Environmental Programs' Comparative and Strategic Analysis: JMU in the National Landscape

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Executive Summary

The purpose of this report is to: (1) compare the environmental programs at James Madison University (JMU) to interdisciplinary environmental (IE) programs nationally based on National Council for Science and the Environment (NCSE) research, and (2) illustrate how JMU is positioned in the national environmental and sustainability higher education landscape. JMU offers twelve education programs with an environmental or sustainability focus: four minors, five concentrations in different disciplines, an undergraduate certificate, a dual MS degree program with the University of Malta, and the Sustainable Engineering Design program. All of these programs were established between 1999-2010—part of the rapid expansion of interdisciplinary environmental and sustainability education programs in higher education that began about 2000 and continues today.

Four of JMU's twelve environmental programs differentiate the university nationally. The School of Engineering program in Sustainable Engineering Design is a pioneering and exemplary model for engineering. The two environmental concentrations offered by the Department of Integrated Science and Technology—Geographic Science: Environmental Conservation, Sustainability and Development (ECSD) and Integrated Science and Technology: Environment (ENV)—and the dual master of science in Integrated Science and Technology and in Sustainable Environmental Resources Management also offered by the department in partnership with the University of Malta are distinctive programs well aligned with expanding environmental and sustainability workforce needs. Very few universities offer programs as cutting edge as the new School of Engineering program in Sustainable Engineering Design or programs similar to those offered by the Department of Integrated Science and Technology. Only two other large master's institutions offer similar applied science and technology programs: Marshall University in West Virginia and Rochester Institute of Technology in New York.

The Biology: Ecology and Environmental Biology (EEB) and Geology: Environmental and Engineering Geology (EEG) concentrations are solid concentrations with a number of students selecting these options within the majors. The Economics: Environmental and Natural Resources Economics (ENRE) concentration is less successful but has high potential given the new global focus on the importance of the economics of sustainability. Three of the four minors—Environmental Science, Environmental Studies and Environmental Management—share a capstone course which investigates a particular environmental topic using a case-study, team-teaching approach. A synthesis capstone course requirement for minors is unusual and is an important strength of these three minors. The fourth minor—Environmental Information Systems—is closely affiliated with the Department of Integrated Science and Technology and serves primarily as a specialization area for a small number of departmental majors. The Advanced Manufacturing Certificate focuses on life cycle analysis, a defined set of methodologies and principles for sustainable manufacturing—knowledge and skills in high demand. It also serves primarily as a specialization area for a small number of business majors. Many of the programs also require an experiential component—an important requirement since experiential experience is highly desired and valued by students, employers and educational experts.

The NCSE study found a number of factors that correlate positively and significantly with enrollment trends in IE degree programs. In the case of undergraduate programs, three program objectives were

positively correlated with undergraduate program growth: preparing students to become leaders and change agents, providing community service, and advancing environmental/sustainability research. Both undergraduate and graduate program growth was positively correlated with inclusion of sustainability in the curricula (as a core principle, in focused coursework, through research experiences, and through applied/service learning opportunities).

These trends are apparent for the JMU environmental programs, the programs that include sustainability and share the programs objectives correlated with undergraduate enrollment growth are thriving—the Geographic Science: ECSD and Integrated Science and Technology: ENV concentrations, the Sustainable Engineering Design program and the Environmental Studies minor all have increasing enrollments. The other programs have low, but steady enrollments.

The NCSE study revealed a consensus field identity for IE programs based on sustainability-oriented scholarship, research and practice with an emphasis on interdisciplinary problem solving as described in the key findings section of this document. Several of JMU's environmental programs align well or fairly well with the key characteristics of the IE field. The Integrated Science and Technology: ENV and the Sustainable Engineering Design programs are well-aligned with the national consensus on IE program field identity. The Geographic Science: ECSD program is well-aligned except for a clear emphasis on synthesis and systems-thinking as key learning outcomes. Although not included in this report, the dual master's degree program in Sustainable Environmental Resources Management/Integrated Science and Technology offered through a partnership with University of Malta appears to also be well aligned with the key characteristics of the IE field.

The minors are fairly well-aligned but do not have a clear focus on the interactions of coupled human-nature systems since they seem to focus primarily on either natural or social systems rather than the coupled human-natural systems interface. Since these programs are minors, students' degrees will align with the IE field more or less depending upon their majors.

