded the Doctorate of Environmental Science and Engineering, or D.Env degree, to nearly 200 students, and UCLA remains unique in the country in awarding such a degree.

Many ESE graduates have gone on to occupy critical positions in environmental research, remediation, and policy throughout the major environmental agencies in California and the nation, including:
- The California Air Resources Board
- Environmental Protection Agency
- California Regional Water Quality Control Board
- South Coast Air Quality Management District
- Army Corp of Engineers
- Association of Bay Area Governments
- Metropolitan Water District of Southern California
- California State Lands Commission
- California Department of Health Services

Other ESE graduates have risen to senior positions in private sector companies conducting environmental research and remediation. Still other graduates are applying scientific solutions to environmental problems at national laboratories such as Oak Ridge, Lawrence Berkeley and Lawrence Livermore, and at research institutes, such as the RAND Corporation.

**Introduction to the D.Env Degree**

In 1971, a group of UCLA faculty led by Nobel laureate Willard Libby, convinced of the need for a new type of environmental professional, proposed the development of an innovative doctoral curriculum. The result was the Doctor of Environmental Science and Engineering (D.Env) degree program, a unique venture in graduate education. It was apparent to these pioneers that future environmental professionals would need to have a broad understanding of the technical, political, and socioeconomic aspects of environmental problems, and that specialists trained in traditional curricula were not likely to have this capability. However, the founders of the Program also recognized the need for each student to have a strong background in a specific scientific or engineering discipline.
The degree program which has emerged, administered by the UCLA Interdepartmental Environmental Science and Engineering (ESE) Program, seeks to provide students with a broad understanding of the environment, and the technical and managerial skills of environmental problem-solving. The curriculum consists of formal course work and interdisciplinary research (the Problems Courses) and is capped with an eighteen to twenty-four month internship in government agencies, national laboratories, industry, or environmental non-profit organizations.

The D.Env is not a research degree in the manner of a Ph.D. It is more applied and more interdisciplinary, and substitutes a research experience in government or industry for an extended research training period on campus. However, candidates for the D.Env must complete an in-depth research project during their internship which results in a dissertation; and they must have depth in an area of specialization usually, but not necessarily, in the field of their master's degree.

The UCLA D.Env degree has historically been highly marketable relative to other doctoral degrees in the environmental field, including the Ph.D. More than 180 graduates of the D.Env program now hold permanent positions, many in leadership roles in the environmental profession.

Administratively, the UCLA Environmental Science and Engineering Program is an interdisciplinary unit of the Department of Environmental Health Sciences of the UCLA School of Public Health. The Program focuses on the critical environmental problems which transcend national borders, but which also have local relevance. Emphasis is on rigorous science, sound methodologies, and attention to fundamentals. ESE Program research and training are both experimental and analytical in nature. They may involve laboratory or field studies; or, they may utilize existing databases. Research and instruction recognize the cross connections between soil, water, air, and biota, as well as the interdependence of human and ecological health. Equally important, the curriculum emphasizes the interactions and interdependencies between science, economics, and law in the protection of the environment and public health.

- Flow Chart of the ESE D.Env Degree Program
- Master's Degree in Science or Engineering Discipline
- Admission to ESE Program
- Breadth Requirements and Core Courses (4-6 Quarters)
- Problems Course (3 Quarters)
- Written Qualifying Examination
- Oral Qualifying Examination
- Internship (18-36 months)
- Dissertation Prospectus (6th-9th Month)
- Present Oral Defense of Dissertation
- File Dissertation
- Doctor of Environmental Science and Engineering Degree (D.Env)

ESE Curriculum Overview

The goal of the Environmental Science and Engineering Program is to provide the multidisciplinary training needed by today's environmental professionals to solve complex environmental problems. The curriculum consists of three components: formal course work, the Problems Course, and the internship.
Formal course work consists of four core courses (in air pollution, water quality, applied ecology, and environmental assessment) and 12 breadth courses chosen from three general areas:

1. environmental science
2. environmental engineering
3. environmental law, management and policy

Within each area, students choose from a list of approved courses taught by a wide variety of departments, including Atmospheric Sciences, Biology, Chemical Engineering, Civil and Environmental Engineering, Economics, Environmental Health Sciences, Geography, Law and Urban Planning. Students typically devote full time to course work during their first year, taking 12 courses, and finish their course work the second year.

During the second year, students focus on the Problems Course. The Problems Course consists of a supervised research project directed towards the solution of a current environmental problem. The intense research effort in the Problems Course occurs over a 9-12 month period, and typically leads to peer-reviewed journal articles. Although Problems Courses take many forms, from intense field or laboratory projects to computer and database analyses, they typically involve technical problems with policy implications. Concurrently with the Problems Course, students participate in a Problems Course Workshop that focuses on developing oral presentation and technical writing skills.

The final component of the curriculum is the Internship. The internship is conducted at an outside institution such as a government agency, national laboratory, non-profit organization, or private company. The internship provides practical experience in environmental analysis and management, as well as the opportunity to conduct dissertation research. The dissertation must be scholarly, original work applied towards solving environmental problems. As with problems courses, dissertations typically address policy as well as technical dimensions of a particular problem. The dissertation should be completed in 18-36 months.

PROGRAM CURRICULUM REQUIREMENTS

General Course Requirements.

Course requirements consist of core and breadth courses, ESE Seminar, and problems courses. Specific course requirements vary from one student to another, depending on background and career goals.

Core and Breadth Courses.

Students take 15 to 16 4-unit courses after admission to the Program (UCLA is on the quarter system). Four of these are offered by Program faculty and are referred to as "core courses." The remaining courses are referred to as "breadth courses." The courses are taken in three general areas: environmental science; environmental engineering; and environmental management, law and policy. The Table of Course Requirements lists the breadth course requirements in each area. The Approved Breadth Elective Courses are selected from a list of approved courses. Courses that are not on the approved list must be approved by the core faculty before they can be used to fulfill a breadth requirement. Core and breadth courses must be taken on a grade basis (not S/U). A minimum of twelve courses must be taken at UCLA or another University of California campus, and at least
seven courses must be at the graduate (200) level. The breadth course requirements are generally completed during the first and second year of the program.

Core Requirements

Number in parentheses after category indicates number of courses required in that category. All courses are 4 units each, except ESE seminar (which is 2 units).

Environmental Science (7)
EHS 264 Transport and Fate of Organic Contaminants in the Aquatic Environment
EHS 225 Atmospheric Transport and Transformations of Airborne Chemicals
EHS 240 Environmental Toxicology
EHS 212 Applied Ecology
( ) Elective in Environ. Biology, Microbiology or Ecology
( ) Elective in Environmental Geology
( ) Elective in Atmospheric Science

Environmental Engineering (5)
CEE 150 Engineering Hydrology
CEE 155 Water Quality Control Systems
( ) Elective
( ) Elective
( ) Elective

Environmental Management, Law, and Policy (4)
EHS 235 Quantitative Methods for Environmental Assessment
UP M264 Environmental Law
( ) Elective
( ) Elective

Problems Courses (3)
ESE 400A ESE Problems Course A
ESE 400B ESE Problems Course B
ESE 400C ESE Problems Course C

Problems Course Workshop (3)
ESE 410A ESE Problems Course Workshop A
ESE 410B ESE Problems Course Workshop B
ESE 410C ESE Problems Course Workshop C

ESE/EHS Seminar
ESE M411 Environmental Science and Engineering/Environmental Health Sciences Seminar
ESE 412 Effective Technical Writing

Note that students may waive out of one or more breadth requirements depending on previous course work. The first course waived reduces the total number of courses required to 15. If more than one course is waived, the courses must be replaced with electives so
that a minimum of 15 breadth courses are taken after admission to the Program. Such "replacement electives" can include any course on the list of approved courses or approved by the core faculty.

**Breadth Elective Courses**

ENVIROMENTAL SCIENCES (4 COURSES)

Elective in Toxicology (1)
Elective in Environmental Biology, Microbiology or Ecology (1)
BIO 116 Conservation Biology
BIO 122 Ecology
BIO C119 Mathematical Ecology
BIO M127 Soils, Plants, and Society
BIO C215 Introduction to Marine Science
BIO 216 Quantitative Methods in Behavior and Ecology
EHS 210 Public Health and Environmental Microbiology
EHS 262 Environmental Microbiology

Elective in Environmental Geology (1)
BIO M127 Soils, Plants and Society
ESS M139 Engineering and Environmental Geology
GEO 107 Soil and Water Conservation
GEO 105 Hydrology

Elective in Atmospheric Science (1)
AS M203A Introduction to Atmospheric Chemistry
AS 142 Atmospheric Circulations
AS 144 Air Pollution Meteorology
EHS 252D Properties and Measurement of Airborne Particles
CHE 240 Fundamentals of Aerosol Technology

ENVIROMENTAL ENGINEERING (3 COURSES)

CEE 164 Waste and Hazardous Waste Management
CEE 151 Introduction to Water Resources Engineering
CEE 153 Introduction to Environmental Engineering
CEE 157B Design of Water Quality Control System
CEE 163 Air Pollution Control
CEE 250A Surface Water Hydrology
CEE 250B Groundwater Hydrology
CEE 252 Engineering Economic Analysis of Water and Environmental Planning
CEE 253 Mathematical Models for Water Quality Management
CEE 254A Aquatic Chemistry
CEE 254C Aquatic Surface Chemistry
CEE 255A Physical and Chemical Processes for Water and Wastewater Treatment
CEE 255B Biological Processes for Water and Wastewater Treatment
CEE 265A Mass Transfer in Environmental Systems
CHE 119 Pollution Prevention for Chemical Processes
CHE 218 Multimedia Environmental Assessment
MANE 103 Elementary Fluid Mechanics
MANE 174 Risk, Reliability and Quality Assurance
MANE 274 Methods of Probabilistic Safety Assessment

ENVIRONMENTAL MANAGEMENT, LAW AND POLICY (2 COURSES)
UP 241C Urban Transportation and Planning III
UP 249 Advanced Workshop in Geographic Information Systems
UP 260A Political Economy of the Environment
UP 260B Politics, Institutions, and the Environment
UP 262A Pollution Prevention: Issues of Science, Engineering and Policy
UP 262B Water Resources Planning: Is a New Discourse Possible?
UP 263 Natural Resource Conservation
UP 267B Rural Development Issues
CEE 106A Principles of Engineering Economy
CEE 175 Elements of Decision Making
CEE 252 Engineering Economy of Water and Related Natural Resources
CEE 275 Multi-Attribute Decision Making
EC 110 Economic Problems of Underdeveloped Countries
EHS 101 Environmental Health
EHS 230 Environmental Management
EHS 231 Environmental Decision Systems Analysis
EHS M249 Preventing Pollution: Issues in Environmental Policy, Science and Engineering
GEO 120 Conservation of Natural Resources in North America
GEO 124 Environmental Impact Analysis
GEO 170 Geographical Information Systems and Analysis
LAW 190A International Environmental Law
LAW 284 Toxic Torts
LAW 292 Water Law
MANE 174 Risk, Reliability and Quality Assurance
MANE 274 Methods of Probabilistic Safety Assessment
MANE 275 Principles and Methods of Risk Assessment

ESE Seminar.

Students are required to enroll in the Environmental Science and Engineering Seminar when it is offered (usually two quarters per academic year) during the first two years. (Recent Seminar Speakers)

Seminar Speakers

Fall 1998
Mustafa Memorial Lecture: Searching for Chronic Effects of Air Pollution in Southern California Children
John Peters, Professor of Preventative Medicine
USC School of Medicine; Director, Division of Occupational & Environmental Health

A Geographic Information System for Non-Point Source Runoff into Santa Monica Bay
Michael K, Stenstrom, Ph.D
Chair, UCLA Dept. of Civil & Environmental Engineering
Acting Director of UCLA Institute for the Environment

Ecotoxicology of PCBs in Estuaries
Mel Suffet, Ph.D, Professor
UCLA Dept. of Environmental Health Sciences

Permeation of Pesticides Through Protective Materials
Shane Que Hee, Ph.D, Professor
UCLA Dept. of Environmental Health Sciences

Return on Health and Safety Investments
Randy Roth, Ph.D, Manager
Corporate Environment, Health & Safety Dept., ARCO

Exposure to Particulate Matter: Do Monitors Actually Reflect Human Exposure?
Steven Colome, Sc.D, Professor
UCLA Dept. of Environmental Health Sciences

Wetland Restoration Studies at Mugu Lagoon
Richard Ambrose, Ph.D, Professor
UCLA Dept. of Environmental Health Sciences

Identification of Diesel Exhaust as a Toxic Air Contaminant
John Froines, Ph.D, Professor
UCLA Dept. of Environmental Health Sciences

Evidence that Baron is the Newest Essential Element
Curtis Eckhert, Ph.D, Professor
UCLA Dept. of Environmental Health Sciences

Spring 1998
Politics Regulation and Science: The New Clean Air Standards for Ozone and Particulate Matter
Mary Nichols, J.D., Executive Director
Environment Now

Measurement of Human Sperm-Cytogenic Damage in Studies of Occupational, Environmental and Lifestyle Exposures
Wendie Robbins, RN, Ph.D., Assistant Professor
UCLA Department of Environmental Health Sciences

Colloidal Transport in Geochemically Heterogeneous Subsurface Porous Media
Menachem Elimelech, Ph.D., Professor
UCLA Department of Civil and Environmental Engineering
Problems Course.

An important part of the D. Env. curriculum is the Problems Course requirement. Problems Courses constitute intensive multidisciplinary, applied, research directed toward the solution of current environmental problems. Problems Courses may take on many forms: basic laboratory or field studies; development and testing of mathematical and computer-based models; evaluation of existing and innovative technologies; analysis of public policy trends and options; and others. Projects commonly address problems having policy implications, either directly or indirectly. Students are required to quantify and measure necessary parameters, perform critical evaluations, edit and process technical and socio-economic information, meet deadlines and communicate through a final report to the competent lay person as well as to the technical specialist. Problems Course research typically leads to peer-reviewed journal articles.

Before proceeding to the Problems Courses, a student must have (1) completed all but six of the required courses, (2) successfully passed all core courses taken with a B-grade or better, and (3) maintained a cumulative GPA of 3.0 for all classes taken after entering the ESE Program. Twenty-four quarter units of the Problem Course (ESE 400 series) must be completed during three quarters prior to advancement to candidacy. The requirement may be met by completing three consecutive quarters (8 units/quarter) on a
single theme, or at least two consecutive quarters devoted to a single theme plus one quarter participation approved by the faculty. Enrollment in more than one Problems Course per quarter is not allowed. No more than 8 units of other course work may be taken when enrolled in a Problems Course. The student must take three quarters of the Problems Course Workshop (ESE 410 series) concurrent with the Problems Course.

Normally, Problems Course credit will only be earned from courses offered through the ESE Program. However, students may petition for permission to earn Problems Course credit through multidisciplinary environmental projects offered in other departments at UCLA.

Current or Recently Completed Problems Course Projects Offered by Dr. Ambrose Bacotoxicology and Wetland Restoration of Mugu Lagoon
Jonathan Lillien
UC Toxic Substances Research and Teaching Program

Marine Protected Areas: A Case Study of A Marine Refuge in Malibu, California
Jih-Shing "Cindy" Lin
City of Malibu, California

Restoration Planning and Monitoring at a Remediated Ordinance Disposal Area at Mare Island, CA
Shawn Daley
UC Toxic Substances Research and Teaching Program

Development of Performance Standards for Wetland Restoration at Mugu Lagoon
Tim McPherson
UC Toxic Substances Research and Teaching Program

Wetland Restoration Planning at Mare Island Naval Shipyard, North San Francisco Bay
Charles Rairdan
UC Toxic Substances Research and Teaching Program

Environmental Assessment of Rocky Intertidal Habitats: Comparison of Sampling Designs in a Heterogeneous Environment
Whitman Miller
California Coastal Commission

Comparison of Communities in Different Rocky Intertidal Habitats in Southern California
Petra Pless
California Coastal Commission

Restoring Sewage Oxidation Ponds at the Mugu Naval Air Weapons Station: Wetland Restoration Issues and Planning
Spencer MacNeil
UC Toxics Substances Research and Teaching Program
Detecting Change in Rocky Intertidal Communities: Analysis of Before-After and BACI Sampling Designs
Jessica Spitzer
California Coastal Commission

Wildlife Value of a Constructed Method and Techniques for the Economic Valuation of Ecosystem Functions
Ben Schweger
Disney Corporation

Assessment of Ecosystem Health at Malibu Lagoon
Timothy Downs
UC Toxics Substances Research and Teaching Program

Environmental Assessment of Malibu Creek and Lagoon
Douglas Meffert
Las Virgenes Municipal Water District

Current or Recently Completed Problems Course Projects Offered by Dr. Duke
Mitzy Taggart
University of California Toxic Substances Research and Teaching Program

Urban Storm Water Pollution from Transportation Industry Sources
Paul R. Beswick
Santa Monica Bay Restoration Foundation

Storm Water Regulations for Industrial Facilities in California: Regulatory Compliance and Water Quality Implications
Kanan Coleman
California State Water Resources Control Board

Improving Risk Assessments of Hazardous Air Pollutants in California
Jignasa Parikh
University of California Toxic Substances Research and Teaching Program
Professors Arthur M. Winer and L. Donald Duke

Pollution Prevention for Printed Circuit Board Manufacturers: Collaboration with Lawrence Livermore National Laboratory
Hyon Chu Chang
University of California Toxic Substances Research and Teaching Program

Ecological Risk Assessment for Mare Island Naval Shipyard
Katharine Gabor, Shawn Daley
University of California Toxic Substances Research and Teaching Program
Current or Recently Completed Problems Course Projects Offered by Dr. Suffet

Modelling Nutrients at Malibu Lagoon
Cris Liban
California Coastal Commission

Humic Materials Characterization in Contaminated Estuarine Sediment Pore Water
Jim Mace
Office of Naval Research

Tastes and Odors Caused by Materials Used in Drinking Water Distribution Systems
Ginachi Amah
AWWA Research Foundation

Anoxic Pore Water of Contaminated Estuarine Sediments - Size Fractionation
Joel Pedersen
Office of Naval Research

Anoxic Pore Water of Contaminated Estuarine Sediments - Polarity Fractionation
Christopher Gabelich
Office of Naval Research

Evaluation of Ozone and Activited Carbon Unit Operations at the Arrowhead Water Reuse Plant
Bruno Levine
Ahmanson Foundation

Evaluation of Powdered Activated Carbons for Removal of Taste and Odor Compounds from Drinking Water
Guixiang Chen
Calgon Carbon Corp.

Evaluation of Acid Base Neutral Trace Organic Compounds at the Aqua III; Water Reuse Plant for San Diego
Srilatha Rajachandran
Western Consortium

Current or Recently Completed Problems Course Projects Offered by Dr. Winer

Indoor, Outdoor and Personal Air Exposure to Toxic VOC’s, Aldehydes and PM-2.5 in the Los Angeles County: The Influence of Mobile Source Emissions
Derek Shendell
U.S. EPA and Mickey Legrand Air Toxics Center

Regional Human Exposure to Benzene in the California South Coast Air Basin
Scott Fruin
UC Toxic Substances Research and Teaching Program
Biogenic Hydrocarbon Inventories for California: Generation of Essential Databases
Jae Chung
California Air Resources Board

Characterization of Ozone Episodes in the South Coast Air Basin: Effects of Air Parcel Residence Time and Weekday/Weekend Differences
Ray Chavira
California Air Resources Board

Characterization of Ozone Episodes in the South Coast Air Basin
Namita Verma
California Air Resources Board
Professors Arthur M. Winer and Warren Blier

Critical Evaluation of A Biogenics Emission System For Photochemical Grid Modeling in California
James Adams
John Karlik
California Air Resources Board

Intermedia Transfer Factors for Toxic Air Pollutants
Lei Zhou
California Air Resources Board
Professors Arthur M. Winer and Yoram Cohen

Written and Oral Qualifying Examinations.
A two-tiered examination sequence, consisting of written and oral examinations, is required for advancement to candidacy to the D.Env. degree. The exams must be successfully completed before the internship can begin. The purpose of the examinations is to test the student's understanding of the core and breadth areas, the master's field, current issues in the environmental field, and subjects covered in the student's problems course experience. The written examination is administered by the core faculty of the Program and is during the middle of the second year. If the examination is failed, one repeat is allowed. The oral examination is administered by the doctoral committee, a four faculty person committee that guides the student through the internship and the preparation of the dissertation. The oral examination may be repeated once. Generally, the doctoral committee will be appointed during the second year of tenure at UCLA. Upon successful completion of the written and oral examination, the student is advanced to candidacy.

Internship.
After advancement to candidacy and completion of course requirements, including the Problems Courses, the student begins an internship in a field of interest at an outside institution. The purposes of the internship are to provide (a) practical experience in environmental analysis and management; and (b) the opportunity to develop a dissertation covering the topic of the internship work. Internships may be served in private industry or
in government laboratories or agencies, usually at salaries typical for environmental professionals. Arrangements for the internship are the student's responsibility, but program faculty will assist. The institution and the nature of the appointment must be approved by the ESE Program Director. Supervision during the field training experience will be by the doctoral committee, the Intern Supervisor, and an appropriate mentor at the host institution. Detailed policies and guidelines for the internship are made available to the intern and the host institution (and reprinted in the next section), and a letter of agreement between UCLA and the institution is required. During each quarter of the internship, the student must register at UCLA for eight units of Environmental Health Science 599 and submit a progress report to the committee Chair and the ESE Program Intern Supervisor.

Current ESE Internship Sites

- Arco, Inc.
- Belt Collins, Hawaii
- California Air Resources Board
- California Dept. of Health Services
- California Dept. of Toxic Substance Control
- California State and Regional Water Quality Control
- Capital Environmental Engineering Corp.
- Centre of International Research for Water and Environment, France
- City of Los Angeles, Department of Water and Power
- City of San Jose, Fire Prevention, Hazardous Materials Program
- City of San Jose, Office of Environmental Management
- City of Santa Monica, City Engineer Office
- Dames and Moore, Inc.
- David Moss and Associates
- Harding Lawson Associates
- Heal The Bay
- Hughes Environmental Systems, Inc.
- Instituto Nacional de Salud Publica de Mexico
- Montgomery Consulting Engineering
- Jacobs Engineering Group, Inc.
- Kennedy/Jenks/Chilton
- Las Virgenes Municipal Water District
- Lawrence Berkeley Laboratory
- Lawrence Livermore National Laboratory
- Leson Environmental Consulting
- Los Alamos National Laboratory
- Meredith/Boli and Associates, Inc.
- Metropolitan Water District of Southern California
- National Steel and Shipbuilding Co.
- Stollar and Associates, Inc.
- Radian Corporation
- RAND Corporation
Policies And Guidelines For Internships

The following policies and guidelines for the internship experience are directed to the D.Env. candidate, the UCLA doctoral committee, and to the institution accepting the intern (the participating institution).

1. The internship may begin after the student has achieved candidacy for the D. Env. degree. This involves the completion of all required course work, including the problems courses, successful passage of the written examination and the oral candidacy examination, and other requirements stipulated by the University.

2. It is the responsibility of the candidate to locate an appropriate institution in which to serve the internship. The ESE Program Director will provide guidance about the suitability of host institutions and mentors. UCLA faculty may also assist in this process, but often the candidate has specific requirements related to the type of institution, the salary level required, and preferred location. For these and other reasons, it is preferable for the candidate to negotiate directly with the institution, with UCLA faculty assisting in whatever ways are appropriate. It is essential, however, that the ESE Program Director and the Chair of the candidate’s doctoral committee be kept informed of the negotiation process so that an inappropriate institution or position will not be chosen by the candidate.

3. Approval of the internship institution and/or position by the doctoral committee Chair and ESE Program Director is required. The Chair and Director are under no obligation to approve an institution and/or position even if the candidate has already accepted a position there. The Approval Form for Internship, Attachment B, should be filed prior to the beginning of the internship signifying acceptance of the terms of the internship by all parties. In some cases it may be that the student has already begun employment at the institution before these documents are filed. However, in such cases, as noted above, the doctoral committee is under no obligation to accept an institution to which the student may have already made a commitment.
4. Internships are for a period of 18 to 24 months, with no commitment required on the part of the institution or the student for employment or services beyond that period. Students are encouraged not to accept internship appointments which are likely to be of shorter duration than 18 months. One year appointments will be approved if there is evidence that the internship will be extremely rewarding or if other factors are compelling. However, in this case, or in the case where an internship is terminated before 18 months, the student may be required to spend another year in a second institution where the theme of the internship can be continued.

5. Interns are required to enroll at UCLA for eight units of Environmental Health Science 599 each quarter in order to remain in good standing with the University. Failure to enroll is tantamount to withdrawing from the ESE Program and may necessitate an application for readmitance. This, in turn, will require payment of a readmission fee and could result in the need for additional course work. An informative "Quarterly Report" must be submitted to each committee member, with a copy to the ESE office, by the eighth week of each quarter as tangible evidence of progress toward completion of the degree in order to receive a "Satisfactory" grade. The Quarterly Report is a minimum requirement, and the actual grade assigned is subject to an evaluation of the intern's progress by the Chair of the Doctoral Committee. A series of "Unsatisfactory" grades may lead to a recommendation that the student be dropped from the program.

6. Ideally the intern should work in a single environmental problem area and should not be shifted to a variety of unconnected projects during the internship period. It is recognized that reassignment of the intern to a new problem area during the internship may become necessary, but the work experience should not be unduly fragmented. There should be a theme of the experience which will become the theme of the dissertation. (See items 11 and 12 below.) In the case where several project assignments are necessary, it will be the responsibility of the intern to develop a dissertation which will expand on one theme and be acceptable by the criteria of item 11 below.

7. It is recognized that some interns may be required to work on confidential subjects which cannot be revealed in the dissertation. Nevertheless, the intern will be required to produce a dissertation, perhaps based in part on independent research, which meets the qualifications stated in the following paragraphs. To avoid breaches of confidentiality, the intern should share the draft of the dissertation with the institutional supervisor. The Chair of the doctoral committee should assume the responsibility for assuring that the rights of the intern and the University are protected in this connection.

8. The participating institution should provide a single individual of appropriate qualifications as the responsible party to represent the institution in the internship agreement. This person should be above the level of immediate supervisor in most cases, i.e., a division head or institutional executive, although there must be some flexibility in the administration of this rule to take into account the local situation.
9. The intern must be given the opportunity to grasp the significance of his/her own efforts to the underlying environmental problem. In general, this means the intern must have access to information on the broader aspects of the problem, including such matters as its history, previous research and techniques, future directions, and possible social, economic and political impacts when relevant.

10. The internship should be carefully monitored by the doctoral committee. Arrangements should be made for periodic conferences between the student's doctoral committee Chair (and other members, if possible) and institutional representatives. The Chair of the doctoral committee is responsible for detailed knowledge of the student's problem area and progress. The student is responsible for submitting quarterly reports to each committee member, with a copy to the ESE Program Office. The quarterly reports are expected to be narrative accounts of the activities of the intern, types of problems being addressed, and other subjects of interest, consistent with policies of the institution with regard to confidentiality and reporting. The quarterly reports are treated as work-in-progress and should not be circulated outside of the doctoral committee and the ESE Program Office.

11. The internship must result in a written dissertation. The dissertation should be a scholarly treatment of the problem area in which the intern has worked, but not a description of the totality of the experience. The dissertation should show evidence of originality and critical thought such that all or parts of it merit consideration for publication in peer reviewed media. It is possible but unlikely that a technical report or compilation of reports prepared on the job will be acceptable as a dissertation.

12. In order to assist the doctoral committee in the guidance of the intern, within nine months of starting the internship (and preferably sooner) a dissertation prospectus should be submitted by the student to the doctoral committee. The prospectus should identify the theme of the dissertation, the context of the theme within the intern's responsibilities at the participating institution, and the general outline of the dissertation. The candidate must return to UCLA in order to present and defend the prospectus before the doctoral committee.

13. The dissertation must be approved by the doctoral committee. Normally it is expected that the chair of the doctoral committee will have approved the final draft of the dissertation four weeks prior to the scheduled date of the final oral examination and before submission of the document to the other members of the committee. The final oral examination may be waived by unanimous consent of the doctoral committee.

14. A complete draft of the dissertation must be in the hands of the Chair of the Doctoral Committee before the end of the quarter preceding the quarter in which the student anticipates filing the dissertation with the Graduate Division. Applications for Doctoral Filing Fees for the final quarter must be approved by the Chair of the Doctoral Committee, who must be satisfied that the student has progressed far enough to be a viable prospect to complete the D. Env. the following quarter. This approval must be communicated to the Director of the ESE Program.
15. The dissertation will be deposited in the University Library and the ES&E Program Office and will be available for public inspection under the same regulations as other doctoral dissertations.

16. The internship requirement should normally be completed within two years after advancement to candidacy. While serving the internship, the student is required to register at UCLA for eight units of course EHS 599 each quarter. If there is a delay in beginning the internship, or if the internship is interrupted, the student is required to file a Leave of Absence Request Form for each quarter not registered. Extension of the internship period beyond the normal term must be petitioned in advance by the student and will require the approval of the ESE Director. Only compelling reasons for extending the term will be considered. Students failing to complete the D. Env. within five years following completion of candidacy requirements will be advised to drop out of the Program and to reapply when they are prepared to continue in a timely manner.

17. The internship at a participating institution may be terminated, after consultation between the responsible UCLA faculty members and representatives of the institution, for student non-performance, failure of the participating institution to provide a satisfactory educational experience, or overriding institutional considerations.

Monitoring And Evaluating The ESE Internship Experience

This section summarizes the guidance given to ESE doctoral committees for monitoring and evaluating the internship and dissertation.

Faculty who consent to be members of an ESE doctoral committee should be aware of the special nature of the degree. The D.Env. degree program is designed to train environmental analysts and managers. It builds on a strong foundation in the natural and physical sciences, but it emphasizes problem solving at the interface between science and policy. The typical ESE student has a specialization in some area of environmental science, engineering or public health, but also holds interests that are less specialized, more policy oriented, and generally more applied than the typical Ph.D. candidate in related fields.

The D.Env. program includes an on-campus experience consisting of core and breadth courses, elective courses, seminars and problem solving courses. Following successful completion of these requirements and the doctoral candidacy examinations, the student secures an internship in an approved institution. Typical institutions include private industry, government agencies, national laboratories or not-for-profit research organizations.

In approving the internship position, the ESE faculty are concerned that the internship institution will be conducive to the growth of the student, that the intern will be properly supervised, that the dissertation project, though not necessarily exclusively, is an integral part of the work experience, and that the internship is very likely to be a continuous (18-24 month) appointment.

The role of the doctoral committee is to monitor the internship and to evaluate the quality of the internship experience and the dissertation. The chair or co-chairs of the committee have a special role in communicating with the candidate and monitoring the quality of the internship experience. More specifically, the committee members and chairs
should assume the following responsibilities for each ESE student on whose committee they choose to serve:

1. Be advised of the placement of the intern (approval by the committee Chair is required) and the nature of the internship work experience anticipated.

2. Review the dissertation prospectus and examine the student at a formal hearing at UCLA within nine months of the beginning of the internship (all members).

3. Review progress reports submitted by the intern on a quarterly basis (all members).

4. Review early drafts (the Chair) and the final draft (all members) of the dissertation.

5. Attend the final dissertation defense of the candidate at UCLA and vote on the acceptability of the dissertation (all members).

Dissertation and Oral Defense.

A dissertation is required and should be a scholarly treatment of the problem area in which the intern has worked. It should show evidence of originality and critical thought such that all or parts of it merit consideration for publication in peer reviewed media. The dissertation must go beyond a description of a problem area. Neither reviews of the current state of a subject nor a chronology of the internship experience are acceptable. While the dissertation should be scholarly in content and presentation, the D.Env. is a more applied degree than the Ph.D., and the dissertation should reflect this orientation. It should generally deal with policy implications of the subject.

Not later than nine months after advancement to candidacy and the beginning of the internship, the student should present a written prospectus for the dissertation, including an outline, and defend it before the doctoral committee. Examples of appropriate prospectuses are available from the Program faculty. Upon completion of the internship, the student must defend the dissertation before the doctoral Committee. The dissertation should be completed before the final oral examination is scheduled. If all elements of the student's performance are judged satisfactory, the degree of Doctor of Environmental Science and Engineering (D.Env.) is awarded.

Time-to-Degree.

Well-prepared students, i.e., those who hold strong baccalaureate and masters degrees and have completed all or nearly all course prerequisites prior to entering the Program, should be able to complete the requirements for the D.Env. degree in 13 to 15 quarters, including the internship period.

Developing the ESE Course of Study

The ESE core faculty will act as a Committee of the Whole in approving the Program of Study of each ESE student. Upon being accepted into the Program, each student will be assigned a faculty advisor, typically from the core faculty. The Petition for Program of Study should be completed by the student in consultation with the graduate advisor prior to registration for the first quarter in residence. This draft will serve to give
the student an overview of the Program course requirements, define which courses are likely to be waived because of prior work, and identify apparent deficiencies. The list of "Courses Approved to Fulfill ESE Requirements" should prove useful in formulating the Program of Study.

Prior to the first quarter in residence, the student and faculty advisor should meet to finalize the Program of Study before submission to the ESE core faculty for approval. The original copy of the Petition will be retained in the student's file. Particular attention should be given during this counseling to the professional goals of the student and the area(s) of specialization which the student plans to pursue. Approval of the Program of Study will be required before the Problems Courses can commence.

The Program of Study should be looked upon as a working document which maybe modified as needed. After approval, the Program of Study represents an agreement between the faculty and the student upon a minimum program of study. However, if the goals of the student change, or other circumstances require it, changes in the Program of Study may be made subject to faculty approval. To ensure adherence to the Program of Study, the student's faculty advisor must approve the student's study list (both previous quarter's final course list and coming quarter's planned schedule) at the beginning of each quarter.

Figure A2.4 is the program description for the University of California: Los Angeles accessible at http://www.ph.ucla.edu/ese/.
Figure A2.5
Washington State University Program
(http://www.sci.wsu.edu/envsci/)

Program in Environmental Science and Regional Planning

Program Description

The Program coordinates two closely related fields of study: environmental science and regional planning. Environmental science is the study of natural and modified environments and their interactions with biological (including human) systems. It emphasizes comprehensive understanding of the environmental/ecological context, assessment of beneficial and disruptive impacts, and methodologies to analyze, interrelate and resolve these complex systems. The regional planning curriculum provides an understanding of basic issues, methods and processes in rural, land use, and regional planning with comprehensive studies of natural and human systems. Students in both fields acquire the holistic and interdisciplinary perspective and ecological understanding necessary to prepare them for a variety of roles in the study, planning, and management of resources and the environment.

The Program offers courses of study leading to the degrees of Bachelor of Science in Environmental Science, Master of Science in Environmental Science, Master of Regional Planning, and Doctor of Philosophy in Environmental and Natural Resource Sciences. The Master's and Bachelor's degrees in Environmental Science are also offered at WSU Tri-Cities.

Because of the diversity of these fields, the course of study for each student is flexibly designed in a unique, multi-optional interdisciplinary context. Specializations other than those identified by the Program may be developed based on specific student and faculty interests. For those seeking a B.S. degree, the Program has identified nine optional areas of specialization: agricultural ecology, biological science, hazardous waste management, human ecology, environmental education, environmental quality (air & water), natural resource management, systems, and environmental/land use planning. Environmental Science majors seeking a M.S. degree can specialize in agricultural ecology, biological science, hazardous waste management, human ecology, environmental education, environmental quality control, systems, natural resource management, or a joint Peace Corps/M.S. option. Environmental Science majors specializing in environmental education can work concurrently on endorsements for senior high school teaching. Regional planning majors can specialize in a variety of areas including land use planning, ecological planning, geographic analysis and assessment and planning & environmental policy. The Program is closely coordinated with University research units. It is administered by the College of Sciences with additional sponsorship by the Colleges of Agriculture & Home Economics, Engineering & Architecture, and Liberal Arts. The participating faculty resource list for the Program includes some 150 members representing over 40 disciplines.

Requirements for the B.S. Degree in Environmental Science

This course of study for the bachelor's degree is organized around the requirements listed below. A sequence will be designed by each student and the major advisor to provide training depth in an optional area of specialization. The Program has identified
nine optional areas of specialization: agricultural ecology, biological science, hazardous waste management, human ecology, environmental education, environmental quality (air & water), natural resource management, systems, and environmental/land use planning. (Fact sheets on each option are available from the ES/RP Program Office.) Students may also, in consultation with their advisors, develop an area of specialization outside of those identified. At least 40 of the total hours required for the Bachelor of Science in Environmental Science must be in upper-division courses, 18 of which are in the chosen area of specialization (normally in not more than two departments). Majors in Environmental Science must satisfy General University Requirements as specified for majors in the College of Sciences. Many of these requirements are built into the curriculum below. Students should note the requirements with respect to Tier I, II, and III courses and also Areas of Coherence. Each major must also complete 8 hours in a modern foreign language unless he/she has completed two years of such language in high school (or one year in high school and four hours in the same language at WSU). The Program provides a strong foundation for advanced study in many professional and basic research fields. The departmental office for the Program in Environmental Science is located in TROY HALL, Room 305. The telephone number is (509) 335-8536. If you have further questions on this degree program, please do not hesitate to speak with or write to one of the faculty.

Certification Requirements
Requirements for certification into the Bachelor of Science Program in Environmental Science:

1) completion of 30 semester hours of course work with a GPA of 2.00 and
2) completion of the courses listed in the catalog in the freshman year of the environmental science curriculum with a grade of C- or better. (Courses not required to fulfill university requirements for graduation may be waived for certification.

Freshman Year
First Semester hours
CHEM 105 Principles of Chemistry I [P] (GER) 4
ENGL 101 Introductory Writing [W] (GER) 3
MATH 140 Mathematics for Life Sciences [N] or 171 Calculus I [N] (GER) 4
Total 14/15

Second Semester hours
ANTH 101 General Anthropology [S] or SOC 101 Introduction to Sociology [S] (GER) 3
CHEM 106 Principles of Chemistry II [P] (GER) 4
ARTS & HUMANITIES [H,G] (GER) 3
ECON 101 Fundamentals of Microeconomics [S] (GER) 3
GENED 110 World Civilization I [A] (GER) 3
Total 16

Sophomore Year
First Semester Hours


<table>
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<tr>
<th>Course</th>
<th>Credits</th>
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<tr>
<td>ARTS &amp; HUMANITIES [H,G] or SOCIAL SCIENCES [S,K] (GER)</td>
<td>3</td>
</tr>
<tr>
<td>BIO S 103 Introductory Biology [B] (GER)</td>
<td>4</td>
</tr>
<tr>
<td>ENGL 201 Writing &amp; Research [W] or 402 Technical &amp; Professional Writing [W] (GER)</td>
<td>3</td>
</tr>
<tr>
<td>ES/RP 210 Microcomputer Models of Environmental Systems</td>
<td>3</td>
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<tr>
<td>PHYS 101 General Physics [P] or 201 Physics for Scientists &amp; Engineers [P] (GER)</td>
<td>4</td>
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<td><strong>Total</strong></td>
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**Second Semester Hours**

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<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>BIO S 104 Introductory Biology [B] (GER)</td>
<td>4</td>
</tr>
<tr>
<td>GENED 111 World Civilization II [A] or GEOL 102 Physical Geology [P] (GER)</td>
<td>3/4</td>
</tr>
<tr>
<td>PHYS 102 General Physics [P] or 202 Physics for Scientists &amp; Engineers [P] (GER)</td>
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<td><strong>Total</strong></td>
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**Junior Year**

**First Semester Hours**

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<th>Course</th>
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<tbody>
<tr>
<td>BC/BP 364 Introductory Biochemistry</td>
<td>4</td>
</tr>
<tr>
<td>ES/RP 335 Environmental Policy [M]</td>
<td>3</td>
</tr>
<tr>
<td>GEN CB 301 General Genetics or MICRO 301 General Microbiology</td>
<td>4</td>
</tr>
<tr>
<td>GENED 111 World Civilization II [A] or SOILS 201 Growth &amp; Development of World Crop Plants [B] (GER)</td>
<td>3</td>
</tr>
<tr>
<td>ELECTIVE</td>
<td>3</td>
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<tr>
<td><strong>(COMPLETE WRITING PORTFOLIO)</strong></td>
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<tr>
<td><strong>Total</strong></td>
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**Second Semester Hours**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ANTH 309 Cultural Ecology [K] (GER)(1)</td>
<td>3</td>
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<tr>
<td>BIO S 372 General Ecology</td>
<td>4</td>
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<tr>
<td>ES/RP 490 Special Topics in Environmental Science (2)</td>
<td>1</td>
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<tr>
<td>STAT 212 Introduction to Statistical Methods [N] (GER) or 412 Biometry</td>
<td>4/3</td>
</tr>
<tr>
<td>ELECTIVE</td>
<td>3</td>
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<tr>
<td><strong>Total</strong></td>
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**Senior Year**

**First Semester Hours**

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<tr>
<th>Course</th>
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<tr>
<td>BIO S 474 Human Ecology</td>
<td>3</td>
</tr>
<tr>
<td>ES/RP 404 The Ecosystem [M]</td>
<td>3</td>
</tr>
<tr>
<td>ES/RP 491 Senior Seminar in Environmental Science</td>
<td>1</td>
</tr>
<tr>
<td>300-400 LEVEL SOC [S,K] (GER)(3)</td>
<td>3</td>
</tr>
<tr>
<td>ELECTIVES</td>
<td>6</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
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**Second Semester Hours**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>300-400 LEVEL ECON (4)</td>
<td>3</td>
</tr>
</tbody>
</table>
ES/RP 444 Environmental Assessment 3
TIER III CAPSTONE (GER) 3
ELECTIVES 6
Total 15

(1) or other 300-400 level ANTH with [I] or [K] designation with advisor's approval
(2) one hour of ES/RP 490, 492, or 493, Special Topics is required
(3) one of the following is suggested: SOC 315, 331, 430
(4) one of the following is suggested: AG EC 311, 425, 480 or ECON 472, 481

NOTES:
• Courses taken to fulfill the above requirements, as listed, cannot be taken to satisfy requirement for the option.
• Beyond those options listed, students are encouraged, in close consultation with an advisor, to create their own options, ones more closely fitted to their specific needs; such option alternatives must be approved by the Program advisor.
• Students with a dual major or who already have a Bachelor's degree may use the other degree program as a substitution for the required option, subject to advisor's approval.
• Students should check Tier I, II, and III and Areas of Coherence requirements.

***

General Requirements for the Master of Science in Environmental Science Degree

The basic requirements for the M.S. Degree in Environmental Science are given below and are subject to completion after entering the Program in Environmental Science/Regional Planning. These requirements may be augmented to compensate for undergraduate deficiencies.

The thesis degree program must consist of not less 32 hours of credit including 6 hours of thesis credit (ES/RP 700) and a minimum of 26 hours of course work. The course work must include a minimum of 21 hours of graded course work. No more than 6 hours of non-graduate credit 300- or 400-level courses may be included. Courses graded S/F, such as ES/RP 600, may not be used for the major or supporting course work but can be included as additional work. Any course included in the advanced degree program in which a grade of C- or below is earned must be repeated but not on a P/F basis. The advanced degree program may not include courses graded P/F.

The non-thesis degree program consists of not less than 32 hours of credit including 4 hours of special problem (ES/RP 702) and a minimum of 28 hours of course work. The course work must include a minimum of 26 hours of graded course work. No more than 6 hours of non-graduate credit 300- or 400-level courses may be included. Courses graded S/F, such as ES/RP 600, may not be used for the major or supporting course work but can be included as additional work. Any course included in the advanced degree program in which a grade of C- or below is earned must be repeated but not on a P/F basis. The advanced degree program may not include course graded P/F.

By the second or third semester following admission to the Graduate School, a student should design a program of study in consultation with an advisor and a thesis committee. This committee is generally nominated by the advisor and the student, approved by the Program Chair, and appointed by the Graduate School. The program is subject to approval by the Chair and the Graduate School.
Minimum Requirements for Admission without Deficiencies

Minimum undergraduate course requirements (semester hours) for admission to the Program without deficiencies are: sociology or cultural anthropology (3); basic course in environmental science (3); biological sciences (3); general chemistry or general physics (6); calculus or statistics (3); and general ecology (4). Students admitted with deficiencies can remove them after arrival by taking suitable courses without receiving graduate credit.

Required Curriculum
Applied, Biological, Physical, or Social Sciences 3 (1)
Ecology 3 (2)
Quantitative Skills 3 (3)

ES/RP 544 Environmental Assessment 3
ES/RP 590 Special Topics 2
ES/RP 593 Graduate seminar 1 (a)
ES/RP 700 Thesis 6 or ES/RP 702 Special Problems (non-thesis) 4

Area of specialization 10/12
Total Must Be At Least 32

(a) Students are expected to take ES/RP 593 four times during the graduate program unless they have conflicts. The one credit in the program is for the semester when the talk is presented. The other credits for ES/RP 593 do not count toward the 32 total.

(1) Students are encouraged to take courses outside of their areas of specialization to fulfill this requirement.

(2) Ecology course options:
ES/RP 504 Ecosystem management
536 Modeling and simulation of ecological systems
BIO S 474 Human ecology
BOT 560 Ecophysiology
562 Community ecology
563 Field Ecology
CE 585 Aquatic system restoration
SOC 531 Human ecology
ZOOL 548 Evolutionary ecology

(3) Qualitative skills options:
AG EC 410 Applied statistical methods in agricultural economics
411 Applied operational research techniques in agricultural economics
510 Statistics for economists
511 Linear and nonlinear programming in agricultural economics
512 Advanced agricultural econometrics
ANTH 537 Quantitative methods in anthropology
E M 540 Operations research for managers
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>DEC S 412</td>
<td>Statistical methods for management</td>
</tr>
<tr>
<td>417</td>
<td>Introduction to simulation</td>
</tr>
<tr>
<td>515</td>
<td>Qualitative methods I</td>
</tr>
<tr>
<td>519</td>
<td>Applied multivariate analysis</td>
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<td>540</td>
<td>Quantitative methods II</td>
</tr>
<tr>
<td>542</td>
<td>Applied stochastic models</td>
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<tr>
<td>SOC 421</td>
<td>Quantitative techniques in sociology II</td>
</tr>
<tr>
<td>ES/RP 512</td>
<td>System dynamics models of environmental systems</td>
</tr>
<tr>
<td>536</td>
<td>Modeling and simulation of ecological systems</td>
</tr>
<tr>
<td>MATH 408</td>
<td>Mathematics for economists</td>
</tr>
<tr>
<td>409</td>
<td>Elements of mathematical economics</td>
</tr>
<tr>
<td>415</td>
<td>Intermediate differential equations</td>
</tr>
<tr>
<td>417</td>
<td>Introduction to simulation</td>
</tr>
<tr>
<td>420</td>
<td>Linear algebra</td>
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<tr>
<td>421</td>
<td>Algebraic structures</td>
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<tr>
<td>430</td>
<td>Statistical methods in engineering</td>
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<tr>
<td>440</td>
<td>Applied mathematics</td>
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<tr>
<td>441</td>
<td>Applied mathematics II</td>
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<tr>
<td>442</td>
<td>Statistical methods for engineers and scientists</td>
</tr>
<tr>
<td>443</td>
<td>Applied probability</td>
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<tr>
<td>444</td>
<td>Introduction to statistical theory</td>
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<tr>
<td>448</td>
<td>Numerical analysis</td>
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<tr>
<td>451</td>
<td>Statistics for teachers</td>
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<tr>
<td>464</td>
<td>Operations research and game theory</td>
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<tr>
<td>466</td>
<td>Optimization in networks</td>
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<td>472</td>
<td>Statistical packages</td>
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<tr>
<td>510</td>
<td>Topics in probability and statistics</td>
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<tr>
<td>512</td>
<td>Ordinary differential equations</td>
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<td>540</td>
<td>Partial differential equations</td>
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<td>541</td>
<td>Partial differential equations II</td>
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<td>548</td>
<td>Statistical theory</td>
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<tr>
<td>549</td>
<td>Statistical theory II</td>
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<tr>
<td>563 (STAT 562)</td>
<td>Mathematical genetics</td>
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<tr>
<td>564</td>
<td>Topics in optimization</td>
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<tr>
<td>573</td>
<td>Reliability theory</td>
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<tr>
<td>586</td>
<td>Topics in mathematical modeling in natural science</td>
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<td>428</td>
<td>Geostatistics</td>
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<td>Statistical methods in engineering</td>
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<td>Statistical methods for engineers and scientists</td>
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<td>443</td>
<td>Applied probability</td>
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<td>444</td>
<td>Introduction to statistical theory</td>
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<td>472</td>
<td>Statistical packages</td>
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<td>510</td>
<td>Topics in probability and statistics</td>
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<td>512</td>
<td>Analysis of Variance and designed experiments</td>
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Options

Specialization areas other than those identified by the Program may be developed based on specific student and faculty interests. The option areas identified within the Program are:

1. Agricultural Ecology
2. Biological Science
3. Environmental Education
4. Environmental Quality Control
5. Hazardous Waste Management
6. Human Ecology
7. Natural Resource Management
8. Peace Corps/M.S. Joint Program
9. Systems

The Doctoral Program

Program description

The Ph.D. in Environmental and Natural Resource Sciences is an interdepartmental degree program at Washington State University sponsored by the Natural Resource Sciences Department and the Program in Environmental Science and Regional Planning.