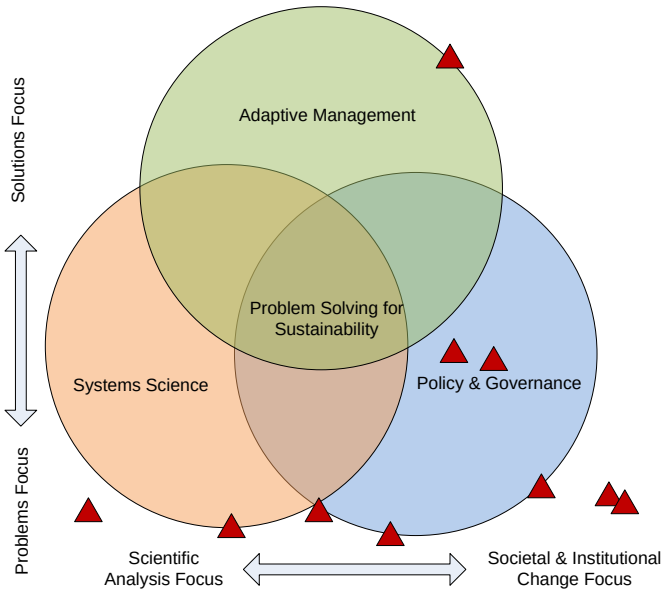
The remaining programs align more closely with their disciplines and professional fields than with IE programs. The Biology: EEB, Economics: ENRE and Geology: EEG programs do not explicitly include sustainability and focus primarily on either natural systems or social systems rather than the interactions of coupled human-nature systems. They also stress disciplinary depth rather than synthesis and systems-thinking. The Advanced Manufacturing Certificate focuses on life cycle analysis, a defined set of methodologies and principles for sustainable manufacturing.

The NCSE study revealed three ideal approaches to IE education that prepare students for three broad categories of IE careers: the *Systems Science* model that prepares students for careers as environmental research scientists and technicians, the *Policy and Governance* model that prepares students for careers as specialists and citizens involved in environmental policy, planning, administration and governance; and the most desirable IE model (most popular among program administrators, students and employers)—the *Adaptive Management* model, that prepares students for careers as environmental and sustainability management and decision making professionals.

Degree programs aligned with the *Adaptive Management* model were more likely to exhibit a growth trend than the other two models. The *Adaptive Management* model is also the model best aligned with

emerging workforce needs. The only JMU environmental program associated with the *Adaptive Management* approach—the Sustainable Engineering Design program—is the program with the highest number of students.

Two of the JMU environmental programs align well with one of the three models—the Geographic Science: ECSD and the Integrated Science and Technology: ENV degrees fit within the *Policy and Governance* model. The other JMU programs are located on the peripheries indicating weak associations with the models. This is not surprising given that the framework is based on IE degree programs and the JMU programs are primarily discipline-based degrees or minors/certificates. The figure illustrates where ten of the twelve JMU programs relate to the framework.[1] See pages 57-60 for the analysis.



A notable difference between JMU and peer institutions is the lack of interdisciplinary environmental or sustainability degree programs and interdisciplinary environmental academic units. Recognition of the importance and urgency that sustainability-oriented problem solving has for the health, security and prosperity of the nation and the world has led to rapidly expanding demand for IE and sustainability education. It has also catalyzed the creation of a steady stream of new research and education centers and institutes, colleges, schools, departments and campuses dedicated to the study of the environment and sustainability.

The National Council for Science and the Environment 2012 census (just completed) reveals that majority of four-year colleges and universities offer IE and/or sustainability degree programs; the proportion has increased 33% since 2008 and the number of degrees offered has increased by 56%. The census also indicates a sharp increase in academic units devoted to interdisciplinary study with a predicted concomitant increase in interdisciplinary faculty positions and expansion of interdisciplinary research and private-public partnerships.

JMU plays an important role as a leader in environmental and sustainability education and research. Continuing to enhance its leadership position will benefit the university and help it achieve the goals of the strategic plan, strengthen its role as an important driver of economic development in Virginia and the region, and increase recognition of its importance as an education and research center preparing a 21st century workforce, conducting significant research, and providing service to society.

The report is comprised of eight sections: (1) a short overview of the JMU environmental programs, (2) an overview of IE programs in the United States, (3) key findings from the NCSE national study, (4)

[1] The dual MS degree offered with the University of Malta was not included in this report and the certificate program in advanced manufacturing did not provide the required data for this analysis.

comparison of the JMU environmental programs' administrative attributes to IE programs nationwide, (5) a comparison of the JMU programs' curricular attributes to IE undergraduate degree programs at peer institutions and nationwide, (6) an overview of the evolving IE and sustainability workforce, (7) summary and national trends in IE and sustainability education, and (8) a summary of the exclusive benefits provided to NCSE Affiliates and NCSE supported resources for students and faculty.