Environmental and natural resource sciences comprise an association of several areas of study at Washington State University. These sciences focus on factors related to the understanding and management of the environment and therefore have a commonality of interest. The Ph.D. program in Environmental and Natural Resource Sciences provides opportunities for doctoral study that involve integration and interaction among these various fields of science. The cooperation of WSU’s faculties in environmental and natural resource sciences in this program foster important exchanges of knowledge that greatly enhance interdisciplinary education.
Graduates of the program will have a special responsibility to address the complicated physical, biological, social and political issues of environmental and natural resource management. As the world's human population continues to grow, the impacts on natural and modified environments and non-urban land uses will increase. It will take responsible, knowledgeable and committed people, backed by a strong ecological and cultural understanding, to integrate resource-oriented positions in policy and planning, and to communicate the principles necessary to resolve environmental and natural resource issues.

As environmental and resource problems are common to many countries (e.g., long-range transport of pollutants, waste management, deforestation of tropics, misuse of rangelands, conservation of wildlife species, growth management), it is expected that a significant international dimension of the program will develop.

Objectives
The objectives of the Ph.D. program in Environmental and Natural Resources are:

1. To provide an atmosphere of scholarship coupled with research opportunities that will produce people capable of responding to the complicated issues of use, management and protection of the environment and its natural resources.
2. To foster the pursuit of interdisciplinary research in environmental and natural resource sciences and to facilitate a better understanding of the ecological, social and economic relationships inherent in environmental and natural resource issues.
3. To produce scientists who will assume leadership roles in the research and management of natural resources and the environment.
4. To prepare students for working with, and within, public and private agencies responsible for the management or protection of natural resources and the environment.

Figure A2.5 is the program description for Washington State University accessible at http://www.sci.wsu.edu/envsci/.
Figure A2.6
University of Virginia Program
(http://www.evsc.virginia.edu/)

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Department of Environmental Science
Advancing Understanding Of The Environment Through Interdisciplinary Research And Education.

Introduction

The Department of Environmental Sciences is an academic department in the College of Arts and Sciences, offering instruction and conducting research in the areas of Ecology, Geosciences, Hydrology, and Atmospheric Sciences. This unique juxtaposition of several sciences in one Department fosters cooperation and exchange among traditional disciplines that share similar methodological and philosophical problems. The research endeavors of both faculty and graduate students, whether disciplinary or interdisciplinary, deal largely with problems of fundamental scientific interest and to a lesser extent with applied science, management or policy making.

In addition to a full undergraduate program, the Department offers graduate degree programs leading to the Master of Science and Doctor of Philosophy, emphasizing basic research of a disciplinary or interdisciplinary nature. The faculty offers a wide range of graduate courses in the above areas, as well as several weekly seminars featuring invited speakers. In addition, the Fred Holmsley Moore lectures bring distinguished speakers to the Department to lecture on issues of broad environmental concern. Students have the opportunity of pursuing their own research questions or participating in faculty research programs.

Environmental Sciences is an interdisciplinary field concerned with the interaction of processes that shape our natural environment. The Environmental Sciences major provides strong preparation for (1) employment in natural resource fields through liberal arts science training; (2) professional schools through a focus on the reasoning, analysis and management skills that involve natural processes; and (3) graduate school in one of the disciplines through its in-depth training in theory and method.

The department of Environmental Sciences, located in Clark Hall, offers core courses in ecology, geosciences, hydrology, and atmospheric sciences as well as liberal arts, science writing, pre-professional, and methodology classes. To complement a strong curriculum the department sponsors the Environmental Sciences Organization (ESO), a majors seminar, and research opportunities. The ESO schedules activities including academic advising sessions, lectures, career talks, receptions, field trips, and parties. The one credit majors seminar introduces the University community to issues and career opportunities in Environmental Sciences. The department encourages all majors to explore opportunities to work with the faculty and graduate students on projects.

For students interested in the Environmental Sciences major/minor or in our graduate program, information is available from our Prospective Students web page; information on the major is also available in the lobby of Clark Hall. Students interested in the major are encouraged to schedule an appointment with one of the faculty members. Students seeking an undergraduate advisor should contact: Wallace Reed at 924-7761. All Environmental Sciences students interested in career opportunities, summer placements,
and academic funding should consult the bulletin boards and literature outside the main office, Clark 204. Telephone: 924-7761.

**History**

The Department of Environmental Sciences was established by President Edgar Shannon in 1969 by amalgamation of the University of Virginia departments of geography and geology. This new academic program, created after one year of intense research and evaluation, was to focus on earth surface processes, or cross-discipline subjects, such as geomorphology, geohydrology, soils, shallow-water oceanography, climatology, and ecology. Initially, emphasis was to be placed on Virginia and the middle Atlantic coast environments, including the Chesapeake Bay and the coastal barrier islands.

When the department was established in 1969 it was the first in the nation to offer degrees from the BA through to the Ph.D. level in the environmental sciences, and although the program has diversified over the past 30 years, the current teaching and research underway in the department still reflects these early plans and goals. Today, the Department has four defined areas of interdisciplinary specialization, surface geology and geomorphology, atmospheric processes, hydrology, and ecology, in addition to a strong research focus in biogeochemistry. The faculty has grown from 12 in 1969 to over 40 today.

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**Undergraduate program**

**Exploring the Major**

Environmental Sciences is an interdisciplinary field concerned with the interaction of processes that shape our natural environment. Because of its interdisciplinary nature, the academic program is broader than most other science programs. The Department of Environmental Sciences conducts research and offers instruction in the areas of Ecology, Geosciences, Hydrology, and Atmospheric Sciences. This unique integration of several sciences fosters cooperation and the exchange of information and ideas on the scientific problems and issues of the environment. The research efforts of both faculty and students, whether disciplinary or interdisciplinary, deal largely with problems of fundamental scientific interest and, to a lesser extent, with applied science, management and policy making.

**Goals:** Study within the department can be structured to meet any of the following objectives:

- preparation for further graduate study within the sciences
- development of a rigorous science background from which to pursue graduate-level training in a professional program such as law, planning, medicine, business, or environmental engineering
- a thorough grounding in a basic discipline as the principle component of a liberal arts education.

**Related Sciences:** Each of the four areas studied within the Department requires the acquisition of knowledge from other fields. Ecology depends upon a basic understanding of chemistry and biology. Hydrology, geosciences, and atmospheric science depend more on physics and chemistry. All of these areas depend on calculus and the techniques of statistics and computer programming. Most applications and analysis of legal or policy
issues depend on basic economics. The Department's required related work in many of these areas fosters success in research and in the competition for top jobs and graduate school.

**Environmental Sciences Home Page:** http://www.evsc.virginia.edu

**Beginning the Major**
There is an extensive array of courses offered through the Department.
Introductory courses are usually conducted in a lecture format. Some of these courses are large, but faculty members are easily accessible. The 100- and 200-level Environmental Sciences non-core courses present a basic introduction to the concepts, methods, and terminology of geosciences, hydrology, ecology, and atmospheric sciences. None of these courses have prerequisites, all are taught by senior faculty and all of them provide an enjoyable means of sampling an areas of environmental sciences. For students well-prepared in related sciences, or with at least one semester of introductory college chemistry, biology or physics, one of the core courses, especially EVSC 280 Physical Geology or EVSC 320 Fundamentals of Ecology, would be an excellent first advanced course. Once a student has completed the core courses in our area, he or she can chose from advanced courses taught in lecture, seminar, laboratory, or field instruction formats. Most of these classes are quite small and all are taught by the faculty.

**Advanced Placement Credit**
Three credit hours toward EVSC 101, Introduction to Environmental Sciences will be granted for achieving a 4 or 5 on the Environmental Sciences Advanced Placement Course exam.

**Options Within the Major**
Many Environmental Sciences majors concentrate their program in one or two fields with professional schools and graduate programs in mind. Others use the breadth and interdisciplinary nature of the curriculum to prepare for careers in science writing and methods, in teaching, or in the management of the environment and environmental programs. Examples of Environmental Sciences careers enjoyed by former majors include:

**Atmospheric Science**
Weather forecasting, air pollution modeling and management, weather modification, bioclimatology and agricultural management, research consulting in meteorology and climatology.

**Geosciences**
Coastal process consulting, engineering geology land use planning and management, groundwater pollution research and consulting, sedimentary process modeling.

**Ecology**
Aquatic ecology and fisheries consulting, forestry and agricultural management, park and recreation planning and management, resource conservation, toxic soil and water pollution research.

Hydrology and Water Resources
Groundwater management, flood and surface water management and consulting, water pollution research and regulation, water project economics, hydraulic modeling and analysis.

For placement and other purposes, the Department maintains close ties with its alumni throughout the world.

Course Requirements

The Major
All Environmental Sciences majors must complete 30 hours of graded course work in the Department. Three of the 30 hours may be taken from any of the 100- and 200-level non-core courses prior to the third year. At least 11 hours must be advanced non-core courses at the 300- or higher level. Four core courses with labs are required of all majors.

EVSC 280+280 L Physical Geology (3) (1)
EVSC 320+320 L Fundamentals of Ecology (3) (1)
EVSC 340+340 L Physical Hydrology (3) (1)
EVSC 350+350 L Atmosphere and Weather (3) (1)

Related Work
The Department also requires related work in math and science. The required related work includes one semester of calculus and two semesters of college-level chemistry, biology, or physics with laboratories. The courses recommended to fulfill this requirement include: MATH 131; and any two of the following: CHEM 141, CHEM 142, BIOL 201, BIOL 202, PHYS 231 or PHYS 232 with their labs. Calculus is a prerequisite for 3 core courses for the major. Ecology depends on a basic understanding of chemistry and biology. Geosciences, hydrology, and atmospheric sciences depend more on chemistry and physics. Additional skills, recommended but not required, include: Computing (CS 101; Statistics (STAT 112); and Economics (ECON 201, 202).

Completing Core Courses Early
Completing Core Courses By The Fourth Year - The interdisciplinary nature of most of Environmental Sciences advanced courses is one of the great strengths and unique features of the major. To take maximum advantage of these interdisciplinary courses, students should complete the 4 core courses by the beginning of their fourth year.

The Minor
The Environmental Sciences minor is an excellent addition to any liberal arts, preprofessional, or science graduate school-oriented major. Many students interested in legal, business, foreign policy, or other applications in natural resources, in writing and
communication involving science, in methods of analysis, or simply in understanding how their natural environment works enjoy the minor. The minor consists of at least 16 hours of Environmental Sciences course work in a program chosen by the student and approved by the Department. The program must include at least two core courses with labs and one advanced non-core course at the 300- or greater level. No more than six hours of non-core courses below the 300- level are counted.

30 HOURS AND ALL THE REST

What is my Major?
The Department is often asked why we will not count specialized courses such as zoology taken at another school, or courses in environmental planning or economics, as part of our major or minor. The reasons are as follows.

The Department believes that its 4 core courses, a 14 hour mix of Environmental Sciences electives and the required related work in science and calculus is the minimum preparation needed to be a competitive environmental scientist. In order to be confident that majors have mastered our way of training, we normally require that all courses taken for the major are taught by our faculty. Thus, we are quite rigid about expecting majors to take at least 30 hours of Departmental courses including the cores. (This is the count of hours used to certify completion of the major for graduation.)

Recognizing that the 30 hour major is a minimum requirement, we hope that majors will take many more courses in Environmental Sciences and in many other areas. Most majors do take work in other areas, and often at other schools here or abroad. Although these hours are not counted into the Departmentally defined major, they are critical to each student's personal major. Your major is the sum of your experiences as they relate to your interests in environmental sciences. It is this full mix of your experience that you will explain to others in covering letters and interviews at each stage of your career advancement. Your official University of Virginia transcript upon graduation will carry the designation Environmental Sciences Major, but will not identify the courses that counted toward the major. Thus, you define and explain your personal major and the relevant experiences each time you are asked. Your transcript designation of the major only certifies that the Department believed you had taken at least the minimum experience needed to be an Environmental Scientist.

Research Opportunities
The Department encourages all majors to explore opportunities to work with faculty and graduate students on projects. Participating in a research project provides practice in using the tools of various disciplines and helps develop career goals and opportunities. Most research with faculty or graduate students can be rewarded with course credit or wages. Examples of projects on which students have worked include: Shenandoah Watershed Study; Virginia Coast Reserve Long-Term Ecological Research Program; and Global Environmental Change Project.

International Exchange Programs
The University of Virginia has formal undergraduate exchange programs with the University of East Anglia, Norwich, England and Lancaster University, Lancaster,
England. Both institutions offer a range of courses in environmental sciences recommended by our Department. Because of the formal agreement, the Department will accept a number of these courses into our 30 hour major. Information on both programs is available in the International Studies Resource Library, Minor Hall 216. Be sure to consult your Departmental advisor concerning course selection.

**Honors and Awards**

The Department participates in the College's Distinguished Majors Program designed for highly qualified students with an overall GPA of 3.4 or above. The level of research achievement determines the level of distinction a student will receive at the end of the fourth year. It is best to begin this program in the early portion of the third year because the research must generally be complete by early March of the fourth year. The graduating major with the overall highest GPA receives the Department's Wallace-Poole Award and the most outstanding graduating students in Geosciences and ecology receive the Wilbur Nelson and Mahlon Kelly awards. The Department awards two additional awards for the outstanding graduating students in atmospheric sciences and hydrology.

**Facilities**

The Department of Environmental Sciences is located in Clark Hall, along with the Science and Engineering Library, on the central grounds of the University. Additional laboratory space is located in Halsey Hall and Maury Hall. Departmental facilities include field vehicles, boats, a machine and electronics shop, environmental chambers, analytical chemistry laboratories with extensive instrumentation, greenhouse and insectory facilities, state-of-the-art computers including a computational hydrology laboratory, GIS facility, NAFAX and FAA weather information, and GOES-Tap satellite receiver. Departmental field facilities include the Pace/Steeger teaching/research site.

Major interdisciplinary research initiatives in the department include the Virginia Coast Reserve/Long-Term Ecological Research (VCR/LTER) studies based on Virginia's Eastern Shore. A laboratory/dormitory facility is located at Oyster, VA, and individuals from all disciplines in the department carry out research related to coastal systems through the LTER program. The Shenandoah Watershed Study (SWAS) operates several calibrated watersheds in Shenandoah National Park to investigate controls on biogeochemical cycling. Blandy Experimental Farm and the Orland E. White Arboretum are centers for ecological research near Front Royal, VA. The Program of Interdisciplinary Research in Contaminant Hydrogeology (PIRCH) is staffed by several department faculty and faculty from other departments. Research on hydrogeology, geochemistry, and microbiology of the subsurface is underway in the laboratory, on the computer, and in the field. Another research focus for faculty and graduate students is the study of Global Environmental Change (GECP), an international research and training program which studies the large-scale dynamics of the earth's surface. The goal of the training program is to understand, at the global scale, the impact of environmental change on terrestrial ecosystems. Its current focus is the development and application of computer models that can predict the responses of the terrestrial surface to changes in the atmosphere. This is a critical task in improving our understanding of how the Earth's surface functions and responds to changed environmental conditions.
Activities and Organizations

Environmental Sciences Organization (ESO): This organization schedules activities including academic advising sessions, lectures, career talks, receptions, field trips, and parties. Activities are arranged to enable the student to become better acquainted and to establish good contacts with other undergraduates, graduates and faculty of the Department outside of classroom and office situations.

General Information

The Environmental Sciences Organization (ESO) provides a link between the Environmental Sciences Department and the students of the University. While the organization is mainly geared toward undergraduate majors and minors in the department, it has its share of members from many different disciplines of the University. However, all members have one thing in common--an interest in the Environmental Sciences.

ESO aims to aid students in becoming more involved in and educated about the Environmental Sciences Department. Members are provided with many opportunities to get to know the professors in the department as well as what the department has to offer outside of a major or minor. One of the organization's core components is the aid, advice, and support that members have to offer each other about courses, activities, and resources within the department. ESO is able to do this through its many activities such as peer advising about courses, seminars about the department and professions in the Environmental sciences, and career and job search resources. However, the organization also offers hiking and other field. All University students are welcome to join and participate in any activity.

Although not sponsored by ESO, the EVSC 493 Majors' Seminar is supported by the organization. The seminar covers the interests of the Department of Environmental Sciences and the specific issues related to the environment. Current research in the department, local concerns, and world-wide environmental issues broadly categorize the seminar topics. The major's seminar is offered every semester. Check the department newsletter in the lobby of Clark Hall for more information. ESO encourages all interested students, particularly majors and minors in the department, to attend the majors' seminar before they graduate.

Meetings

Meetings are held every Tuesday evening at 5:00 PM in Clark 145. They include announcements about activities in the department as well as the University. Members then break up into committees often chaired by the officers by the organization, however the organization encourages any member to devise and chair a committee if they so choose. The role of the committees is to individually focus on the many activities that the organization has to offer. Members are welcome to join as many or as few committees as they please and to be as active in the organization as they desire. There are no dues, so membership is based on attendance at the weekly meetings. All are welcome.

Contact Information

Spring 1999:
Melissa Kenney, President mak3w
Cory Shapard, Vice President cjs4v
Cat Shaw, Secretary cas8d
Melanie Allen, Treasurer mla9t
Ashley Townsend, Historian att7e
List of Officers
ESO offers a number of leadership positions within the organization. Each officer is encouraged to chair a committee within the organization. Many times, the officers are declared majors or minors in the department. They usually have much experience with the department and its professors. There are typically five of these positions:
The President typically plans and runs the meetings and coordinates the activities of the various committees. He/she aids the other officers in their committees while often chairing a committee as well. The president serves as the prime liaison between the department and ESO members. This officer is also the contact for others outside the department and University about opportunities for students interested and involved in environmental sciences. The Vice President aids the president in his/her responsibilities. In the absence of the President, the Vice President will often take his/her place in a meeting or activity. This officer may be in charge of smaller planned activities that do not require committees or may chair more than one committee. The Secretary takes the minutes for each meeting. He/She is responsible for e-mailing members weekly reminders about meetings and other activities. This officer also posts each meeting’s minutes on e-mail for those students who were not able to attend the meeting. The Treasurer is in charge of handling and recording any expenses and earnings of the organization. Most importantly, the/she works with the president to gain financial appropriations from Student Council each year through the writing and presentation of a proposal. The Historian is responsible for documenting the organization's activities. He/She often attends many of the activities in order to photograph the events. This officer then assembles the pictures and information gained at these activities in a scrapbook and/or posts them on the ESO bulletin board and the webpage.

Upcoming Activities
Fall Fair The Fall Fair is sponsored by ESO every fall semester. It is a presentation of the four concentrations offered by the department, along with other opportunities for students interested in the Environmental Sciences Department. Majors and faculty are present to answer any questions that students may have about the department, including advice about classes and opportunities outside of classes. The fair provides a good chance for students involved or interested in the department to become acquainted with one another and with the faculty. The event is accompanied by a reception. Hiking Trips Due to the beautiful weather during the beginning of the fall semester, ESO tries to plan at least one hiking trip around that time. In the past, the organization has sponsored trail-rebuilding projects as well. These events are often popular and always a good time. Come join us if you're interested.

Majors Seminar (EVSC 493): This one-credit seminar organized by ESO introduces the University community to issues, research and career opportunities in Environmental Sciences. Recent topics have included park resource protection, estuarine processes, sustainability, managing industrial wastes, environmental law, and graduate schools.
Sigma Gamma Epsilon (SGE): SGE is the National Earth Sciences Honor Society. Students who have performed well in the area of hydrology and Geosciences are eligible for membership in the University's Beta Kappa chapter.
Additional Information

The Department encourages anyone with an interest in Environmental Sciences to schedule an appointment with one of the faculty members. A current list of peer major advisors is also available from the faculty. Students should contact:

Wallace Reed, Faculty Advisor
Department of Environmental Sciences
Clark Hall, University of Virginia
Charlottesville, VA 22903
Phone: (804) 924-0567
e-mail: wer@virginia.edu

Majors Newsletter
New courses, Department events, opportunities and career advising.

Course Listings
Descriptions of all Environmental Sciences undergraduate courses.

Environmental Sciences

EVSC 101 - (3) (Y) Introduction to Environmental Sciences
Introduces the principles and basic facts of the natural environment. Topics include earth materials, land forms, weather and climate, vegetation and soils, and the processes of environmental change and their implications to economic and human systems.

EVSC 120 - (3) (Y) Elements of Ecology
A basic introduction to the science of ecology and its application to current environmental issues. A number of topics relating to population growth and regulation, biodiversity, sustainability, and global change are used as a framework to investigate basic ecological principles. Emphasis is placed on the application of basic science to the understanding and mitigation of current environmental problems.

EVSC 140 - (3) (Y) Water on Earth
Study of the natural history of the Earth's hydrosphere, including its origin, evolution, and importance in Earth processes. Introduction to the hydrological cycle and the role of water in a variety of Earth processes. Discusses human influences on the hydrosphere and current topics in hydrological science and water resources, such as contamination and resource allocation, with an emphasis on the scientific basis for past, present, and future decisions.

EVSC 148 - (3) (Y) Resources and the Environment
Explores the impact of people on the environment in the past and present with projections for the future. Addresses the phenomena and effects of food and energy production and industrial processes. Topics include lead pollution, acid rain, the greenhouse effect, and the disposal of radioactive waste. Course format demonstrates how
the environment works in the absence of humans and then discusses how human use of resources perturbs the environment.

EVSC 161 - (3) (SS) Land Use and Environmental Impact
   Introduction to atmospheric, hydrologic, geologic and biologic process effecting land usage. Analysis of land use change due to physical and economic processes.

EVSC 181 - (3) (Y) Climate Change: Past and Future
   Exploration of past changes of the Earth's climate system (atmosphere, oceans, vegetation, land surface and ice sheets) caused by changes in atmospheric CO2, the strength of the sun, the Earth's orbit around the sun, volcanic eruptions, and plate tectonics. Future climate change is projected based on past changes.

EVSC 186 - (3) (Y) Climate Change: Past and Future
   Exploration of past changes of the Earth's climate system (atmosphere, oceans, vegetation, land surface and ice sheets) caused by changes in atmospheric CO2, the strength of the sun, the Earth's orbit around the sun, volcanic eruptions, and plate tectonics. Future climate change is projected based on past changes.

EVSC 201 - (3) (S) Materials That Shape Civilizations
   Review of the structure, properties, methods of production, uses, and world supply of the materials on which present and past civilizations have been based; including materials used in heavy industry, construction, communications, medicine, as well as textiles and naturally occurring organic materials. Special emphasis given to effects of environment on materials and energy relationships.

EVSC 210 - (3) (Y) Beaches, Coasts and Rivers
   Study of the geologic framework and biophysical processes of the coastal zone, and the role of the major river systems in modifying the coastal environment. Emphasizes human modifications, including case studies along the Atlantic, Gulf and Pacific coasts.

EVSC 215-- (3) (Y) Introduction to Oceanography
   Analysis of the basic principles which govern the world's oceans and their integration into an understanding of the major marine environments. Associated topics include marine pollution, global climate, and marine policy.

EVSC 222 Conservation Ecology: Biodiversity and Beyond
   Conservation Ecology is an exploration of the scientific basis of environmental conservation in its broadest sense: maintaining environments, not simply maintaining species. The course will focus on essential ecological concepts for sustaining populations, species, ecosystems and the biosphere. Investigation of the biodiversity crisis will go beyond the functioning of individual species to interactions among species and influences of species on critical ecosystem functions. The effect of environmental changes that do not threaten particular species, but substantially alter the nature and services of ecosystems will also be stressed. Case studies from around the world will demonstrate links between
human-driven environmental change and the health of the biosphere at all levels from the organism to the planet.

EVSC 230 Introduction to Environmental Policy

EVSC 250 - (3) (Y) Man's Atmospheric Environment
Long-term global climatic controls and short-term severe weather events such as hurricanes and tornadoes are treated in terms of the physical laws governing the motions of the atmosphere and the energy driving the system. Climatic and atmospheric events which severely impact upon human behavior are discussed. Explores responses by early and modern man to perturbations in the weather and climate. Examines utilization of renewable energy residing in the sun, wind, and water; and advertent and inadvertent weather modification.

EVSC 280 - (3) (S) Physical Geology
Prerequisite: None; Recommended: at least one semester of college chemistry with lab such as CHEM 141, 142

Studies the composition, structure, and internal processes of earth; the classification, origin, and distribution of earth materials; earth's interior; and the interpretation of geological data for the solution of problems of the natural environment.

EVSC 280L - (1) (S) Physical Geology Laboratory
Corequisite: EVSC 280
Field and laboratory experimentation into the nature of earth materials and processes especially as applied to use and human problems.

EVSC 320 - (3) (S) Fundamentals of Ecology
Prerequisites: One semester of calculus; Recommended: at least one semester of college-level chemistry and biology with labs such as CHEM 141, 142 and BIOL 202

Study of energy flow and nutrient cycling and allocation in natural ecosystems. Organization of species at the population and community levels. Interaction between man and the biosphere.

EVSC 320L - (1) (S) Fundamentals of Ecology Laboratory
Corequisite: EVSC 320
Field and laboratory experimentation illustrative of ecological systems, and their checks, balances, and cycles.

EVSC 340 - (3) (Y) Physical Hydrology
Prerequisites: One semester of calculus

Study of the physical principles governing the flow of water on and beneath the earth's surface. Includes fundamental concepts of fluid dynamics applied to the description of open channel hydraulics, ground water hydraulics, and dynamics of soil moisture. Provides an introduction to elements of surface water and ground water hydrology. Explores man's influence on his hydrological environment.
EVSC 340L - (1) (Y) Physical Hydrology Laboratory  
Corequisite: EVSC 340  
Field and laboratory experimentation illustrative of the hydrological cycle, including energy and mass transfer in surface and ground water.

EVSC 350 - (3) (Y) Atmosphere and Weather  
Prerequisite: One semester of calculus; Recommended: at least one semester of college physics with lab such as PHYS 231, 232  
An introduction to the physical laws governing atmospheric behavior which provides an understanding of atmospheric variables and their role in the fluid environment of the earth.

EVSC 350L - (1) (Y) Atmosphere and Weather Laboratory  
Corequisite: EVSC 350  
Study of the principles of measurements, instrumentation for measuring atmospheric parameters, and methods of observing and calculating atmospheric variables.

EVSC 362 - (3) (S) GIS Methods  
Prerequisites: The equivalent of the College natural science/mathematics and social science area requirements. Experience with word processing, file managers, and other computing skills is essential.  
Explores the theory of Geographic Information Systems (GIS) and their applications in a range of disciplines. Various GIS software packages are utilized. Example applications are from physical and social sciences, often with a focus on the Charlottesville-Albemarle area. For students interested in immediate applications of GIS in their work.

EVSC 384 - (4) (Y) Earth Surface Processes and Landforms  
Prerequisites: EVSC 280 or permission of instructor  
Examination of erosional processes and their role in creating landforms. Explores the influence of processes and landforms on land use and the human environment, including hazards from floods and landslides.

EVSC 385 - (3) (Y) Geodynamics  
Prerequisites: EVSC 280, calculus and physics  
Study of the basic principles of continuum mechanics and their application to problems in the geological sciences, including the behavior of the Earth's lithosphere, rock mechanics, and flow of water.

EVSC 386 - (3) (IR) Introduction to Geochemistry  
Prerequisites: CHEM 141, 142 and EVSC 280  
Study of the principles that govern the distribution and abundance of the elements in the Earth's lithosphere, hydrosphere, biosphere, and atmosphere.

EVSC 401 - (3) (Y) Evolutionary Biology
Prerequisites: MATH 131 and EVSC 320 or BIOL 201 and 202, or permission of instructor

Provides an evolutionary approach to population ecology, animal behavior, and genetics. Topics include the principles of natural selection and the evolution of the phenotype, population regulation and life history evolution, mating systems, foraging behavior, speciation, and phylogeny reconstruction. Includes a weekend field trip to Mountain Lake Biological Station.

EVSC 415 - (3) (IR) Topics in Oceanography
Prerequisites: One year college-level science

An introduction to oceanography together with a survey of marine resources and the scientific basis for their management.

EVSC 420 - (3) (Y) The Ecology of Coastal Wetlands
Prerequisite: EVSC 320 or equivalent

A detailed investigation of the ecology of coastal interface ecosystems, including sea grass, mangrove, and salt marsh. Emphasizes biogeochemistry, succession, and dynamic processes related to the development and maintenance of these systems. The differences between tropical and temperate coastal systems are also explored.

EVSC 421 - (3) (IR) Population Ecology
Prerequisites: EVSC 320 and one year of college-level biology

Analysis of the processes of population growth, dispersion, natural control of numbers, and species interactions in plants and animals. Explores strategies of population management. Three lecture and three field or laboratory hours.

EVSC 423 - (3) (O) Marine Environments and Organisms
Prerequisite: EVSC 320 or equivalent

A survey of the major habitats of marine and estuarine areas and the organisms which have adapted to life in these environments. Emphasizes the organisms and communities which have evolved in response to stress and competition in the sea, and the systematics and natural history of marine organisms.

EVSC 425 - (3) (O) Plants and Insects
Prerequisites: EVSC 320 or permission of instructor

Study of the classification, evolution, anatomy, ecology, and interactions of insects and flowering plants. Topics include the evolution of insect body plans and life-histories, and of floral anatomy and pollinator specificity, plant and insect coloration, mimicry and crypsis, breeding systems in plants, sociality in insects, sexual selection, herbivory, pollination, and seed predation and dispersal.

EVSC 425L - (1) (O) Plants and Insects Laboratory
Prerequisite or corequisite: EVSC 425

Laboratory exercises and field trips demonstrating the anatomy, morphology, identification, and classification of plants and insects.
EVSC 426 - (3) (E) Biogeography
Prerequisite: EVSC 320
A critical discussion of the roles of earth history, adaptation to the physical environment, and biological interactions in determining plant and animal distributions. Geographical patterns in species diversity, composition, morphology, and abundance are examined with reference to insular situations. Includes a historical development of ideas in biogeography as well as quantitative analysis of geographical patterns. Examines implications of biogeographic data for ideas about community ecology.

EVSC 427 - (4) (Y) Soil Science
Prerequisites: EVSC 280 and EVSC 320; one year college chemistry or permission of instructor
Introduction to the study of soils as a natural system. Topics include the fundamentals of soil chemistry, hydrology, and biology with respect to genesis, classification and utilization.

EVSC 428 - (4) (Y) Environmental Microbiology
Prerequisites: BIOL 201, CHEM 141, 142, EVSC 320
Analysis of the impact of microbial physiologic reactions on environmental quality: microbes as transformers of chemical pollutants; microbes as transformers of nutrient elements; microbes as agents of energy transfer in ecosystems; and microbes as contaminants. Emphasizes the quantitation of microbial activities.

EVSC 430 - (3) (0) Management of Forest Ecosystems
Prerequisites: EVSC 320, EVSC 340 or EVSC 350 recommended
An integrative study of processes in forest ecosystems which effect management decisions. Emphasizes the interactions between the physiological processes of plants and system level functions such as the cycling of nutrients and the flow of energy and water. Examples of current and projected uses of forest systems are discussed throughout including harvesting for fiber and energy, and the preservation of forests as water purification and air pollution control systems.

EVSC 443 - (3) (IR) Statistical Hydrology
Prerequisites: EVSC 340 and MATH 111, 112 or equivalent
Application of elements of mathematical statistics and probability theory to sampled data of hydrological processes, and the synthesis of data for information applicable to the design and management of water resources systems.

EVSC 444 - (4) (Y) Applied Hydrology
Prerequisite: EVSC 340
Introduction to hydrology as applied to environmental problems including water resources, systems analysis, and the effects of urbanization and land use on the hydrological cycle. Three hours lecture, two hours laboratory.

EVSC 447 - (3) (Y) Introduction to Climatological Analysis
Prerequisites: One semester of calculus; recommended: EVSC 350
Discussion of the general circulation of the atmosphere, followed by quantitative analyses of climatic fluctuations and their impact upon ecologic and economic systems.

EVSC 455 - (3) (O) Synoptic Climatology
Prerequisite: EVSC 350 or equivalent, or permission of instructor
Study of the formation, movements, and meteorological and climatological attributes of synoptic-scale weather systems and the impact on the environment. Explore the relationship of these systems to problems such as air quality, atmospheric transport, climate change, and evaporation and precipitation regimes.

EVSC 457 - (3) (Y) Microclimatology
Prerequisite: EVSC 350 or permission of instructor
Analysis of the principles governing atmospheric processes occurring at small temporal and spatial scales near the Earth's surface, including energy, mass and momentum transfer. Topics include features of the atmospheric environment effecting plants and feedback mechanisms between plants and their local microclimates, trace gas exchange between the terrestrial biosphere and the atmosphere, energy budgets, evapotranspiration, and motions near the surface.

EVSC 458 - (3) (O) Introduction to Tropical Meteorology
Prerequisite: EVSC 350 or equivalent course in introductory meteorology; or permission of instructor
Study of the atmospheric processes of the tropics and the role which the tropics plays in the global atmosphere.

EVSC 459 - (3) (E) The Weather of the Rain Forest
Prerequisites: EVSC 350 or equivalent course in introductory meteorology; or permission of instructor
The equatorial rain forest is presented as an interactive system where the state of the atmosphere is an integrated result of interactions between the hydrosphere, biosphere and atmosphere.

EVSC 462 - (3) (Y) Land Use Management
Prerequisites: ECON 201, 202 recommended, two environmental sciences core courses
Study of the techniques for analyzing, projecting, and managing land usage. Examines goals for, and the interaction of economic, social and physical processes in land use management.

EVSC 464 - (3) (Y) Land Use and Environmental Models
Prerequisites: Some computer programming experience
Analysis of experimental applications of environmental and land use models and modeling.

EVSC 466 - (3) (S) GIS and Arc/Info
Prerequisites: The equivalent of the College natural science/mathematics and social science area requirements. Experience with word processing, file managers, and other computing skills is essential.

Explores the theory of Geographic Information Systems (GIS) and the use of Arc/Info software for research and other applications in a range of disciplines. Example applications are from physical and social sciences, often with a focus on the Charlottesville-Albemarle area. For students interested in research and longer term applications of GIS.

**EVSC 478 - (3) (O) Groundwater Geology**
Prerequisites: EVSC 280, EVSC 340

Study of the mechanics of groundwater flow, with attendant heat and mass transport; regional geological controls on groundwater occurrence and movement; and the role of groundwater in geological processes.

**EVSC 480 - (4) (Y) Mineralogy**
Prerequisites: EVSC 280; prerequisite or corequisite: one year of college chemistry

Study of crystallography, crystal chemistry and optical mineralogy; mineral symmetry as it relates to chemical bonding; interaction of crystals with polarized light; and the identification of minerals by physical, optical and X-ray diffraction techniques. Field experience and laboratories are included.

**EVSC 481 - (4) (O) Petrology**
Prerequisite: EVSC 480

Study of the origin and classification of igneous, metamorphic and sedimentary rocks. Emphasizes rock series and tectonic associations of rock types. Study of thin sections and hand samples in the laboratory. Field experience and laboratories are included.

**EVSC 482 (3) (IR) Stratigraphy and Sedimentation**
Prerequisite: EVSC 280

Explores the fundamentals of geological chronology including principles of sedimentation and sequences in layered rocks, and stratigraphic classification of sedimentary rocks, emphasizing spatial and temporal relationships; study of lithofacies and biofacies for interpretation of geologic history; and systematic examination of geologic periods.

**EVSC 483 - (3) (Y) Earth's Climatic History**
Prerequisite: EVSC 280

Analysis of changes through geologic time of the Earth's climate system (ice sheets, oceans, atmosphere, vegetation) in response to solar variability, sea-floor spreading, mountain building, atmospheric CO2 levels, volcanic eruptions, and earth-sun orbital changes.

**EVSC 484 - (3) (E) Engineering Geology**
Prerequisites: EVSC 280 and EVSC 340
Study of engineering properties of earth materials and their behavior in response to surface processes as they effect land use and natural resource utilization. Two lecture hours and three field or laboratory hours.

**EVSC 485 - (3) (Y) Coastal Processes**  
**Prerequisite:** EVSC 280

A review of wave generation, wave prediction, wave refraction, transformation, shoaling, and associated inshore currents. Topics include the generation of littoral drift and shallow water surge; beach and barrier island geomorphology and problems of erosion. Includes the historical development of research in coastal processes and a quantitative analysis of spatial patterns along sandy coasts.

**EVSC 485L - (1) (Y) Coastal Processes Laboratory**  
**Corequisite:** EVSC 485

Laboratory analysis of sediment, map, and aerial photo data sets. Lab demonstrations with the wave tank and rapid sediment analyzer. Weekly exercises and research projects required.

**EVSC 487 - (3) (Y) Global Biogeochemical Cycles**  
**Prerequisites:** One semester of college chemistry and one or two of the EVSC core classes.

Study of the processes which regulate the cycling of carbon, nitrogen, sulfur and phosphorus within and between oceans, continents and atmosphere.

**EVSC 488 - (3) (0) Planetary Geology**  
**Prerequisite:** Introductory course in geosciences or astronomy

Study of the origin and evolution of the solar system, with an emphasis on the geology of the planets and satellites of inner solar system and the satellites of the gaseous planets. The Earth is compared and contrasted with Venus and Mars.

**EVSC 489 - (4) (E) Structural Geology**  
**Prerequisites:** EVSC 280, or permission of instructor

Study of the origin, development and classification of microscopic and macroscopic structures in folded and faulted rocks; the response of rocks to stress and strain; brittle and ductile deformation; and the tectonic evolution of mountain belts. Includes field experience and laboratories.

**EVSC 493, 494 - (1-3) (IR) Independent Study**  
**Prerequisite:** Permission of instructor

Specialized topics in ecology, atmosphere, hydrology, environmental geology, or environmental systems not normally covered in formal classes under the direction of the faculty.

**EVSC 495, 496 - (3) (IR) Supervised Research**  
**Prerequisite:** Permission of instructor

Original research usually involving a field or laboratory problem in the environmental sciences under the direction of one or more faculty members. The results
may form the basis of an undergraduate thesis which is required to partially fulfill the Distinguished Majors Program in environmental sciences.

**EVSC 503 - (4) (Y) Applied Statistics for Environmental Scientists**  
Prerequisites: MATH 111 or MATH 112; corequisite: EVSC 503L  
Provides a firm knowledge of experimental design, hypothesis testing, and the use of statistical methods of data analysis.

**EVSC 503L - (0) (Y) Applied Statistics Laboratory**  
Corequisite: EVSC 503  
Use of computer laboratories in the analysis of quantitative data.

**EVSC 511 - (4) (E) Systems Analysis in Environmental Sciences**  
Prerequisites: MATH 132 or equivalent, computer programming experience  
The application of a variety of techniques of systems analysis to the environmental sciences, particularly ecology. Simulation models of ecosystems, of biological populations, and of hydrological, atmospheric and geological systems are examined and used to address scientific questions in the environmental sciences. Student projects apply techniques to specific problems.

**EVSC 521 - (3) (IR) Air Quality Planning**  
Study of methods for formulating and evaluating air quality plans, and techniques and strategies for air quality management.

**EVSC 544 - (3) (O)**  
**Physical Oceanography**  
Prerequisites: PHYS 231, 232 or equivalent, two semesters calculus, MATH 131, 132 recommended, or permission of instructor  
Study of the physical properties, processes and structure of the oceans; mass and energy budgets; methods of measurements; and the nature and theory of ocean currents, waves and tides in the open sea, near shore and in estuaries.

**EVSC 560 - (3) (Y) Land Use Policies**  
Prerequisites: ECON 201, 202  
Topics include goals for land use, analysis of legislation, and land use controls, evaluation of resource allocation, and environmental impacts of national and local land use policies.

**Atmosphere**  
**EVAT 541 - (4) (Y) Atmospheric Dynamics**  
Prerequisites: MATH 131, 132 and PHYS 231, 232  
An introduction to theoretical meteorology encompassing dry and moist air thermodynamics, the mechanics of atmospheric motion, and the dynamics of atmospheric weather systems.

**EVAT 542 - (3) (Y) Microclimate**
Prerequisites: EVSC 350 or permission of instructor

Principles of radiation transfer, soil heat flux, atmospheric heat transfer, atmospheric moisture, and evapotranspiration, motions near the Earth's surface, and surface energy balances are covered to provide a basis for describing the microclimate of various surfaces.

EVAT 550 - (3) (O) Environmental Climatology
Corequisites: EVSC 350 or the text The Science and Wonders of the Atmosphere

An advanced-level survey of the theoretical and experimental research areas in climatology and meteorology, with particular emphasis on environmental problems associated with the atmosphere. Fundamental principles used in these studies are introduced and discussed, along with procedures used to present and analyze atmospheric information.

Ecology

EVEC 521 - (4) (Y) Aquatic Ecology
Prerequisites: EVSC 320, EVSC 340, EVSC 420, integral calculus, or permission of instructor

Analysis of the physics and chemistry of fresh-water and marine environments; functional classification of organisms in aquatic communities; and the energy and nutrient dynamics of aquatic communities. Three hours lecture, three laboratory hours.

EVEC 522 - (4) (O) Terrestrial Ecology
Prerequisites: EVSC 320 and permission of instructor

Analysis of the patterns and processes in terrestrial ecosystems. Topic include macro- and micro-meteorological factors; producer, consumer and decomposer processes; hydrologic and biogeochemical pathways; and changes through space and time. Three lecture and four field or laboratory hours.

EVEC 523 - (3) (Y) Microbial Ecology
Prerequisites: EVSC 280, EVSC 320, EVSC 340, EVSC 350, or permission of instructor

The relationships of microorganisms to similar organisms, to dissimilar (macro) organisms and to the physical-chemical environment are treated both as a demonstration of basic ecological theory and to indicate the importance of the microbes in maintaining the world as we know it. The major subject divisions of the course are: the organisms, microbial habitats, community formation and structure, interspecific relationships, nutrient cycling, and anthropogenic ecology.

EVEC 523L - (1) (Y) Microbial Ecology Laboratory
Prerequisites: permission of instructor; corequisite: EVEC 523

Intended to complement EVEC 523 which is a corequisite for registration in this course. Provides an opportunity to learn and experience the techniques used in microbial ecological research. Both classic techniques and state-of-the-art methods for determination of microbial biomass in nature are utilized. Various methods of determining microbiological activity are covered. Several exercises involve field sampling and analysis.
EVEC 525 (3) (Y) Ecological Issues in Global Change
Prerequisites: EVSC 320 or equivalent, one year of college calculus, or permission of the instructor

An introduction to development and application of theoretical constructs and mathematical models for projecting the dynamics of terrestrial ecosystems to large scale changes in the environment. Course has a required computer-based laboratory (EVEC 525L) to provide an increased familiarity with ecological models used in global change studies.

EVEC 525L - (1) (Y) Ecological Issues in Global Change Laboratory
Corequisite: EVEC 525

A computer-based laboratory in the application of ecological models to problems in evaluating the responses of terrestrial ecosystems to large scale environmental change. Designed to parallel lecture material in EVEC 525.

Geoscience

EVGE 504 - (3) (O) Geochemistry
Prerequisites: CHEM 141, 142, EVSC 280, EVSC 480, two semesters calculus, MATH 131, 132 recommended

The study of the principles which govern the distribution and abundance of the elements in the earth's lithosphere, hydrosphere, biosphere, and atmosphere.

EVGE 507 - (4) (Y) Aqueous Geochemistry
Prerequisites: 1 year of calculus, 1 year of chemistry, 1 mineralogy or petrology course

Study of the principals of thermodynamics as applied to mineral-water systems. Treatment includes mineral stability, phase diagrams, solution thermodynamics, electrolyte theory, aqueous complex and hydrolysis equilibria, and electrochemical equilibria.

EVGE 582 - (4) (Y) Geomorphology
Prerequisites: EVSC 280 or EVSC 340

Study of the processes which shape the land surface and their relationship to human activity.

EVGE 584 - (3) (Y) Sediment Processes and Environments
Prerequisites: One year of calculus and physics, or permission of instructor; corequisite: EVGE 584L

Study of the erosion, transport, and deposition of sediment; initial motion of sediment, bedload and suspended load transport and bedforms; and important sediment-transporting environments. Application of sediment transport theory to problems of geological and environmental interest.

EVGE 584L - (1) (Y) Sediment Processes Laboratory
Corequisite: EVGE 584

Laboratory investigation of sediment transport phenomena and readings of classic and current research.
Hydrosphere
EVHY 544 - (3) (Y) Catchment Hydrology: Process and Theory
Prerequisite: EVSC 340
   An introduction to current theories of the hydrological response of catchments. The course takes an integrative approach, seeking to illuminate the derivation of theory in the light of the time and location of the process studies on which they were based.

EVHY 545 - (4) (Y) Hydrological Transport Processes
Prerequisites: EVSC 280 and EVSC 340
   Study of the physical principles governing the transport of dissolved substances and of sediment and particulate matter in the terrestrial portion of the hydrological cycle.

EVHY 547 - (4) (Y) Environmental Fluid Mechanics
Prerequisites: One year of calculus and physics or permission of instructor
   Study of the mechanics of fluids and fluid-related processes occurring at the earth's surface, including laminar, inviscid, and turbulent flows, drag, boundary layers, diffusion and dispersion of mass, flow through porous media, and effects of the Earth's rotation. Special attention is given to topics related to the environmental sciences.

EVHY 578 - (4) (Y) Groundwater Hydrology
Prerequisites: EVSC 280, EVSC 340 or equivalents, two semesters calculus, CHEM 141, 142 or equivalents
   An introduction to physical and chemical groundwater hydrology. Topics include the mechanics of groundwater flow, emphasizing geological factors influencing groundwater occurrence and movement; the influence of natural geological heterogeneity on groundwater flow patterns; and mass and heat transport in groundwater flow systems. The accompanying laboratory examines methods of hydrogeological data acquisition and analysis.

Environmental Literacy
The Environmental Literacy Program is an interdisciplinary program initiated by the Department of Environmental Sciences at the University of Virginia to bring together studies of the physical, biological, and social environment. The objective of the program is to provide members of the academic community, both students and faculty, with the opportunity to grow in their understanding of environmental issues facing society today and into the future.

A major activity of the Program is the development of an environmental curriculum within the University. An important component of this activity is to identify current course offerings throughout the University that explore some aspect of the environment. An extensive guide to current environmental courses is provided here.

About the Program
Environmental literacy can be defined as the development of an understanding of the patterns and processes which influence the functioning of the physical, biological and social environment of our planet, and the inherent link between these three components. As such, the concept of environmental literacy is by definition interdisciplinary. However,
the traditional academic study of these three components has been separated along disciplinary lines.

The Department of Environmental Sciences is one of only a handful of academic programs in this country that bring together the physical and biological sciences within the framework of an interdisciplinary program aimed at understanding pattern and process in the natural environment. It has worked over the years at developing an undergraduate and graduate curriculum that integrates an understanding of the physical and biological environment, providing students with the fundamental scientific background needed to address current environmental issues. It is now our belief that it is time to expand this framework to include the third component of environmental literacy, that of the social environment. This next step will function to open a dialogue between the natural sciences and the social sciences and humanities. The natural sciences will provide a framework for understanding the patterns and processes that control natural systems, while the social sciences and humanities provide an understanding of the integral role of human society on the environment.

Traditionally, the human element of environmental studies has focused, primarily, if not solely, on the exploitation and impacts of human society on the natural (physical and biological) environment. However, this is an extremely limited, one-dimensional view of the interaction of human society and the natural environment. It provides no insight into the manner in which human perceptions of the environment are formulated. This is a critical step, since it is these perceptions that influence/determine economic and political policy that defines societal interactions with the natural environment.

Careers, Research, Placement

Environmental Sciences is a vibrant and exciting field with excellent career opportunities throughout the economy. The careers of the nearly 2000 alumni of our program provide insight into the types of interesting things one can do as an Environmental Scientist. Below are listings of the types of employment reported by our alumni in 1997. The types of positions and responsibilities reflect the success of our training for the changing economy and environmental movement over the past 30 or more years. The role our alumni have assumed in the public and private economy of the United States and world is a matter of great pride to us. For advice on getting started in a career and preparing for placement in graduate school or employment, please visit the Office of Career Planning and Placement web page.

The Department of Environmental Sciences has over 2000 alumni located throughout the world. Some of the types of employment they report are listed below. The listing is organized by general type of employer and general type of work activity.

PUBLIC AGENCIES

Federal
EPA, Legal, management, research, enforcement. DOI—USGS, hydrology, geology, NPS research, management, USDA - USFS research, forestry NOAA, weather forecasting, DOT, transportation planning, FEMA, FAA DOD -- Corps of Engineers, Coast Guard, US Army mapping. Peace Corps, AmeriCorps, volunteers Congress, research aid Center for Disease Control, research

State
Environmental Quality, Agriculture, Transportation, Geological Surveys, Natural Resources, Environmental commissions

Local Planning, Engineering

PRIVATE SECTOR Organizations
American Waste Water Association, Nature Conservancy, Piedmont Regional Education Program

Consulting

Engineering
Land and community developer, Environmental Engineering, Geology, Electric power

EDUCATION
Higher Education Instruction

Attending Graduate School
Stanford, MIT, Duke, UNC, Cornell, Johns Hopkins, William and Mary, Virginia Tech, Virginia Commonwealth Univ. Virginia Institute of Marine Sciences, Univ of Virginia, Univ. Washington, Northwestern

K - 12
Virginia, Maryland, Vermont

OTHER
Public Service And Adult Education
Environmental Educator, Freelance writer, Science writer, editor

Military Service
Army, Navy, Air Force, Coast Guard, and Civilian Employees

Health Services
Physicians, Dentists, Veterinarian, Public Health, HMO, Insurance

Legal Professions
Public, Private, Public agency practice

Media
Television weather forecaster

Other
Carpenter, Computers, Motherhood, Salvage and diving, Airlines, Church management

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Graduate Program

About the Graduate Program
General information for students interested in graduate study in Environmental Sciences. Application information can be found at our Prospective Graduate Students web page.

Program of Study

The Department of Environmental Sciences (EVSC) is an academic department offering instruction and conducting research in the areas of ecology, geosciences, hydrology, and atmospheric sciences. This unique juxtaposition of several sciences in one department fosters cooperation and exchange among traditional disciplines that share similar methodological and philosophical problems. The research endeavors of both faculty and graduate students, whether disciplinary or interdisciplinary, deal largely with problems of fundamental scientific interest. Research fields include environmental biogeochemistry, coastal processes, hydrogeology, catchment hydrology, microbial ecology, wetlands ecology, terrestrial ecology, boundary-layer meteorology, atmospheric chemistry, and climatology. Initiatives involving groups of faculty in contaminant hydrogeology, global environmental change, and coastal ecosystems encompass a number of graduate research opportunities.

The department offers two graduate degree programs: The Master of Science and the Doctor of Philosophy. The M.S. program emphasizes research in addition to fundamental coursework. A degree candidate must complete a minimum of 24 credit hours of coursework, including one course from each of the four core areas of the department (ecology, hydrology, geosciences, and atmospheric sciences). The Ph.D. program degree emphasizes original research and independent study. The degree candidate is required to complete the four core-area courses as for the M.S., one 700-level course in an area outside of their area of specialization, and a minimum of 54 credit hours including thesis research. Thesis committees are usually interdisciplinary and are composed according to the type of research to be conducted. Ph.D. candidates must pass a written and oral comprehensive examination administered by their dissertation committee within four semesters of entering the program.

Research Facilities

Departmental facilities include field vehicles, boats, a machine and electronics shop, environmental chambers, analytical chemistry laboratories with extensive instrumentation, greenhouse facilities, state-of-the-art computers including a computational hydrology laboratory, GIS facility, NAFAX and FAA weather information, and GOES-Tap satellite receiver. Departmental field facilities include the Pace/Steger teaching/research site. Major interdisciplinary research initiatives with off-site research stations includes the Virginia Coast Reserve/Long-Term Ecological Research (VCR/LTER) studies of marsh and barrier island ecosystems on Virginia's Eastern Shore. Blandy Experimental Farm and the Orland E. White Arboretum are the focus of ecological research near Front Royal, VA. The Program of Interdisciplinary Research in Contaminant Hydrogeology (PIRCH), which includes EVSC and Engineering faculty and students, conducts research on hydrogeochemical and microbial processes in the subsurface. The Shenandoah Watershed Study (SWAS) investigates catchment biogeochemical and hydrological processes in the Blue Ridge region. An active research group focuses on the study of global environmental change.

Financial Aid
All students who complete applications by January 15 are considered for financial aid that is awarded on the basis of background and merit. Fellowships are awarded to the most academically qualified students. Teaching assistants teach laboratory sections of undergraduate and graduate courses. Research assistantships are available through individual professor's research projects; potential advisors should be contacted directly. At present, 98% of our graduate students receive financial support. A full stipend is $9,480-$11,120 for nine months; most students receive an additional $3,000-$4,000 summer research stipend. Most entering students are awarded a full tuition fellowship. Small grants to support research and travel to professional meetings are routinely awarded.

Cost of Study
Tuition, depending on course load, ranges between $1,881 and $4,870 per academic year for Virginia residents and $5,489 and $15,818 per academic year for out-of-state students. Students with financial awards receive partial or complete tuition fellowships.

Living and Housing Costs
A variety of affordable housing options exists, from small apartments near Grounds to houses in the country. Most students live off-grounds in shared apartments or houses. The rent for an individual in a shared arrangement ranges from $250 to $350, excluding utilities. Living alone costs $350-$500. Most graduate students are able to meet their living expenses with their stipends.

Student Group
Currently 104 students are enrolled; 53 in M.S. and 51 in Ph.D. programs. Students choose at least one area of specialization in their graduate programs: 38 in ecology, 34 in geosciences, 19 in hydrology, and 13 in atmospheric sciences. 45% are women. Students come from a wide range of scientific backgrounds, including geology, chemistry, biology, physics, and engineering. Occasional students have completed non-science undergraduate degrees and have prepared for graduate study through continuing education.

Student Outcomes
EVSC maintains an exceptional placement record, largely due to the rigorous interdisciplinary training program, with emphasis on research, and the reputation and connections of departmental faculty. Ph.D. students find employment in universities and colleges, federal laboratories and agencies, and research institutes. M.S. students find employment in federal and state laboratories and agencies, in foundations, and in private industry. Examples include USGS, NASA, NOAA, EPA, and DOE national laboratories at the national level.

Location
The University Grounds are located in Charlottesville, beside the foothills of the Blue Ridge Mountains in central Virginia. The University is 110 miles from Washington, D.C., with its varied cultural and scholarly resources, moments from the mountains, a two-hour drive from the Chesapeake Bay, and four hours from the Atlantic Ocean.
The University and the Department
The University of Virginia was founded in 1819 by Thomas Jefferson. The original buildings, designed by Jefferson, represent one of the great achievements of American architecture and help to make the Grounds of the University of Virginia one of the most attractive campuses in the United States. The total University enrollment is 20,000 with 10,000 in the College of Arts and Sciences. EVSC, founded in 1970, is among the oldest and best known interdisciplinary environmental sciences programs in the country.

Applying
To apply for admission, submit to the Graduate School of Arts and Sciences by January 15: (1) an application, (2) an official transcript of your entire college record, (3) results of the Graduate Record Examination (only the verbal and quantitative aptitude tests), and (4) at least two letters of recommendation. Other information indicative of applicant's academic and research abilities should be included. Direct contact with faculty with similar interests is essential. A personal interview is recommended.

Correspondence and Information
Graduate Admissions Chair
Department of Environmental Sciences
Clark Hall
University of Virginia
Charlottesville, Virginia 22903 U.S.A.
Telephone: (804) 924-7761
FAX: (804) 982-2137
World Wide Web: http://www.evsc.virginia.edu

Graduate Program Degree Requirements
Course requirements, committees, defenses, etc. for M.S. and Ph.D. students. Approved by the Faculty, April 11, 1994

This document serves as the official record of the requirements for graduate degrees in the department of Environmental Sciences. The Department generally offers two graduate degrees, the M.S. and the Ph.D.

M.S. PROGRAM
(1) Advisors - Upon arrival, each student will be assigned an advisor from his/her field of interest. This advisor may be replaced at any time by the student's choice for his or her research committee (major professor + at least two advisors from the department).
(2) Course Requirements - The Graduate School requires that each M.S. student complete at least 24 hours of coursework; in practice, most students accumulate more hours than the required. Courses offered under the same name and number and containing substantially the same material may be counted only once toward the coursework requirement for the Master's degree.

During each semester that a student is officially registered at the University of Virginia, he or she must be registered for a minimum of 12 hours of graduate credit; the 12
hours do not have to be in formal courses. Non-topical Research (EVSC 897-898, 998-999) should be used to augment regular coursework to bring the total to 12 hours.

Undergraduate majors in Environmental Sciences at the University of Virginia who desire to obtain a Master's degree in an accelerated program may petition the Dean of the Graduate School to count excess graduate level courses taken as an Undergraduate toward the graduate degree. Excess is defined as courses taken over and above the 120 hours required for the Bachelor's degree. All final decisions rest with the Dean; however, under no circumstances will courses be credited toward both the Bachelor's and Master's degrees.

(3) Area Requirements - All graduate students are required to take 4 courses - one from each of the disciplinary areas of the department, viz. Geology Hydrology, Ecology, and Atmospheric Sciences. Any courses listed in the area at the 500-level shall meet this requirement (i.e. EVGE 5xx, EVHY 5xx, EVEC 5xx, EVAT 5xx). Courses offered in the EVSC-area or at the 700-level may be used to fulfill this requirement only with prior approval of the GARC. In addition, each student must register for EVSC 790-791, Department Seminar once during the Masters' candidacy (This course may be counted only once toward the M.S.). These requirements must be fulfilled prior to defense of the thesis.

(4) Committee Formation - Each student should form a permanent committee consisting of a major professor and at least two other department faculty at least one of whom must be from outside the student's area of specialization. Selection of individuals for this committee is dictated by the type of research to be conducted.

(5) Thesis Proposal - During, or as soon as possible after formation of the committee, preliminary discussions are held between the student and the committee members concerning the proposed research. This leads to a formal written proposal from the student including a literature review and experimental plan. After allowing the committee at least a week to read the proposal, an open meeting is held for the purpose of discussing the proposed research, making modifications, and, finally, approving the proposal. It is in the student's best interest to solicit committee input before the research is done.

(6) Thesis Defense - Clean, final copies of the thesis should be circulated to committee members at least two weeks prior to the defense. Announcements of the thesis defense should be circulated to all faculty and students one week before the defense. After the defense, suggested changes from the committee members and faculty should be made by the student under the major professor's supervision. Finally, the student must provide committee members with a final, clean copy of the thesis; the chairman receives a bound copy from the student. A copy of the signed title page should be deposited in the student's file to indicate successful completion and defense of the thesis.

Ph.D. Program

(1) Admission to Ph.D. Program for M.S. Students - A student getting an M.S in our department who wishes to enter our Ph.D. program (either prior to or at the time of completion of the M.S. degree) must write a formal letter of application to the Admissions Committee stating that they want to enter the Ph.D. program and who their advisor would be. In addition, the M.S. committee of the student must write a letter in support of this request. All members of the committee must sign. If there is a member of the committee who does not think the student should enter the Ph.D. program, the letter should reflect this fact. Or, if the M.S. committee does not think a student should enter the Ph.D. program, the
letter should state this fact. Upon receipt of the letter from the student and the letter from
the student's M.S. committee, the Admissions Committee will take the appropriate action.
(2) Advisors - University of Virginia M.S. students continue to utilize their M.S.
committee for course advice until a Ph.D. committee is formed. Students from other M.S.
programs are assigned a temporary advisor as described earlier.
(3) Course Requirements - For the Doctor of Philosophy degree, a student must complete a
minimum of 72 graduate credit hours including at least 54 credit hours in graduate courses
other than Non-Topical Research (EVSC 897-898 or 998-999) and pay the tuition and fees
associated with these courses. The 54 hours of coursework may be comprised of any
combination of regularly scheduled courses or EVSC 993-994: Research Problems. Part of
the 54 hours will consist of the Core-Area Courses as described below. Students holding an
M.S. from another graduate school, must complete at least 30 credit hours of graduate
coursework other than non-topical research and pay the associated tuition and fees.
Students who obtain their M.S. from the University of Virginia are normally allowed to
count all graduate hours earned (except for Non-Topical Research) toward the Ph.D. In any
event the M.S. plus Ph.D. hours must equal at least 54.
(4) Area Requirements - All Ph.D. students are required to fulfill the area requirement
described in the M.S. program. In addition, Ph.D. candidates must pass one 700-level
course in an area outside their area of specialization. For example, an ecology student
could not use an EVEC 7xx course to fulfill this requirement. Use of EVSC 7xx courses
may be appropriate, but approval of use of the course for this requirement from the GARC
must be obtained before the fact.
(5) Committee Formation - The directive committee can be formed by the student at any
time after entry and must be approved by the Graduate School. The committee consists of
at least four faculty: three from the department (including one member of the department
outside the student's area of specialization) and one Graduate Committee representative
(from another department). Sometimes committee members (but not the Graduate School
representative) may be chosen from other institutions (Note: this a graduate school rule that
is sometimes interpreted differently by the Deans.)
(6) Comprehensive Examination - Within four semesters of entering the Ph.D. program, all
Ph.D. candidates take a Comprehensive Examination. This examination consists of a
written examination created by the student's committee (possibly in collaboration with
other faculty members whose expertise is needed) administered over a 2-day period
followed by an oral examination. The written examination is based in part on the student's
coursework and in part on the general background that the committee thinks is necessary to
address specifically the proposed area of the dissertation research. The aim of the
examination is to require students to review all prior coursework, to test their ability to
synthesize and interpret information in the critical intellectual fashion expected of Ph.D.
candidates, and to judge the aptitude of the candidate for carrying out original scientific
research. Copies of the examination questions along with the candidate's answers will be
placed in the student's department file. Oral examinations normally will be scheduled
within two weeks of the written examination. Oral examinations are open to all faculty but
they are not normally open to other students. The examinations will be held at a convenient
time during the year for the committee and the student and preferably should not be held
during regular examination periods. An announcement must be distributed at least one
week prior to the oral examination. The results of the written and oral examination will be
announced immediately following the oral exam. The results will be pass, conditional pass, or fail. A conditional pass is accepted to mean pass, providing the student subsequently demonstrates elimination of inadequacies by means stipulated by the committee. In the event of a failure, the committee may elect to allow a single repetition of the examination.

(7) Dissertation Proposal - This consists of a written document circulated to the student's committee at least a week prior to the oral presentation. The latter is open to any student or faculty who wishes to attend. (See comments under M.S. thesis proposal.)

(8) Seminar - All candidates for the Ph.D. are required to deliver a Department-level seminar on the results of their thesis work sometime before the dissertation defense. The degree will not be conferred until this obligation is met.

(9) Dissertation Defense - (See comments under M.S. thesis defense.) This defense cannot be held within four months of presentation of the dissertation proposal. Because publication of research results is an important professional activity, conference of the Ph.D. will be approved by the department only after a manuscript arising from the thesis has been accepted as suitable for submission for publication by the committee at the time of the thesis defense. It is understood that the manuscript is to be submitted for publication as soon as possible.

**NOTE:** Questions or problems concerning application of the regulations to specific student programs should be directed to the GARC chairman or your advisor.

**Environmental Sciences Graduate Students**

The current graduate students of the department are listed alphabetically below. For many, the graduate student name is also a link to either an individual home page, or a description of the research in which that individual is engaged.

ANGELINI, Isabella (M.S. Macko) ima4g@virginia.edu Isotope Geochemistry
Research Project: Water balance in the Amazon Basin.

ARANIBAR, Julieta (M.S. Shugart) jna3h@virginia.edu Ecology

BICKNELL, KeriAn (M.S./Ph.D. Mills) kb2b@virginia.edu Microbial Ecology

BILLMARK, Kaycie (M.S./Ph.D. Macko) kab4z@virginia.edu Atmospheric Sciences

BOLSTER, Carl (Ph.D. Mills) chb5h@virginia.edu Microb. Ecology/Hydrology
Research Project: Bacterial transport in subsurface environments.

BOWNE, David (Ph.D. Bowers) drb9d@virginia.edu Landscape Ecology/Animal Movements
Research Project: Landscape ecology of eastern painted turtles.

BRICKER, Eric (M.S./Ph.D. Zieman) bricker@virginia.edu Aquatic Ecology
Research Project: Factors effecting seagrass productivity and population demographics.

BUFFAM, Ishi D. (M.S. Galloway/ Blum) ishi@virginia.edu Ecology/Hydrology

CALLAGHAN, Amy (M.S. Mills) avc2u@virginia.edu Hydrology/Ecology
Research Project: Biological removal of nitrate from a coastal aquifer.

CARR, Joel (M.S. Wiberg) jac6t@virginia.edu Hydrology

CAYLOR, Kelly (Ph.D. Shugart) kkc9q@virginia.edu Ecology
Research Project: Ecological models of the dynamics of mixed life form ecosystems.

COOPER, Owen (Ph.D. Moody) orc3j@virginia.edu Atm. Science

CORMESE, Nicole (M.S./Ph.D. Macko) nac3c@virginia.edu Geosciences
Research Project: Intrinsic stable isotope tracers of environmental contaminants.

CYRUS, Ann. (Ph.D. Mike Bowers) Ecology
Research project: Within and between home range movement patterns of small mammals: landscape versus species effects.

DARIA, "Sunny" (Ph.D. Shugart) fad8t@virginia.edu Ecology

DRUCKENBROD, Dan (M.S./Ph.D. Shugart) dld5k@virginia.edu Ecology
Research Project: Application of a spatial simulation model to forest dynamics in the central piedmont.

DUSTERHOFF, Scott (M.S. Wiberg/ Albertson) srd2t@virginia.edu Geosciences
Research Project: Soil moisture and runoff processes.

FERAL, Christie (Ph.D Epstein) goellphoto@compuserve.com Ecology

FRANKLIN, Rima (M.S. Mills) rbf2t@virginia.edu Microbial Ecology
Research project: Spatial variability in microbial community structure.

FRANKOVICH, Thomas (Ph.D. Zieman) frankovich@virginia.edu Ecology
Research project: The distribution, abundance, and productivity of seagrass epiphytes in Florida Bay.

FRAUENFELD, Oliver (Ph.D. Davis) owf2u@virginia.edu Atmospheric Sciences
GAWTRY, Stephen (Ph.D. Michaels) sdg6g@virginia.edu Atmospheric Sciences
Research project: Analyzing three-dimensional radiosonde direct temperature measurements and remote sensing proxy temperature measurements for trends and biases.

GIANNOTTI, Amy (M.S. McGlathery) alg8q@virginia.edu Marine Ecology
Research project: Grazer control of macroalgal distribution in a barrier island lagoon system.

HARLEY, Douglas (M.S. Shugart) dh6r@virginia.edu Ecology

HEITZ, Ryan (Ph.D. Fuentes) rch4e@virginia.edu Atmospheric Sciences

HEROD, James (M.S. Smith, D.) jamhe@aol.com Ecology

HILL, Amber (M.S. Shugart) a9h8a@virginia.edu Ecology
Research project: Fire in the Boreal Forests of Siberia.

HILL, Brooke (M.S. Hornberger) beh6c@virginia.edu Hydrology
Research project: Self-affine scaling of elevations and soil depths in a catchment in the Rocky Mountains: effects on surface and subsurface flows.

HOWARD, Gerald (M.S. T. Smith) wgh6u@virginia.edu Ecology

HUX, J. Dustin (M.S./Ph.D Davis) jdh2r@virginia.edu Atmospheric Sciences
Research project: Atmospheric circulation and the January thaw in the United States.

HYER, Ken (Ph.D. Hornberger) keh3p@virginia.edu Hydrology
Research project: Colloid-facilitated transport in an agricultural catchment in Shenandoah Valley, Virginia.

IRWIN, Ross (M.S. Howard) rpi7d@virginia.edu Geomorphology
Research project: Evolution of ancient cratered terrain on mars.

JOHNSON, Stephanie (Ph.D. Herman) sej2e@virginia.edu Aqueous Geochem.
Research project: Quantitative influence of aging on contaminant mass transfer and bioavailability in model sorbents and soil.

JONES, Kevin (M.S. Howard) kjones@virginia.edu Geology
Research project: Geochemical effects of extreme flooding on the Staunton River, Madison County, Virginia.

KANG, Sanghoon (M.S. Mills) sk7k@virginia.edu Ecology

KNOFF, Amanda (M.S./Ph.D. Macko/Erwin) ajk4z@virginia.edu Ecology
Research project: Trophic structure of laughing gulls using stable isotopes.
KURC, Shirley (Ph.D. Albertson) sak2w@virginia.edu Hydrology
Research project: Turbulent fluxes of water vapor and CO2 over forests.

LANCASTER, Luke (Ph.D. Mills) ll6v@virginia.edu Microb. Ecology
Research project: Phenotypic and genotypic comparisons of subsurface microbial communities.

LAUCK, Elizabeth (M.S. D. Smith) ewl4a@virginia.edu Ecology
Research project: Spatial and seasonal nekton habitat utilization of a submerged cypress environment in a tidal freshwater marsh.

LAWRENCE, Amy (M.S. Bowers) apl3f@virginia.edu Ecology
Research project: Use of indicator species to access changes in environmental quality.

LAWRENCE, David (Ph.D. Shugart) dml2s@virginia.edu Ecology
Research project: Tree-ring analysis of the distribution of North American spruce.

LAYMAN, Craig (M.S. D. Smith) cal8e@virginia.edu Fish Ecology

LEVEY, Kevin (Ph.D. Garstang) km15h@virginia.edu Atmospheric Sciences
Research project: Increasing the accuracy of convective forecast models using high resolution water vapor.

LOWIT, Michael (Ph.D. Blum) mbl2g@virginia.edu Microbial Ecology
Research project: Relationship between estuarine microbial community phenotype and genotype.

MACAVOY, Stephen (Ph.D. Macko) sem7e@virginia.edu Ecology
Research project: Marine contributions to exotic aquatic predators in tidal river ecosystems of Virginia.

MCINTYRE, Wendy (Ph.D. Shugart) bmm6e@virginia.edu Ecology
Research project: Associated impacts of land use and management of the tussock grassland, Australia on the Flock Bronzewing Pigeon.

MCLAUGHLIN, Scott (M.S. Mills/Herman) sam5x@virginia.edu Geosciences

MICHAELS, Rachel (M.S. Zieman) remicha@students.wisc.edu Ecology

O'DONNELL, Thomas (Ph.D. Macko) tho4b@virginia.edu Geosciences
Research project: Late Pleistocene geochronology of the Southeastern Atlantic Coastal Plain.

POCHATILA, Joy (M.S. Raffensperger) jp9r@virginia.edu Hydrogeology
Research project: Hydrological controls on weathering fluxes from a saprolitic catchment.

POPE, Joan (Ph.D Dolan/Wiberg) Geosciences
Research project: Coastal storm surges.

PUSCHER, Monika (Ph.D. Shugart) mp6t@virginia.edu Ecology

READ, Larissa (M.S. Lawrence) lread@virginia.edu Ecology

REIDEL, Sebastian (M.S. Epstein) smrh@pge.com Ecology

REINHARDT, Keith (M.S. Galloway) ksr9f@virginia.edu Aqueous geochemistry

RICE, Karen (Ph.D. Hornberger) kcr4y@virginia.edu Hydrology/Geochemistry
Research project: Historical reconstruction of metal fluxes to a suburban lake in Reston, Virginia.

RICHARDSON, Dave (M.S. Shugart) dlr2n@virginia.edu Ecology
Research project: Succession models for coastal barrier systems.

ROSINSKI, Jennifer (Ph.D. McGlathery) jlr3c@virginia.edu Ecology

ROSS, Katie (M.S./ Ph.D Howard) kmr4z@virginia.edu Geology/Ecology
Research project: Effects of large-magnitude floods on floodplain sediments and vegetation.

RUSSELL, Kristina (Ph.D. Galloway/ Keene) kmr9d@virginia.edu Atmospheric Sciences
Research project: Organic nitrogen in the atmosphere.

SCANLON, Todd (M.S. Raffensperger/ Hornberger) tms2v@virginia.edu Hydrology
Research project: Modeling silica variations in stream water at the catchment scale: a hydrological pathway approach.

SCHWARZSCHILD, Art (Ph.D. Zieman) acs7q@virginia.edu Seagrass Ecology
Research project: Population dynamics and growth patterns of the three main species of seagrasses growing in the Florida Keys, with the intention of creating demographic based models of seagrass growth and productivity.

SIGLER, Jeff (M.S. Fuentes) jms9z@virginia.edu Micrometeorology

SNYDER, Bridget (M.S. Galloway/Herman) brs136@psu.edu Geology

STAPLES, Robert (M.S. Emmitt) rhs@thunder.swa.com Hydrology/Atm. Sciences
Research project: Analysis and modeling of the physical stability and internal fluid dynamics of processed, utility grade, bituminous coal stock piles.
SZUBA, Thomas (Ph.D. Shugart) tszuba@sprintmail.com Ecology

THOMAS, Cassondra (Ph.D. Blum) crt6b@virginia.edu Ecology

THOMSEN, Mads (Ph.D McGlathery)mads_thomsen@earthlink.net Ecology

TODD, Debbie (M.S. Keene/ Galloway) dlt2f@virginia.edu Atmospheric Sciences
Research project: Impact of wet deposition on optical properties of the atmosphere.

TURAKSI, Steven (M.S. Wiberg) sjt3b@virginia.edu Hydrology
Research project: Erosional processes on tidal salt marshes.

TUREKIAN, Vaughan (Ph.D. Macko) vct8c@virginia.edu Organic Geochemistry
Research project: Sources of organic nitrogen and carbon in atmospheric aerosols.

TYLER, Christy (Ph.D. McGlathery) tyler@virginia.edu Ecology
Research project: Nutrient dynamics, environmental stresses and aquatic plant physiology in estuarine ecosystems.

WALKER, Sarah (M.S./ Ph.D. Desanker) sw2t@virginia.edu Ecology

WELSH, Daniel (Ph.D. Hornberger) dlw3x@virginia.edu Ecology

WIMMERS, Anthony (M.S./ Ph.D. Moody) ajw7g@virginia.edu Atmospheric Science
Research project: Research project: Real-time remote sensing of specific humidity in the mid-to-upper troposphere.

YANIK, Peter (M.S./ Ph.D. Macko) pjy2a@virginia.edu Geosciences
Research project: Compound specific analysis of hydrocarbon contaminants in aquatic systems.

YIP, Carmen (M.S. Fuentes) cy6f@virginia.edu Atmospheric Sciences

**Graduate Student Association (GSA)**
Events, mentoring program, graduate student profiles, Enviroday

**The Mentoring Program**
Goals:
- To encourage undergraduate involvement in field and laboratory scientific research.
- To expose undergraduates to the development and the investigation of scientific questions outside the classroom. To provide valuable assistance to graduate students with field and laboratory research.
- To introduce graduate students to advising and instructing on an individual basis.
- To bridge the gap between undergraduates and graduates by encouraging interaction on a research level.

Participants:
Undergraduate students, Graduate students, and Faculty.

Selection Process:
A list of graduate student research interests is provided on the Graduate Student Association web page (www.evsc.virginia.edu/~evscgsa). Undergraduates interested in the program should fill out an application listing no more than two graduate students with whom they would like to work.

Applications will be available on the web page. Returned applications will be distributed to the appropriate graduate students. Selections for undergraduate participation will be made by the graduate students. Graduate students will contact undergraduates with whom they are interested in working. Neither party is obligated to participate in the program until an agreement is made to work together.

Format of Program:
After selection, the mentor team will meet the graduate student’s Faculty advisor to discuss expectations, academic credit, and a tentative research outline for the semester. This meeting should take place prior to the Add Deadline for the semester in which credit is to be awarded. The mentor team should report on their progress to the graduate student’s Faculty advisor two-three times per semester.
The framework of the program will be developed around the undergraduate and graduate student relationship. Individual programs will be catered to the specifics of the undergraduate’s interests and the graduate student’s needs.

Guidelines:
Academic credit: Academic credit, though not a requirement of the program, may be assigned under EVSC 494 Independent Study or 496 Supervised Research. 1-4 credit hours is recommended for each semester the undergraduate participates in the mentor program. The faculty advisor and mentor team will come to an agreement on the appropriate number of credit hours for the semester. The faculty advisor and the graduate student will meet at the end of the semester to evaluate the undergraduate student’s fulfillment of the goals and objectives established at the beginning of the semester.

Research Program:
Two types of programs are possible: (1) undergraduates may assist graduate students with field and laboratory work; or (2) they may conduct their own research project. A combination of these two types of programs is encouraged. Again, the structure of the mentor program is liberal and designed to fit the individual needs of the participants. These two guidelines merely provide a basic framework for each mentor team.

Questions can be directed to Kelly Caylor:
caylor@virginia.edu
982-2333

Graduate Course Offerings in Environmental Sciences

COURSE DESCRIPTIONS
Environmental Sciences
EVSC 503 - (4) (IR) Applied Statistics for Environmental Scientists
Prerequisite: Introductory course in probability or statistics; corequisite: EVSC 503L
A one-semester course designed to provide a firm knowledge of experimental design, hypothesis testing, and the use of statistical methods of data analysis.

EVSC 503L - (0) (IR) Applied Statistics Laboratory
Corequisite: EVSC 503
Use of computer laboratories in the analysis of quantitative data.

EVSC 511 - (4) (Y) Systems Analysis in Environmental Sciences
Prerequisites: Introductory statistics or integral calculus, Fortran programming, and permission of instructor
The holistic concepts of modern ecology and environmental sciences are introduced through various approaches to systems analysis. Simulation models are produced for both analog and digital computers, and their properties are explored.

EVSC 521 - (3) (IR) Air Quality Planning
Study of methods for formulating and evaluating air quality plans; and techniques and strategies for air quality management.

EVSC 544 - (3) (O) Physical Oceanography
Prerequisites: One year of college calculus, one semester of calculus-based college physics, or permission of instructor
Topics include physical properties, processes and structure of the oceans; mass and energy budgets; methods of measurements; the nature and theory of ocean currents; and waves and tides in the open sea, near shore and in estuaries.

EVSC 560 - (3) (Y) Land Use Policies
Prerequisites: Two semesters of economics
Topics include goals for land use, analysis of legislation and land use controls, evaluation of resource allocation, and environmental impacts of national and local land use policies.

EVSC 710 - (3) (IR) Advanced Quantitative Methods
Prerequisite: Permission of instructor
A survey of statistical and mathematical models used in environmental sciences. Emphasis on assumptions used, experimental design, and analysis of empirical data.

EVSC 760 - (3) (Y) Microclimatology
Prerequisites: EVSC 350 or permission of instructor
Study of the principles governing atmospheric processes occurring at small temporal and spatial scales near the Earth’s surface, including energy, mass and momentum transfer. Includes features of the atmospheric environment effecting plants and feedback mechanisms between plants and their local microclimates, trace gas exchange
between the terrestrial biosphere and the atmosphere, energy budgets, evapotranspiration, and motions near the surface.

EVSC 778 - (4) (E) Quantitative Contaminant Hydrology  
Prerequisite: A 500-level course in geology or hydrology  
Provides an integrated interdisciplinary approach to quantitative aspects of the physics, chemistry, and biology of groundwater systems. Focuses on problems involving contamination of groundwaters. Emphasizes numerical solutions of the equations through the use of digital computers. Laboratory exercises are heavily oriented toward computer modeling, but also involve laboratory and field work.

EVSC 782 - (4) (IR) Environmental Chemistry  
Prerequisites: One year of college chemistry with laboratory, EVSC 386 or its equivalent  
Study of the natural and anthropogenic mechanisms that control the chemistry of the environment through biogeochemical cycling. Provides an introduction to more specialized topics as atmospheric chemistry and aqueous geochemistry.

EVSC 786 - (3) (O) Isotope Geochemistry  
Prerequisite: Permission of instructor  
An investigation of natural phenomena by means of stable and unstable isotopes and of changes in their abundance including isotope fractionation. Applications include age dating, paleotemperature determination, and isotope tracers in natural systems.

EVSC 790, 791 - (1) (S) Departmental Seminar  
Study of current problems in environmental research management or public policy as presented by visiting speakers, faculty, or advanced graduate students.

EVSC 795, 796 - (3) (S) Special Topics in Environmental Sciences  
Prerequisite: Permission of instructor  
Interdisciplinary focus on current problems and research in integrated areas of environmental sciences.

EVSC 890, 891 - (3) (S) Seminar in Environmental Sciences  
Prerequisite: Permission of instructor  
A central interdisciplinary research topic used as the focus of journal papers to be summarized and discussed by the participants. Proposals for original research within the selected area are also explored.

EVSC 895, 896 - (3) (S) Advanced Topics in Environmental Sciences  
Prerequisite: Permission of instructor  
Interdisciplinary treatments of environmental systems wherein the interrelationships of hydrosphere, atmosphere, biosphere, and lithosphere are explored and analyzed.

EVSC 897 - (3, 6, 9, 12) (S) Non-Topical Research, Preparation for Research  
For masters research, taken under the supervision of a thesis director.
EVSC 898 - (3, 6, 9, 12) (S) Non-Topical Research
  For masters thesis, taken under the supervision of a thesis director.

EVSC 993, 994 - (1-9) (S) Research Problems
  Individual or group research on interdisciplinary problems in environmental sciences.

EVSC 997 - (3, 6, 9, 12) (S) Non-Topical Research, Preparation for Doctoral Research
  For doctoral research, taken before a dissertation director has been selected.

EVSC 999 - (3, 6, 9, 12) (S) Non-Topical Research
  For doctoral research, taken under the supervision of a dissertation director.

**Atmospheric Sciences**

EVAT 541 - (4) (Y) Atmospheric Dynamics
  Prerequisites: Two semesters of integral calculus and two semesters of calculus-based college physics.
  An introduction to theoretical meteorology encompassing dry and moist air thermodynamics, the mechanics of atmospheric motion, and the dynamics of atmospheric weather systems.

EVAT 542 - (3) (Y) Microclimate
  Prerequisite: One semester course in atmospheric sciences or permission of instructor
  Principles of radiation transfer, soil heat flux, atmospheric heat transfer, atmospheric moisture, and evapotranspiration, motions near the Earths surface, and surface energy balances are covered to provide a basis for describing the microclimate of various surfaces.

EVAT 546 - (4) (Y) Synoptic Meteorology
  Prerequisite: EVAT 541 or permission of instructor
  An introduction to weather analysis and forecasting, with attention to temperature and precipitation forecasting, and the diagnosis and prediction of atmospheric weather systems.

EVAT 550 - (3) (O) Environmental Climatology
  Corequisites: One semester course in atmospheric sciences or permission of instructor
  An advanced-level survey of the theoretical and experimental research areas in climatology, emphasizing environmental problems associated with the atmosphere. Fundamental principles used in these studies are introduced and discussed, along with procedures used to present and analyze atmospheric information.

EVAT 793 - (1-6) (S) Independent Study
  Individual or group study in developing or special areas of atmospheric sciences and interrelated areas.

EVAT 795, 796 - (3) (S) Special Topics in Atmospheric Sciences
Prerequisite: Permission of instructor

Intensive presentation of selected interdisciplinary areas which stress atmospheric systems rarely covered in the established curricula.

EVAT 895, 896 - (3) (S) Advanced Topics in Atmospheric Sciences
Prerequisite: Permission of instructor

Detailed, integrative treatments of the atmospheric systems in which the nature and dynamics of the atmosphere are central to understanding them.

Ecology
EVEC 521 - (4) (Y) Aquatic Ecology
Prerequisites: One semester of ecology, one semester of hydrology, one year of college chemistry, and integral calculus, or permission of instructor

Review of the physics and chemistry of fresh-water and marine environments; functional classification of organisms in aquatic communities; and the energy and nutrient dynamics of aquatic communities. Three lecture hours, three laboratory hours.

EVEC 522 - (4) (O) Terrestrial Ecology
Prerequisites: One semester of ecology or permission of instructor

Topics include the patterns and processes in terrestrial ecosystems: macro- and micro-meteorological factors; producer, consumer, and decomposer processes; hydrologic and biogeochemical pathways; and changes through space and time.

EVEC 523 - (3) (Y) Microbial Ecology
Prerequisites: One semester of ecology, one semester of hydrology, or permission of instructor

The relationships of microorganisms to similar organisms, to dissimilar (macro) organisms, and to the physical-chemical environment are treated both as a demonstration of basic ecological theory and to indicate the importance of the microbes in maintaining the world as we know it. Topics include the organisms, microbial habitats, community formation and structure, interspecific relationships, nutrient cycling, and anthropocentric ecology.

EVEC 523L - (1) (Y) Microbial Ecology Laboratory
Prerequisite: Permission of instructor; corequisite EVEC 523 Complements EVEC 523.

Provides the opportunity to learn and experience the techniques used in microbial ecological research. Utilizes both classic techniques and state-of-the-art methods for determination of microbial biomass in nature. Includes various methods of determining microbiological activity, and several exercises involving field sampling and analysis.

EVEC 525 (3) (Y) Ecological Issues in Global Change
Prerequisites: EVSC 320 or equivalent, one year of college calculus, or permission of the instructor

An introduction to the development and application of theoretical constructs and mathematical models for projecting the dynamics of terrestrial ecosystems to large-scale
changes in the environment. Course has a required computer-based laboratory to provide an increased familiarity with ecological models used in global change studies.

EVEC 525L - (1) (Y) Ecological Issues in Global Change Laboratory
Corequisite: EVEC 525
   A computer-based laboratory in the application of ecological models to problems in evaluating the responses of terrestrial ecosystems to large-scale environmental change. Designed to parallel lecture material in EVEC 525.

EVEC 722 - (3) (E) Estuarine Ecology
Prerequisites: EVEC 521, EVGE 584, introductory chemistry, and permission of instructor
   Topics include hydrology, sediments, and biogeochemical cycles of the estuarine environment; organisms and their physiological adaptations, primary production, trophic relationships, and man-induced alterations.

EVEC 793 - (1-6) (S) Independent StudyEcology
   Individual or group study in developing or special areas of ecology and interrelated areas.

EVEC 795, 796 - (3) (S) Special Topics in Ecology
Prerequisites: One semester of ecology and permission of instructor
   Selected interdisciplinary topics, stressing current problems and research in various areas of ecology and related fields.

EVEC 895, 896 - (3) (S) Advanced Topics in Ecology
Prerequisite: Permission of instructor
   Detailed integrative treatments of ecosystems wherein an understanding of the dynamics of components and processes is fundamental to comprehension and analysis.

Geosciences
EVGE 504 - (3) (O) Geochemistry
Prerequisites: College chemistry and calculus, an introductory geology course, and a course in mineralogy
   Study of the principles which govern the distribution and abundance of the elements in the earth's lithosphere, hydrosphere, biosphere, and atmosphere.

EVGE 507 - (4) (Y) Aqueous Geochemistry
Prerequisites: One year of college chemistry and calculus, and one mineralogy or petrology course
   Study of the principals of thermodynamics as applied to mineral-water systems. Treatment includes mineral stability, phase diagrams, solution thermodynamics, electrolyte theory, aqueous complex and hydrolysis equilibria, and electrochemical equilibria.

EVGE 578 - (3) (Y) Groundwater Hydrology
Prerequisites: EVSC 280, EVSC 340 or equivalents, two semesters calculus, CHEM 141, 142 or equivalents
An introduction to physical and chemical groundwater hydrology. Topics include the mechanics of groundwater flow, emphasizing geological factors influencing groundwater occurrence and movement; the influence of natural geological heterogeneity on groundwater flow patterns; and mass and heat transport in groundwater flow systems. The accompanying laboratory examines methods of hydrogeological data acquisition and analysis.

EVGE 582 - (4) (Y) Geomorphology
Prerequisites: EVSC 280 or EVSC 340
Study of the processes that shape the land surface and their relationship to human activity.

EVGE 584 - (3) (Y) Sediment Processes and Environments
Prerequisites: One year of calculus; corequisite: EVGE 584L
An introduction to important sediment properties and processes, including size distributions, initial motion, bed load and suspended load transport, bed forms, erosion and deposition, flocculation, sedimentary structures, and animal sediment interactions. Several depositional settings are investigated, including coastal, wetland, and fluvial environments.

EVGE 584L - (1) (Y) Sediment Processes Laboratory
Corequisite: EVGE 584
Laboratory and field investigations of sediment properties and phenomena.

EVGE 780 - (4) (IR) Engineering Geology and Soil Physics
Prerequisites: EVSC 280 and EVSC 340
Topics include the physics and mechanics of soils, measurement and mapping of soil properties, and implications for human activities and land use.

EVGE 793 - (1-6) (S) Independent Study-Geosciences
Individual or group study in developing or special areas of geosciences and interrelated areas, emphasizing earth-surface processes.

EVGE 795, 796 - (3) (S) Special Topics in Geosciences
Prerequisite: Permission of instructor
Selected interdisciplinary areas which stress current problems and research in earth-surface processes and their application to the environments impacted by human activity.

EVGE 895, 896 - (3) (S) Advanced Topics in Environmental Geology
Prerequisite: Permission of instructor
Interdisciplinary study of the physical processes and responses which modify environmental systems. Exhaustive treatments of the nature and analysis of earth materials as environmental substrates and their responses to stress are represented, as are other techniques in geosciences focusing on earth-surface properties.

Hydrology
EVHY 544 - (3) (Y) Catchment Hydrology: Process and Theory
Prerequisite: EVSC 340 or equivalent

An introduction to current theories of the hydrological response of catchments. Using an integrative approach, the course illuminates the derivation of theory in light of the time and location of the process studies on which they were based.

EVHY 545 - (4) (Y) Hydrological Transport Processes
Prerequisites: Introductory geology and hydrology

Study of the physical principles governing the transport of dissolved substances, and of sediment and particulate matter in the terrestrial portion of the hydrological cycle.

EVHY 547 - (4) (Y) Environmental Fluid Mechanics
Prerequisites: Integral calculus and calculus-based physics, or permission of instructor

Study of the mechanics of fluids and fluid-related processes occurring at the Earth's surface, including laminar, inviscid, and turbulent flows, drag, boundary layers, diffusion and dispersion of mass, flow through porous media, and effects of the Earth's rotation. Emphasizes topics related to the environmental sciences.

EVHY 744 - (3) (IR) Dynamic Hydrology
Prerequisites: Introductory hydrology and differential equations, or permission of instructor

Study of the interrelationships of the various phases in the water cycle; principles governing that cycle; and the influence of human activity on natural circulation of water at or near the Earth's surface.

EVHY 747 - (3) (O) Numerical Methods in Hydrology
Prerequisites: EVHY 500-level course

Application of numerical methods to the solution of hydrological problems. The Matlab computational and plotting software is used for all examples and assignments, including finite difference and finite element solutions to equations describing the flow of water and transport of contaminants in the terrestrial environment. Prior knowledge of Matlab is not required.

EVHY 793 - (1-6) (S) Independent Study Hydrology and Water Resources

Individual or group study in developing or special areas of hydrology and water resource analysis and interrelated areas.

EVHY 795, 796 - (3) (S) Special Topics in Hydrology and Water Resources
Prerequisite: Permission of instructor

Study of particular and specific problems in hydrology and water resources not covered in regular course work.

EVHY 895, 896 - (3) (S) Advanced Topics in Hydrology and Water Resources
Prerequisite: Permission of instructor

Specialized research into specific hydrologic or water management problems. Emphasizes an integrative analysis of the physical, social, and economic nature of these problems.
Information and Links for Current Graduate Students
Research funding, TA guide, awards, annual reports, seminar, FAQ.

Research Funding
The responsibilities formerly handled by the Department's Research Committee are now being handled by the GARC. In this capacity the GARC is charged with recommending to the Chair distribution of monies earned by sponsored research in the Department and accruing in the Indirect Cost Recovery account (currently 1-90270, often called the "Overhead Account"). The specific duties of the Research Committee are:

1) Make recommendations to the Chair concerning the utilization of the overhead account pertinent to the support of research activities in the Department.
2) Provide advice to the Chair on requests from Faculty for expenditures of Overhead funds that exceed a faculty-established limit (currently $5,000).
3) Administer distribution of overhead and non-overhead funds that are awarded to graduate students in support of research. Instructions for application, selection criteria, amounts and due dates will be published as part of the Department’s World Wide Web page. (URL, http://atlantic.evsc.virginia.edu/evsc) Specifically, the awards are:

- Mini-grants for graduate research. These are awards for conducting research toward a degree by graduate students who have little or no other funding. Awards of up to $1000 may be made by the Research Committee to students applying for such funds.
- Travel grants for graduate students. Graduate students may apply no more than once per degree for assistance (up to $400 per request) to attend a regional or national meeting at which the student is presenting a paper on work conducted during the graduate tenure in the department.
- Research Awards: Graduate students may compete for additional research funding from several research prizes. These prizes include the Fred H. Moore Research Awards, The Bannon Award (for coastal research), and the Odum Foundation Award. Currently, the award amounts are up to $2500 for a Ph.D. award and up to $1500 for an M.S. award.

TA Survival Guide
Teaching this semester? Find out all you need to know how to be a successful Teaching Assistant in the TA Survival Guide.
http://www.evsc.virginia.edu/~evscta/TAGUIDE/home.html

Department Awards to Graduate Students

Teaching Awards
Fred Holmsley Moore Teaching Award - An endowment set up by Fred H. Moore along with matching donations from Mobil Oil Company to sponsor high caliber lecturers also funds a student teaching award given at the end of the academic year. Nominations for this award are solicited annually with a due date around Feb 1. Instructions for nomination will be posted about December 1st each year.
Teaching Resources Graduate Teaching Award - to recognize commitment to and excellence in undergraduate education. Awarded by the University's Teaching Resource Center. The Teaching Resource Center will ask for nominations in mid February. The Graduate Academic Review Committee will determine if any of the candidates for the Moore Teaching Award should be submitted for the GRT prize, and further if any should be nominated for the All-University Graduate Teaching Award whereupon additional instructions will be provided to the nominators.

Research Awards (and grants)
Details and specific instructions for applying for each of the research awards can be found on the Graduate Academic Review Committee's Research web pages.

Moore Research Awards - the Moore Research Awards, based on merit are also supported by the Fred Holmsley Moore Endowment, and were initiated in the early 1980's to help sponsor the dissertation and thesis work of environmental sciences graduate students. Our department's graduate students submit proposals to the Graduate Academic Review Committee which reviews and evaluates these proposals. Traditionally, we recognize both Master's level and Doctoral level efforts by supporting a Moore Research Award at each. Deadline for submission of proposals is on or about April 1 of each year.

Bannon Research Award - This research award, based on merit, is supported by an endowment made possible by the generosity of Mr. William Bannon and the Bannon Foundation. Created in 1991, this Research Award supports outstanding graduate student research that concentrates on the Chesapeake Bay or the Eastern Shore of Virginia. Deadline for this proposal is on or about April 1 of each year.

Odum Research Award - this Research Award was created in 1994 when Dr. and Mrs. Eugene Odum created an endowment to honor their late son William E. Odum. Bill was a colleague in our Department until his death in 1991. He was an outstanding scientist, educator and friend that also served as Department Chairman. Bill's dedication to his graduate students led his parents to create this award to support graduate student work on wetland and marsh environments, the research area where Bill himself excelled. Deadline for this proposal is on or about April 1 of each year.

Department Mini-Grants - Although not an award per se, the Department does have limited funds available for support of student research that has no other source of funding. See the Graduate Academic review Committee's Research web pages for details and instructions for applying for one of these grants.

Scholarship Awards
Arthur A. Pegau (graduate) - The heirs of the late Dr. Arthur A. Pegau, who taught in the Department for more than twenty years, set up an endowment fund for an award to assist students in their research towards a graduate degree in Geology. This award recognized the outstanding graduate student having completed a full year in the Department whose area of interest and focus within environmental sciences is geology. The Graduate Academic Review Committee will select the awardee with input from the faculty in geosciences.
Graduate Atmosphere Award (graduate) - Sponsored by the department, this award recognizes the outstanding graduate student having completed a full year in the department whose area of interest and focus within environmental sciences is atmospheric sciences. The Graduate Academic Review Committee will select the awardee with input from the faculty in atmospheric sciences.

Graduate Ecology Award (graduate) - Sponsored by the Department, this award recognizes the outstanding graduate student having completed a full year in the Department whose area of interest and focus within environmental sciences is ecology. The Graduate Academic Review Committee will select the awardee with input from the faculty in ecology.

Graduate Hydrology Award (graduate) - Sponsored by the Department, this award recognizes the outstanding graduate student having completed a full year in the Department whose area of interest and focus within environmental sciences is hydrology. The Graduate Academic Review Committee will select the awardee with input from the faculty in hydrology.

Maury Environmental Sciences Prize - This is the premier prize award in the Department of Environmental Sciences. This prize was established by Dr. F. Gordon Tice in 1992. The purpose of the Prize is to foster environmental research, and scholarship and to recognize and honor the outstanding undergraduate or graduate student for their contributions to environmental science, their ability to communicate their findings, and their potential to better the understanding of our environment. Students are nominated by members of the faculty and the award will be approved by the entire faculty upon recommendation of the Graduate Academic Review Committee. The deadline for nominations will be on or about April 1 each year. Instructions are located in the Graduate Academic Review Committee web pages.

Other Awards
Joseph K Roberts - From the income of this endowment, an award is given annually entitled the Joseph K. Roberts Award. This award will be in the form of a book containing an appropriate plate and costing about $15. It will be given to a UVa student (graduate or undergraduate) who presents the most meritorious paper on geology research to the Geology Section of the Virginia Academy of Science. Students who present such papers should forward a copy of the abstract to the Chair of the Graduate Academic Review Committee at the time of the meeting of the Academy.

W. E. Odum Memorial Endowed Fellowship Fund - The purpose of this is Fund is to provide fellowships to Arts & Sciences graduate students who are doing research on wetland and marsh environments. Inquiries about this award should be directed to the Financial Aid Committee.
Chair's Award - to recognize an undergraduate or graduate student that has performed extraordinary services to the department and demonstrated an interdisciplinary approach to both teaching and research. This is award at the Chair's discretion.

**Graduate Seminar Schedule**
The seminar schedule listing the appropriate speakers and short descriptions of proposed seminars.

**Department Seminar Schedule - Spring 2000**
All seminars are held Thursday afternoons in 147 Clark Hall at 4:00 PM. Reception at 3:30 PM in foyer in front of Clark 147.

January 20
Harry Lins; USGS, Reston.
"Wetter But Less Extreme: Twentieth Century Trends in Floods, Droughts, and Everything in Between." (Host: Bruce Hayden)

January 27
DATE STILL OPEN

February 3
Steven Macavoy; UVa
"Anadromous fishes as vectors for the transport of marine nutrients to freshwater systems" ("Host": Steve Macko)

February 10
Roger Pielke; Colorado State.
Vegetation Cover and the Genesis of Thunderstorms (Host: Bruce Hayden)

February 17
Reserved for Geoscience Position Applicant (could be shifted a week)

February 24
Predicting the integrated effects of ozone, CO2, N deposition and climate change on temperate forest ecosystems. (co-Hosts: Jim Galloway and Tom Smith)

March 2
Reserved for Geoscience Position Applicant (could be shifted a week)

March 9
Ecosystem-level artificial acidification at Bear Brook Watershed, Maine - The first ten years (Host: Jim Galloway)

March 16
Spring Break

March 23
Sybil Seitzinger; Rutgers University.
Nitrogen Export by World Rivers to Coastal Ecosystems and Associated Nitrous Oxide Production: A Global Perspective. (Host: Jim Galloway)

March 30
Tom Crowley; Texas A&M.
Modeling climate change over the last 1000 years (Host: Mike Mann)

April 6
Chuck Hopkinson; Woods Hole.
Stoichiometry of Oceanic Dissolved Organic Matter (Host: Karen McGlathery)

April 13
Scott Bair; Birdsall-Dreiss Lecturer.
"Contamination of Woburn Wells G & H - What the Experts Said at Trial, What We Know Now" (Host: George Hornberger)

April 20
Tom O'Donnell; Uva.
Isotopic Composition of Amino Acids in the Calcified Tissue of the Hard Clam, Mercenaria mercenaria: geochronological and paleoenvironmental implications. ("Host": Steve Macko)

Department Undergraduate Seminar Schedule - Spring 2000
Seminar speakers and titles for the current semester. Seminars are at 4:00pm Tuesdays, Clark 147.

January 25
Ms. Karen Kneirim, Assoc. Director, OCPP, University of Virginia
"Finding Opportunities For A Career In Environmental Sciences"

February 2
Ms. Emily Greenfield, Fund for Public Interest, Washington, DC
"Mobilizing Public Policy"

February 9
Dr. Stuart Piketh, Univ. of the Witwatersrand, South Africa
"Progress and the Changing Environment of South Africa"

February 16
Ms. Robin Hubbard, State PIRGs, Washington, DC
"Environmental Campaigns and Public Interest Research Groups"
February 22
Mr. Charles Lancaster, Consultant, Media-Tech, Inc.
“Environmental Policy Partnering: Experience and a Forecast from the Field of Environmental Negotiation”

February 29
Dr. Mike Erwin, Patuxant Wildlife Research Center, USGS and UVA
“Conflict of Urban Wildlife and Resources”

March 7
Mr. Randy Holladay, Earth Sciences, Louisa County Schools
“Earth Ships”

March 14
Spring Break

March 21
Mr. James Sparks, Richmond, VA
“Is There a Future for Brazilian Jaguars?”

March 28
Dr. Edmund Russell, Div. Tech. Cult. and Comm., UVA
“The History of the Environmental Movement”

April 4
Dr. Howard Epstein, Environmental Sciences, UVA
“Sustainability of Arctic Communities: Native People, Caribou and Vegetation”

April 11
Dr. Deborah Lawrence, Environmental Sciences, UVA
“Human Impact on the Rain Forests of Indonesia”

April 18
Mr. Thomas Wilcox, Dept. of Game and Inland Fisheries, Richmond, VA
“Present and Future Environmental Issues of Natural Resources in Virginia”

April 25
Undergraduate Distinguished Majors, Department of Environmental Sciences
“Undergraduate Reports on Research in Environmental Sciences”

May 2
Undergraduate Distinguished Majors, Department of Environmental Sciences
“Undergraduate Reports on Research in Environmental Sciences”
Shenandoah Watershed Study Seminar Series - Spring 2000 Seminar speakers and titles for the current semester. 12:00 - 1:00, Odum Room, 4th floor Clark Hall, University of Virginia.

Presentations Related to the Biogeochemistry of Watersheds

12:00 - 1:00, Odum Room, 4th floor Clark Hall, University of Virginia brown bag lunch - all are welcome

January 24
Henry Wilbur (University of Virginia): Spatial ecology of salamanders: hydrology and chemistry meet population dynamics.

January 31
Frank Gilliam (Marshall University): Temporal and spatial variation in soil nitrogen transformations in a nitrogen saturated system.

February 7
Frank Thornton (Tennessee Valley Authority): Environmental impacts of short rotation woody crops.

February 17
Dave DeWalle (Pennsylvania State University): Use of tree ring chemistry to detect environmental change.

February 24
John Aber (University of New Hampshire): Nitrate retention in ecosystems: biotic or abiotic?

February 28

March 10

March 20
Mary Beth Adams (USDA Forest Service): What we have learned about nitrogen cycling from watershed acidification studies.

March 27

April 3
Mark Castro (University of Maryland): Contribution of atmospheric deposition to the total nitrogen loads in 34 estuaries of the Atlantic and Gulf coasts of the U.S.

April 10
Jack Cosby (University of Virginia): Trends in acidification of streams in response to recent changes in atmospheric deposition in the mid-Atlantic highlands.

April 17
Dawn Kirk (USDA Forest Service): Planning and implementation of liming St. Marys River and its tributaries.

April 24
Bill Currie (University of Maryland): Coupling and decoupling of carbon and nitrogen cycling in temperate forest ecosystems.

May 1
For additional information, contact Rick Webb: 804-924-7817;
rwebb@virginia.edu

FAQ
How to post a defense notice, file an annual report, register for Non-Topical Research, submit a petition.

Figure A2.5 is the program description for the University of Virginia accessible at http://www.evsc.virginia.edu/
APPENDIX 3

EVSC STUDENT GUIDEBOOK

This appendix contains information intended to assist Environmental Science students. A general problem-solving process, description of useful research tools as well as tips regarding communication are included. These same materials can assist program developers with the process of creating continuity and interdisciplinary consistency in the program.
A3.1 Introduction

This appendix provides useful information, guidelines, and intellectual tools for students in EVSC programs. After having conducted the research for this dissertation, the material listed below was identified as helpful to students and important to the success of EVSC programs. Creating better students inherently allows for better outcome attainment in programs.

Each EVSC student needs to be prepared to ask questions to understand and clarify the material presented in the courses they take. In addition, the students must be prepared to utilize tools in order to conduct research for the classes and as part of their career as an environmental professional. All of these skills come from the awareness of the aspects of the learning process discussed throughout the dissertation. A well prepared student, who can think and ask questions is essential. The first step in preparing better students is to provide them with a common methodology they can utilize to approach, research, analyze, and solve problems.

A3.2 Problem-solving

Though all the aspects of education are important, problem-solving can be most universally transferred. It is the one aspect that applies most directly to higher education. The first step in being able to problem solve is to have a systematic methodology for and understanding of what problem solving is exactly. Too often, methods for research or decision-making are substituted for true problem-solving. Problem solving requires a rational, thoughtful progression through a series of steps that can be iterated to arrive at a well-defined and rationally justified solution to a problem.
Many different problem-solving strategies have been discussed in books and articles. (Cougar, 1995; Noone, 1993; Oppenheimer, June 1995; Future Problem Solving Program, 2000; Creative Competitions Inc., 2000) Unfortunately, many of these systems only look at part of the overall process or assume that certain aspects of the process are easily attainable and do not need to be discussed. The following steps have been developed by the author as a methodology for general problem-solving that can be used in any discipline at any level to approach, work-through, and solve problems. In this case, the word “problem” has been used but could be substituted with the word “issue,” “concern,” “assignment,” “dilemma,” or any other statement denoting a challenge or unknown. The model below is a way to rationally approach situations and move through them thoughtfully and in a way that each decision can be justified when examined critically.

The process provides the students with a step-by-step intellectual model that can be followed throughout the curriculum as well as help to tie each course together as similar terminology and methodologies are used. Once the students understand the model, they can be shown how the tools of particular disciplines can be utilized within the general overarching framework of the general problem-solving process. In the end, the process can help to draw together the entire curriculum so that the capstone or thesis is simply one example of the application of the process taught throughout the entire curriculum.

**A3.3 General Problem-solving Process**

**A3.3.1 Introduction**

The following is a general problem-solving process that characterizes the steps that can be followed by any discipline when approaching and rationally solving a problem. When used in conjunction with reasoning and decision-making skills, the process works well for
one or more participants. Its main purpose is to guide participants through a procedure for solving many types of problems that have a varying level of complexity.

More importantly, the process is both descriptive and prescriptive. This means it can be used to look at past, present, and potential future problems and their solutions in a clear systematic way that is consistent and able to be generalized. At each step along the way to a solution, various types of research must be conducted to successfully accomplish the steps of the process and thus arrive at an effective solution that is viable. A description of research follows the problem solving process. In both the problem solving and research processes, good decision-making, critical-thinking and self-assessment is vital to a high quality result. At each step in the process, the problem-solver may need to go back to earlier steps and reexamine decisions made. It is this revisiting of earlier choices that make the process iterative and allows for improvement of the final outcomes.

**Figure A3.1**

**Steps in the General Problem-solving Process**

1. Become aware of the problem
2. Define the problem
3. Choose the particular problem to be solved
4. Identify potential solutions
5. Evaluate the valid potential solutions to select the best one
6. Develop an action plan to implement the best solution

Figure A3.1 lists the steps of the general problem solving process developed by the author.

**A3.3.2 Become Aware of the Problem**

The first step of any problem-solving process is becoming aware. This awareness can be generated from inside or outside the individual. Many times the awareness is part of a stated task or assignment given to the individual by someone else. In other cases, a person can observe a specific problem or a clear gap in knowledge that they feel must be addressed. In the end, as long as a problem is perceived by oneself or others, awareness of
this problem is achieved. However, the level of awareness and the research associated with this level is vital to the initiation of the problem solving process.

A3.3.3 Define the Problem

After the problem is recognized, research is conducted. Initially, research must be done to help define the problem as well as identify the assumptions being made and determine the parameters of the situation.

In the end, the main purpose of this step is to evaluate the constraints on the problem and the problem solver to better understand the goals that are trying to be reached. Once these goals are identified, the objectives that must be attained in order to reach the goals can be specified and utilized to help narrow the scope of the problem. Once the goals and objectives are clearly understood, the problem to be solved can be selected. An easy way to think of goals and objectives is that goals are what you hope to achieve while objectives are how you will go about accomplishing the goal.

Just as research might have been the impetus for engaging in the problem solving process—it made the problem-solver aware—research is vital to the specification of parameters and assumptions. The heart of this step is the series of decisions made to narrow the scope of the problem made by the problem-solver. Parameters are those factual boundaries and constraints set by the problem statement or discovered through research. Assumptions by contrast are those constraints that the problem-solver sets without having incontrovertible factual backing for those decisions. A clear understanding of the assumptions being made when engaging in the process is important. If an unsatisfactory outcome is reached, it may be necessary to adjust these assumptions. Even if the final
solution is arrived at, knowing one’s assumptions assists the problem-solver in explaining and defending their conclusions.

**A3.3.4 Choose Which Problem to Be Solved**

Once a goal and set of objectives has been specified and the parameters and assumptions have been identified, it is necessary to choose a particular problem to solve. Any large problem can be broken into smaller problems that are in turn broken into even smaller problems to be addressed. Each problem is an achievable goal that consists of objectives. Each of these objectives is a sub-problem that must be solved first in order to solve the larger overarching problem.

There are many different reasons to choose a particular problem to solve. It is important to do risk assessment on the problems involved and examine why the problem is being solved. There are many reasons why a particular problem is chosen as the one to solve. For example, the problem might be the most important, most immediate, most far reaching, or most politically important at the moment. Whatever the choice, the individual or group must have clear reasons why they choose the problem to be solved.

Once the aspects of the problem are known, the problem must be phrased as a question that each solution can answer affirmatively. An example of a problem statement might be “How might I increase the use of problem solving techniques by college graduates of four year universities in America today?” This specific type of question has four separate parts: question statement, active verb, object, and parameters and assumptions.

The first part is the question statement which transforms the problem into a question to be answered. It takes the form “How might I” or “In what ways might I.” If
the process is being undertaken by a group, it should be phrased as we instead of I. At times, an individual or a group may examine an issue concerning a third party. For example, students may work on problems facing their institution or that must be handled by the government. In this case, the question might become, "how might our school," or "In what way might the United States government." In all of these cases, the object is to create a question that must be answered as well as specify the group who is designated to answer it. Each solution must then apply to that group and be able to be accomplished by them as well.

Next is the active verb or the action used to solve the problem. Some of the most useful of these active verbs are the ones that describe change without specifying an absolute end or any one action. For example: Accelerate, alleviate, broaden, increase, minimize, reduce, and stabilize. It is important to realize that the stronger the verb, the more difficult it might be to accomplish workable solutions. For example, it is easier to reduce crime than to eliminate it. Keep this in mind when choosing verbs because verb choice is vital to good solution finding. If necessary, two or more verbs can be used and should be separated by the following conjunctions: And, Or, or And/Or. To assist in the verb choice process, some active verbs are listed below:
Figure A3.2
Active Verbs

<table>
<thead>
<tr>
<th>Accelerate</th>
<th>Control</th>
<th>Improve</th>
<th>Process</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accomplish</td>
<td>Coordinate</td>
<td>Improvise</td>
<td>Program</td>
<td>Strengthen</td>
</tr>
<tr>
<td>Accommodate</td>
<td>Counsel</td>
<td>Increase</td>
<td>Promote</td>
<td>Stretch</td>
</tr>
<tr>
<td>Achieve</td>
<td>Create</td>
<td>Initiate</td>
<td>Propose</td>
<td>Structure</td>
</tr>
<tr>
<td>Act</td>
<td>Define</td>
<td>Inspect</td>
<td>Protect</td>
<td>Study</td>
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<tr>
<td>Add</td>
<td>Demonstrate</td>
<td>Institute</td>
<td>Prove</td>
<td>Summarize</td>
</tr>
<tr>
<td>Administer</td>
<td>Design</td>
<td>Introduce</td>
<td>Provide</td>
<td>Supervise</td>
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<tr>
<td>Advise</td>
<td>Determine</td>
<td>Invent</td>
<td>Publish</td>
<td>Support</td>
</tr>
<tr>
<td>Alleviate</td>
<td>Develop</td>
<td>Launch</td>
<td>Recruit</td>
<td>Surpass</td>
</tr>
<tr>
<td>Analyze</td>
<td>Earn</td>
<td>Lead</td>
<td>Redesign</td>
<td>Survey</td>
</tr>
<tr>
<td>Arrange</td>
<td>Eliminate</td>
<td>Locate</td>
<td>Reduce</td>
<td>Synthesize</td>
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<td>Assemble</td>
<td>Employ</td>
<td>Maintain</td>
<td>Reorganize</td>
<td>Systematize</td>
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<td>Assess</td>
<td>Ensure</td>
<td>Manage</td>
<td>Report</td>
<td>Teach</td>
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<td>Audit</td>
<td>Establish</td>
<td>Market</td>
<td>Represent</td>
<td>Terminate</td>
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<td>Avert</td>
<td>Evaluate</td>
<td>Maximize</td>
<td>Research</td>
<td>Test</td>
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<tr>
<td>Broaden</td>
<td>Examine</td>
<td>Minimize</td>
<td>Resolve</td>
<td>Tighten</td>
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<td>Build</td>
<td>Execute</td>
<td>Monitor</td>
<td>Reverse</td>
<td>Trace</td>
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<tr>
<td>Centralize</td>
<td>Expand</td>
<td>Motivate</td>
<td>Review</td>
<td>Train</td>
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<tr>
<td>Change</td>
<td>Expedite</td>
<td>Negotiate</td>
<td>Revise</td>
<td>Translate</td>
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<tr>
<td>Clarify</td>
<td>Fabricate</td>
<td>Operate</td>
<td>Schedule</td>
<td>Trim</td>
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<tr>
<td>Collaborate</td>
<td>Follow</td>
<td>Organize</td>
<td>Select</td>
<td>Uncover</td>
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<td>Compete</td>
<td>Form</td>
<td>Originate</td>
<td>Serve</td>
<td>Unify</td>
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<td>Compile</td>
<td>Formulate</td>
<td>Participate</td>
<td>Settle</td>
<td>Unravel</td>
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<td>Compose</td>
<td>Find</td>
<td>Perform</td>
<td>Shape</td>
<td>Utilize</td>
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<tr>
<td>Conceive</td>
<td>Generate</td>
<td>Persuade</td>
<td>Simplify</td>
<td>Verbalize</td>
</tr>
<tr>
<td>Conclude</td>
<td>Guide</td>
<td>Plan</td>
<td>Slow</td>
<td>Verify</td>
</tr>
<tr>
<td>Conduct</td>
<td>Head</td>
<td>Predict</td>
<td>Solve</td>
<td>Visualize</td>
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<td>Conserve</td>
<td>Hire</td>
<td>Prepare</td>
<td>Stabilize</td>
<td>Widen</td>
</tr>
<tr>
<td>Consolidate</td>
<td>Identify</td>
<td>Preserve</td>
<td>Start</td>
<td>Withdraw</td>
</tr>
<tr>
<td>Construct</td>
<td>Implement</td>
<td>Prevent</td>
<td>Stimulate</td>
<td>Work</td>
</tr>
</tbody>
</table>

Figure A3.2 is a list of action verbs that can be used when formulating a problem statement.

The third part of the problem statement is the object of the sentence that relates to the problem being solved. The object states what is being acted upon by the verb to help solve the problem. Each solution must directly or indirectly affect this object. In our earlier statement, "How might I increase the use of problem solving techniques by college
graduates of four year universities in America today?” the object is “use of problem solving.”

Finally, the parameters and assumptions that are bounding the solution are listed. These help to focus the solutions that are generated. Though parameters are not necessary, they are often useful to help limit and focus the scope of the process. Be careful not to leave too broad a problem. Broad problems lead to a wide number of solutions that can be difficult to choose between and implement with weak or ineffectual results. At the same time, an overly narrow problem statement can lead to a small number of solutions that provide little usable results. In our example, “college graduates of four year universities in America today?” are the parameters. This is identified with the conjunction ‘by’ and is used to mark who should have the use of problem solving increased.

Once the problem statement is phrased properly, solutions can be generated. However, it is important to note that this statement might have to be modified as more research becomes available or as the remainder of the process is worked through. As the process is iterated, small modifications to the problem statement can be made and refinements in the scope and specificity accomplished through changes in the verb, object and parameters.

A3.3.5 Identify Potential Solutions

Once the problem statement has been chosen, it is necessary to generate potential solutions. This is the most creative portion of the process. Even so, conducting research into existing solutions to the problem or similar problems is helpful to generate workable solutions. The main criteria for judging solutions in this step is simply whether or not they answer the problem statement with a ‘yes.’ At this point, it may also be possible to eliminate some
solutions because they do not agree with commonly held moral and ethical guidelines. Even though not stated specifically, these guidelines are understood and assumed to be upheld when reviewing solutions. For example, a solution to global pollution might be to kill every human. This is obviously not a good solution even though it would give a 'yes' answer to the question of “How might we minimize global air pollution caused by humans?”

When working in groups, it is important to work together to generate solutions. Also, it should be realized that the solution process takes time depending upon the problem complexity. At this point, do not judge solutions for more than their ability to answer the stated problem questions with a “yes” because they will be evaluated more closely in the next step. Many times it is possible to use discarded solutions to develop new ideas for solutions. However, it is important to be able to distinguish between similar solutions. Saying the same thing in ten different ways may not be ten different solutions. Try to group similar solutions together. If all the solutions fall into one group, then perhaps the best solution is to implement that group with different variations for different cases of the problems. Just as there are many unique problems, the solutions to these problems are all unique and need to be adapted to the particular situations being discussed. This will be addressed in the last section of the problem solving process.

A3.3.6 Evaluate the Valid Potential Solutions to Select a Best Solution

Once a list of potential solutions has been generated, the evaluation process can begin. First, a list of criteria for judging all solutions equally must be chosen. It is vital to eliminate personal bias towards particular solutions as well as to utilize a consistent set of criteria to evaluate all solutions fairly. For example: most cost effective, most socially
acceptable, most easily implemented, most directly solves the problem, most far reaching effects, most lasting effects, least government intervention required, least limiting to development, or quickest to implement. It is important to have research and logical reasons for the criteria chosen as well as factual support for the rankings given to a particular solution for each criteria.

Once the criteria are chosen, they should be given a weighting. In most cases, all the criteria have the same weight. However, it is possible to give other weightings to criteria so that a particular factor is seen as more important. Many times, the cost, time to complete, or political nature of a project is more important than other factors and so that criteria may have a higher ranking than others used to judge.

Once the criteria are chosen and weighted, all qualified solutions must then be ranked. Two types of procedures for ranking exist. If the number of solutions is large, usually greater than ten, an independent ranking must be conducted to narrow the number of choices. Each solution is listed along one side of a grid and then given a score for each criteria from 1-5 where 5 is the highest (other ranges can be used). The rankings for the various criteria are then totaled and a score for each solution is reported. These scores are compared to create a subset of solutions that have the highest score.

If the number of solutions is initially small or the independent ranking has been conducted, the remaining solutions are placed into a grid with the criteria for a comparative analysis. Though all the solutions may be seen as good, the comparative analysis gives the best solution. The total number of solutions listed gives the range of numbers for each criteria. For example, if there are six (6) solutions, then the rankings will go from 1-6 with 6 being the highest. Each solution is ranked for each criteria in comparison to the other
solutions for that criteria. However, within a criteria no two solutions can have the same number. If two are equal, the adjacent numbers should be added and then divided by 2. The result is then placed in the space for each solution. See the charts below for an example. If the question being asked was “How might we control development in order to preserve the integrity and character of the town of Bedminster?”

**Figure A3.3**
Sample Table of Potential Solutions

<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Re-Zoning</td>
<td>Re-zone to eliminate large high-density developments.</td>
</tr>
<tr>
<td>2</td>
<td>Committee</td>
<td>Form a committee to evaluate the impact of proposed development and present it in town meetings scheduled specifically for it to be voted on by town residents.</td>
</tr>
<tr>
<td>3</td>
<td>Developer responsibility</td>
<td>Make developers responsible for civil improvements made necessary by their development.</td>
</tr>
<tr>
<td>4</td>
<td>Building rights Forfeited</td>
<td>Allow forfeit of building rights to the township as a tax write-off so that upon eventual sale, the parcel will be sold whole and never developed.</td>
</tr>
<tr>
<td>5</td>
<td>Purchase rights</td>
<td>Purchase of building rights from private landowner by township.</td>
</tr>
<tr>
<td>6</td>
<td>Donation as ‘Greenway’</td>
<td>Donation of a piece of land in a chain of parcels that provide a continuous stretch of land for wildlife to travel.</td>
</tr>
</tbody>
</table>

Figure A3.3 is a list of the potential solutions to be evaluated.

**Figure A3.4**
Sample Table of Evaluation Criteria

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Cost</td>
<td>Amount of money town and taxpayer pay to implement the plan.</td>
<td>1</td>
</tr>
<tr>
<td>B Implementation</td>
<td>Amount of time to put plan into action.</td>
<td>1</td>
</tr>
<tr>
<td>C Social acceptance</td>
<td>How acceptable is the plan to the ones whom this policy will affect.</td>
<td>1</td>
</tr>
<tr>
<td>D Environmental</td>
<td>Most beneficial to the environment</td>
<td>1</td>
</tr>
<tr>
<td>E Social impact</td>
<td>Effects on the everyday workings of the town of Bedminster.</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure A3.4 is a list of the criteria to be used to evaluate the potential solutions.

**Figure A3.5**
Sample Table of a Comparative Analysis

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
<th>Time</th>
<th>Acceptance</th>
<th>Environment</th>
<th>Impact</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Re-Zone</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>2 Committee</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>3 Developer $</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>4 Forfeited</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>27</td>
</tr>
<tr>
<td>5 Purchase rights</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>6 Greenways</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>23</td>
</tr>
</tbody>
</table>

Figure A3.5 is a comparative analysis of the solutions from the table in figure 6 based upon the listed criteria shown in figure 7 for the problem stated earlier. The values used for scoring range from 6 as most satisfies criteria to 1 that least satisfies criteria.
Once all the solutions are ranked for all criteria and the weighting is applied appropriately, the scores for each solution are totaled. The highest score is then the best solution. If two solutions are close in score then there may be two solutions that are equally as good but differ in their strong points.

It is important to remember that the criteria that are used to judge the solutions are reflective of the choices being made. Each criteria is a ruler or a gauge by which to measure an outcome. Different rulers will yield different results so be sure to choose the proper rulers as well as use them properly. In order to choose the correct ruler and interpret it in the correct way, it is necessary to understand many different disciplines and the tools they use. In the end, however, each individual must have good decision-making skills to choose and use criteria.

A3.3.7 Develop an Action Plan to Implement the Solution

After selecting the best solution, it is necessary to give some thought to the way in which it might be implemented. Giving insight into funding, potential problems with implementing the solution, and the time frame of the solution is necessary for any workable solution to a problem. Not all solutions can be implemented. Unforeseen problems may arise as solutions are tested and put to work. Many times, unexpected resistance to solutions can be encountered. Other times, unacceptable results can require that another solution be used.

In some circumstances the problem may have been originally selected incorrectly, have been misunderstood, or have changed as a result of research or altered circumstances. In the end, mistakes happen and the action plan helps the problem solver be prepared for
such eventualities. In any event, the action plan can be used to make others aware of potential problems that might be faced while putting the selected solution into effect. Even when solving a current problem, this process will automatically assist the problem solver in thinking of potential problems and thus assist in avoiding unwanted outcomes. Whatever the outcome, it is vital to understand that the choices made during this entire process rely upon research.

A3.4 Research Methods

A3.4.1 Introduction

Underlying the problem-solving process is the idea of good critical thinking, decision-making, and research skills. Critical thinking is the ability to objectively examine a problem, understand motivations behind decisions, and rationally evaluate different facets of a problem or issue. Decision-making is the process by which informed choices are made in order to evaluate, narrow, refine, or choose between alternatives. In order to have good critical thinking and decision-making, it is vital to be well informed. Thus, research is needed to inform the decision-makers, and good research skills are necessary to find answers to questions and help support the decisions made.

Research is investigation aimed at creating a better understanding of a subject. This process of gathering information can be through introspection, self-analysis, thought, observation, experimentation, or a review of existing literature and past research done by others. One of the most commonly discussed and employed methods of research and experimentation is the scientific method.
A3.4.2 The Scientific Method

The scientific method is defined as the logical approach to the solution of problems that lend themselves to investigation by observing, generalizing, theorizing, and testing. It is a research method focused on experimentation to derive knowledge about occurrences. Though often associated with the natural and physical sciences, the method can be used with any experimental science including those in the Humanities and Social Sciences such as Psychology.

The method itself has steps but is not necessarily linear. As with any problem solving process or research method, iteration is vital to attaining usable and valid results.

Figure A3.6
Steps of the Scientific Method

1. Identify a problem or gap in knowledge
2. Collect relevant information
3. Formulate a hypothesis
4. Experiment to test the hypothesis
5. Observe the experiment
6. Organize and record data from the experiment
7. Draw conclusions based on experimental facts to confirm or refute hypothesis
8. Communicate research methods, findings, & conclusions

Figure A3.6 lists the steps of the Scientific Method used to make observations and conduct research in order to test hypothesis and reliably draw conclusions.

Each of the steps listed above has specific methodology related to them in order to achieve a final solution or valid conclusion. The way each of these methodologies is set down and carried out depends upon the discipline utilizing the method. For example, the way in which a chemist creates and runs an experiment may be different from the process used by a physicist or a biologist. Though all three may look at the same occurrences in an attempt to gather information, the scale of the experiment, the process examined, and the hypothesis tested can be completely different. Each discipline has its own set of tools, processes, and guidelines by which experiments are carried out. Despite these differences,
the reported results have a systematic way of being tested and reported so that all those who understand the method used can understand and utilize these results whether or not they are within the discipline or not.

In many cases, the type of questions that are answered and the perspective from which these answers come change. Even so, the same basic steps of the Scientific Method are used to systematically and rationally research so that others can understand and duplicate the findings of researchers. A specified research method allows for various disciplines to speak a common language. Only the tools and particular processes change from expertise to expertise. The underlying methodology of research remains the same.

At the heart of the scientific method is clear rational thought that examines its own assumption, parameters and decisions to justify choice and conclusions. Faulty logic or experimentation qualifies or even invalidates any results that have been attained. As a result, the iterative process of the Scientific Method as well as other research methods are only as strong as the underlying critical thinking that underpins the research design. The abilities of the research to be organized, thorough and clear during all phases of the research process are vital to good results. As seen below, a good research method is centered around good thought processes.
A3.4.3 Other Methods

Though the scientific method is a popular and useful method of research, many other methods of research are also employed. In general, all of these methods share the common idea of systematically examining a situation to find common trends that can be understood by others. Also, any theory needs to be reproduced by others as they look at similar subjects in similar conditions.

When examining the actions of people, other methods than the scientific are sometimes employed. By looking at cases, conducting personal interviews, and examining the overall picture, insights can be found. Texts such as Yin’s (March 1994) *Case Study Research*, Aday’s (1996) *Designing and Conducting Environmental Health Surveys A Comprehensive Guide*, Strauss, & Corbin’s (1998) *Basics of Qualitative Research: Techniques and Procedures For Developing Grounded Theory*, and Weiss’ (1998) *...*
Evaluation all give other methods for conducting research into various areas. No matter how it is accomplished, the idea that problem-solvers and decision-makers must have information to assist in the work they do is clear. More importantly, students should be exposed to these skills early in their academic lives rather than later. Knowing how to find answers and do research to inform decisions and solve problems is not part of any one discipline, but rather necessary to all.

A3.5 Other Student Skills

A3.5.1 Introduction

Beyond the common standing of problem-solving and research, EVSC students must be given other tools to assist them in becoming better learners. Being aware is an important first step and to become aware means asking questions. As students enroll in and work through courses in the curriculum, each student must be aware of what each course offers and intends to teach.

Each student must begin by knowing the definition of the course being examined as well as the specific subdivision of the discipline that the class is contained within. For example, a Physics class can cover many areas—mechanics, electromagnetic waves, or quantum mechanics. Similarly, a class in chemistry can cover basic principles, organic or inorganic chemistry, analytic methods, or be focused on the chemistry of the environment or one of many other specific applications.

Once the definition of a course has been established, other questions should be asked. Having a clear understanding of the course and its materials is essential to having active and educated students.
Course content
• What are the goals of the course?
• What are the objectives of the course?
• What are the theories presented in the course?
• What are the applications of the theories presented in the course?
• What are the limitations of the theories and application presented?
• How can the material of the class be applied to EVSC?

Research methods
• What tools are used by practitioners as they gather data to support the theories and applications in the course?
• What are the limitations of the material presented?
• How reliable is data collected by the research methods?
• How can the tools be applied to EVSC?

Overall knowledge
• When is it appropriate to utilize the course material with regard to EVSC?
• How well does the material from the course interface with other disciplines?
• How easily can the tools and other material from the course be transferred to other disciplines?

A3.5.2 Internet Research

As students research material for classes, having good places to start would also be helpful. Below are two tables of web page addresses that can serve as starting points for various types of research into fields related to EVSC. Table 8 shows several governmental pages that provide a vast array of information.
Figure A3.8

<table>
<thead>
<tr>
<th>Organization</th>
<th>World Wide Web Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Committee on the National Institute on the</td>
<td><a href="http://www.cnie.org">http://www.cnie.org</a>.</td>
</tr>
<tr>
<td>Environment</td>
<td></td>
</tr>
<tr>
<td>Federal Wildlife Officers Association</td>
<td><a href="http://www.fwoa.org/">http://www.fwoa.org/</a></td>
</tr>
<tr>
<td>United States Food and Drug Administration</td>
<td><a href="http://www.fda.gov/">http://www.fda.gov/</a></td>
</tr>
<tr>
<td>National Aeronautic and Space Administration</td>
<td><a href="http://www.nasa.gov/">http://www.nasa.gov/</a></td>
</tr>
<tr>
<td>National Institute of Environmental Health Sciences</td>
<td><a href="http://www.niehs.nih.gov/">http://www.niehs.nih.gov/</a></td>
</tr>
<tr>
<td>National Library for the Environment</td>
<td><a href="http://www.cnie.org/nle/">http://www.cnie.org/nle/</a></td>
</tr>
<tr>
<td>National Oceanic and Atmospheric Administration</td>
<td><a href="http://www.noaa.gov/">http://www.noaa.gov/</a></td>
</tr>
<tr>
<td>United States Department of Agriculture</td>
<td><a href="http://www.usda.gov/">http://www.usda.gov/</a></td>
</tr>
<tr>
<td>United States Bureau of Land Management</td>
<td><a href="http://www.blm.gov/">http://www.blm.gov/</a></td>
</tr>
<tr>
<td>United States Department of Interior</td>
<td><a href="http://www.doi.gov/">http://www.doi.gov/</a></td>
</tr>
<tr>
<td>United States Environmental Protection Agency</td>
<td><a href="http://www.epa.gov/">http://www.epa.gov/</a></td>
</tr>
<tr>
<td>United States Fish and Wildlife Service</td>
<td><a href="http://www.fws.gov/">http://www.fws.gov/</a></td>
</tr>
<tr>
<td>United States Forest Service</td>
<td><a href="http://www.fs.fed.us/">http://www.fs.fed.us/</a></td>
</tr>
<tr>
<td>United States National Park Service</td>
<td><a href="http://www.nps.gov/">http://www.nps.gov/</a></td>
</tr>
</tbody>
</table>

Figure A3.8 lists internet URL addresses for several governmental web pages.

Table 9 shows several general Internet pages that provide links to a variety of useful information related to EVSC.
Figure A3.9 lists Internet URL addresses for several general information web pages.

<table>
<thead>
<tr>
<th>Organization</th>
<th>World Wide Web Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Info Science Gateway</td>
<td><a href="http://www.academicinfo.net/subsci.html">http://www.academicinfo.net/subsci.html</a></td>
</tr>
<tr>
<td>Chemistry and Environmental Science Dictionary</td>
<td><a href="http://EnvironmentalChemistry.com/yogi/chemistry/dictionary/">http://EnvironmentalChemistry.com/yogi/chemistry/dictionary/</a></td>
</tr>
<tr>
<td>Earth Vision Network</td>
<td><a href="http://www.earthvision.net/">http://www.earthvision.net/</a></td>
</tr>
<tr>
<td>Econet</td>
<td><a href="http://www.igc.org/igc/gateway/enindex.html">http://www.igc.org/igc/gateway/enindex.html</a></td>
</tr>
<tr>
<td>Environmental Defense</td>
<td><a href="http://www.edf.org/">http://www.edf.org/</a></td>
</tr>
<tr>
<td>Environmental News Network</td>
<td><a href="http://www.enn.com/">http://www.enn.com/</a></td>
</tr>
<tr>
<td>Environmental Science Links</td>
<td><a href="http://www.uea.ac.uk/~e907122/envlink.html">http://www.uea.ac.uk/~e907122/envlink.html</a></td>
</tr>
</tbody>
</table>
| Environmental Science Resources—St. Anselm College                           | http://www.anselm.edu/homepage/jpitocch/rese
 nv.html |
| Greenpeace USA                                                              | http://www.soton.ac.uk/~engenvir/environment/biodiversity/bio.html |
| Greenwire                                                                   | http://nationaljournal.com/samples/greenwire/front.htm    |
| Internet Resources For The Environmental Scientist                           | http://www.imt.net/~dcouncil/env.html                     |
| National Writing Centers Association                                        | http://departments.colgate.edu/diw/NWCA.html               |
| Natural Resources Conservation Service                                       | http://www.ncrsc.usda.gov/                                |
| Natural Resources Defense Council                                            | http://www.nrdc.org/                                      |
| Northern Prairie Wildlife Research Center                                    | http://www.npwrc.usgs.gov                                  |
| Oak Ridge National Laboratory Environmental Sciences Division                | http://www.esd.ornl.gov/journals.html                     |
eton/online/ESI-links.html                                                   |
| Public Interest Research Groups                                              | http://pirg.org/index.html                                |
| Purdue University                                                           | http://owl.english.purdue.edu/Files/34.html.               |
| The National Center for Ecological Analysis and Synthesis                   | http://www.nceas.ucsb.edu/                                |
| WWW Virtual Library: Environment                                            | http://earthsystems.org/Environment.shtml                 |

The table above lists the Internet URL addresses for several general information web pages.
A3.6 Communication

A3.6.1 Introduction

Beyond providing a methodology to solve-problems and assisting students to conduct research, other skills are necessary to improve the performance of EVSC students. One of the most important areas is that of communication. Without good communication skills, an active student may not be able to be as effective in the learning process or function as well in their professional life.

Though communication is difficult to teach, certain skills are vital. Writing and public speaking are two vital skills necessary in all disciplines and at all levels of education. In many classes, too much reliance is placed upon the work of others to have accomplished the goals of educating students about communication prior to their enrollment in non-communication-based classes such as technical writing or public speaking. The assumption is that when a paper or presentation is assigned, students have already learned what is needed, have the skills from other sources, or will learn by doing without much guidance. Unfortunately, for many students none of these are true and they are left to flounder while trying to determine what is expected and how to improve themselves with little direction.

What follows are simple descriptions of general rules that all students should know and follow. With a good basic understanding, the job of all educators will be easier because, as with problem-solving, the uniformity will help highlight where students have problems. In addition, good skill-transfer early in the academic life of a student will allow them to hone the skills throughout their career as opposed to having to only partially learn them repeatedly throughout, acquiring bad habits and contradictory notions along the way.
A3.6.2 Writing

When writing a paper, it is important to begin by understanding the purpose or the goal of the writing assignment. Papers can be written to explain, inform, impress, or persuade a reader. Every paper has different lengths, audiences, intentions and many other factors that must be considered. Once the goal of the paper is understood, the process of writing can begin. Every person has their own method for creating a paper—researching, writing, and reworking. Even so, all paper writing can be broken into two divisions—form and content. Both of these parts consists of a four step process—creation, revision, editing, and proofreading. Many times when writing a paper for a class, the form is specified and a word processing program provides the template to use. This eliminates most of the process for the form. In the same way, some students try to eliminate the process for content. This is Plagiarism. Any work handed in must be of your own creation. If material is taken, it must be properly cited using a specified format such as Modern Language Association (MLA) or American Psychological Association (APA) format.

Though every paper can be broken into form and content, it is important to understand that most, if not all, follow a similar outline. Though the specifics of the form and content vary, the sections listed below will appear in most papers. It is also important to realize that as the length of the paper increases the requirements change. Though any paper may have section headings, once the paper reaches a length of 6 pages, they are usually expected and beyond ten pages almost always required. As the length increases beyond that, an abstract and a table of contents are usually included as well. Below are some brief guidelines for sections that should be found in your papers.
Title page: Every paper should begin with information about the author and the assignment. This can include author’s name, due date, class, professor name and many other things. On longer assignments, such as term papers, and those written by multiple authors, a separate cover sheet is used. Directly following this heading, the title of the work should be centered on the page. For works with a separate title page, the title may be centered vertically on the page as well. Be sure to use a title that gives insight into the topic being covered in the paper (Do not use ‘Assignment #1’).

Contents: In large papers, there is a need for a table of contents that helps the reader understand how the work is organized. Each heading in the text should be used as an entry in the table of contents along with any other graphs, tables, figures or other inserts.

Abstract: This is a summary of the paper that is intended to review the thesis and the major points of evidence used to support that thesis. It is usually only included with a larger writing assignment and should be no longer than 250 words. In business works, an executive summary can be substituted for the abstract. The executive summary gives the project that was originally assigned, the assumptions and parameters made by the author, and the conclusions that were found.

Introduction: This is the opening of a paper. It is intended to catch the audience’s attention and focus it upon the main idea or thesis of the paper. It may also contain an outline of the evidence presented in the paper that supports the thesis being discussed.

Background: This section is not necessary for every paper but helps the audience understand what is being discussed and provides useful definitions and other material that appears in the body.

Body: This section logically develops the topic specified in the thesis statement and supports it with evidence and examples.

Conclusion: This section draws the paper to a close by summarizing and bringing together the relevant facts and arguments that were presented earlier in the paper. It concisely crystallizes the significant points of the paper. It can also give the audience insight into how the topic is connected to other areas or has implications for further exploration and research.

Some information about the writing process can be found at the following web pages:

Purdue Online Writer’s Lab: http://owl.english.purdue.edu/handouts/research/r_apa.html
National Writing Centers Association: http://nwca.syr.edu
American Psychological Association: http://www.apa.org/journals/webref.html
A3.6.3 Public Speaking

As with writing a paper, the first step in a good oral presentation is understanding the goal of the speech. Every speech has two major divisions, content and form or presentation—what you say and how you say it. The content of a speech is the material and message the speaker wishes to convey to the audience. The form of the speech is the way in which the speaker delivers it to that audience. Both are vital to making a good speech and depend on the skills of the speaker and the topic being discussed. Below is a brief outline that can help when developing a speech. These areas are the ones that a judge might look for when evaluating a good speech.

I. SELECTION
   A. Purpose - To explain, impress, convince, or persuade
   B. Central Idea - The matter in general
   C. Method of Development - Clear, simple, orderly, logical: listing details, examples, and extended example comparison and contrast; argument and persuasion analysis

II. DEVELOPMENT
   A. Focus on Main Points - The matter in particular
   B. Proportionate Elaboration - Illustrations and emphasis
   C. Transitions - Sensible progress

III. PRESENTATION
   A. Diction and Tone - Choice of words and evidence of an appropriate attitude
   B. Voice Control - Pitch, rate, volume
   C. Pronunciation and Articulation - Clearness and emphasis
   D. Projection - Rapport, consciousness of audience reaction

Though every speech can be broken into form and content, it is important to understand that most, if not all, speeches follow a similar outline. Though the specifics of the form and content vary, the sections listed below will appear in most speeches. Also, remember that every speech should begin with a salutation such as “hello” followed by the name(s) of the speaker(s) as well as the topic to be discussed. This will be immediately followed by the overview of the speech.
Overview: This is a description of the entire presentation so that the audience can know what to expect. It is similar to a table of contents in a text.

Introduction: This is similar to the opening of a paper. It is intended to catch the audience’s attention and focus it upon the main idea or thesis of the speech. It may also contain an outline of the evidence presented in the speech that supports the thesis being discussed.

Background: This section is not necessary for every speech but helps the audience understand what is being discussed and provides useful definitions and other material that appears in the body.

Body: This section logically develops the topic and supports it with evidence and examples.

Conclusion: This section draws the speech to a close by summarizing the points made and restating the thesis. It can also give the audience insight into how the topic is connected to other areas or has implications for further exploration and research.

Below is a link that can be helpful with public speaking preparation. Public Speaking: http://www.zap.org/terdoyle/pubspeak/assess.html

A3.6.4 Team Interactions

Beyond the individual ability to communicate effectively, it is important for EVSC students to be able to understand others and be able to work in groups. Due to the interdisciplinary nature of the field, good group dynamics and group communications skills are useful, if not vital, to a good EVSC professional. Not only will these skills assist the student to better understand the various other disciplinary experts working to solve the environmental problem, these group communication skills will provide an avenue for leadership and unification. The one who understands how to relate to all those on the team as well as communicate with each team member should emerge as the leader.

Though there are many ways to approach team work and improve the necessary skills, the first step is to know what is involved and be prepared when approaching a
situation involving team work. Before even engaging in a team activity it is important to understand that there is a difference between working as a team and coming together as a group to divide work. Though a report may be assembled by many people, if there is no collaboration and exchange of thoughts, it is not a team effort. A team must work together to assess the various aspects of a problem. Though there may be division of labor and a leader is selected, all members of the team should have an opportunity to give input and make decisions.

To assist the EVSC student with team work, there are several key things to remember when working with others in a team. It is important to clearly identify roles in the groups as well as the strengths and weaknesses of each team member. At the same time, the problem being solved must also be understood and defined so the proper skill-sets can be isolated and those with the needed skills can be assigned to the appropriate aspects of the problem. Having specified some definitions, the team may wish to elect a leader or someone to be the facilitator and coordinator of the group’s activities. This is not intended to give one person all the power or all the work.

Each team member should agree to their role in the project. In larger or longer-term projects, team members may consider signing a contract with the other group members. The contract can help to define roles, assign responsibilities and mark deadlines and other scheduling issues. Having the contract can add clarity to team work and help to eliminate the duplication of effort or the incompleteness of team projects.

The last issues that will be addressed in this short primer on group work is individual conduct. Each member of the group, whether or not they are the leader, plays an important role. Knowing simple rules of conduct can help make any team experience more
rewarding. Each member of the team should work to maintain focus while working. To this end, each individual should strive to reduce conflict in the group while promoting healthy interaction. Another way to reduce conflict and maintain focus is by being aware of the space in which the team is working. Team members can avoid unnecessary arguments by respecting the others in the group. Finally, when speaking with others, try to allow others to speak while still contributing. A balance in listening time and speaking time is important to healthy team work.

No team can be guaranteed success. However, well prepared team members can improve the chances of success. Unfortunately, sometimes only by removing team members can the team become truly successful. However, if you remove everyone from the team, you are no longer part of it yourself. Each individual brings unique knowledge and perspective to each team effort. It is this unique interaction that makes team work desirable and successful.

**A3.7 Final Thoughts**

All of the information in this appendix is designed to assist students. However, none of it guarantees success. The program must decide to implement a common set of guidelines for students to follow. In addition, the program must incorporate the teaching of these skills into the curriculum so that the lessons are repeatedly reinforced in the students’ minds.

Once the continuity is contained within the program, is will become the responsibility of the student to understand these lessons and become proficient in the skills suggested. Rather than seeing these skills as an obstacle to overcome at the time of a test, paper, or presentation, these skills will be part of the learning process. This will create
better students that are able to be proactive in their education, communicate about and solve problems as well as express themselves when interacting in a variety of settings.

Though some specifics were given in this section, they are meant only as guidelines. Any coherent set of rules can be chosen and implemented. Often, professional societies or institutional administrations can provide such rules of conduct for a program. If not, these rules can be agreed upon by those in the program and adopted. In the end, it is continuity and consistency that is sought rather than strict adherence to dogma.
REFERENCES


Himelstein, N. (Fall 1998) *Types of Managers*. Organizational Behavior Lecture, New Jersey Institute of Technology.