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Section I – Overview of the JMU Environmental Programs

Institution Carnegie Classification Information

- *Basic Carnegie Class/Control:* Master's colleges and universities, larger programs, public control
- *Size and Setting:* Large, primarily residential (FTE enrollment of at least 10,000 degree-seeking students; 25-49% of degree-seeking undergraduates live on campus and at least 50 percent attend full time).
- *Enrollment Profile:* Very high undergraduate (professional/graduate students < 10% FTE enrollment); more selective, lower transfer-in
- *Community Engagement:* Curricular engagement, outreach and partnerships

The Carnegie Classification has been the leading framework for recognizing and describing institutional diversity in U.S. higher education since 1970. The Carnegie Commission on Higher Education developed a classification of colleges and universities to support its program of research and policy analysis. The Carnegie Classification framework has been widely used in the study of higher education, both as a way to represent and control for institutional differences, and also in the design of research studies to ensure adequate representation of sampled institutions, students, or faculty. The attributes listed here for James Madison University (2010 profile) are used to tailor this report.

Environmental Programs

- Minors
    - Environmental Science (Office of Cross Disciplinary Studies and Planning)
    - Environmental Studies (Office of Cross Disciplinary Studies and Planning)
    - Environmental Management (Office of Cross Disciplinary Studies and Planning)
    - Environmental Information Systems (Department of Integrated Science and Technology)
- Environmental Concentrations/Focus Area/Dual Degree
    - Biology: Ecology and Environmental Biology (Department of Biology; College of Science and Mathematics)
    - Economics: Environmental and Natural Resource Economics (Department of Economics; College of Business)
    - Engineering: Sustainable Engineering Design (School of Engineering)
    - Geographic Science: Environmental Conservation, Sustainability and Development (Department of Integrated Science and Technology; College of Integrated Science and Technology)
    - Geology: Environmental and Engineering (Department of Geology and Environmental Science, College of Science and Mathematics)
    - Integrated Science and Technology: Environment (Department of Integrated Science and Technology; College of Integrated Science and Technology)

  - Dual MS in Integrated Science and Technology and Sustainable Environmental Resources Management (College of Integrated Science and Technology and University of Malta) (not included in report)

- Undergraduate Certificate Programs (College of Business)
  - Advanced Manufacturing
  - Environmental Sustainability/Business Sustainability (discontinued)

How the overall educational purposes are defined for the environmental programs are an important consideration for the report, therefore statements from the JMU website describing the various programs are included in this section.

All Environmental Programs: James Madison University supports a variety of environmental majors and minors that are part of a larger hub of academic and applied environmental initiatives at JMU. There are many options for students to learn about the natural, human, and technological dimensions of environmental systems and sustainability. Students can major in a science or social science with an environmental emphasis, or they can partner an environmental minor with any major. In the majors and minors listed here, research projects, field studies, and scientific experimentation are integrated into the curriculum to provide hands-on experience with current technologies and relevant environmental policies and regulations. Students pursuing an interest in environmental study will find themselves well prepared for advanced graduate study or workforce success.

The Minors: The Environmental Management, Environmental Science and Environmental Studies take an interdisciplinary approach that prepares students to develop and apply science and technology to environmental problems in a variety of professional settings. The interdisciplinary minor in Environmental Information Systems is designed for undergraduates interested in using computer and information management technology to solve environmental problems and improve environmental stewardship. Any of the three environment minors may be taken in conjunction with any JMU academic area. Environmental Management, Environmental Science and Environmental Studies are united by a common capstone. In this course, students converge and work with a faculty team on environmental problem solving from this cross-disciplinary nexus.

The Concentrations: The concentration in Ecology and Environmental Biology is designed for students with interests in ecology, field biology, natural resources, environmental biology, conservation biology, evolution, animal behavior, and organismal biology.

The concentration in Environmental & Natural Resource Economics is for students with specific interests in forests, fisheries and wildlife or those with a more general interest in both environmental and natural resource issues.

The Geographic Science concentration in Environmental Conservation, Sustainability and Development allows students to explore human and environmental change in depth through a focus that brings together environmental and economic questions.

The concentration in Environmental and Engineering Geology presents specialized study focusing on earth materials, internal and external earth processes, and analysis of earth history and application of geology to environmental and engineering issues.

In the Integrated Science and Technology concentration in Environment, students learn to apply natural and social sciences to address and manage practical, real-world environmental problems faced by modern society. Through coursework, students learn about the natural, human, and technological dimensions of environmental systems and sustainability. Research projects, field studies, and scientific experimentation are integrated into the curriculum to provide hands-on experience with current technologies and relevant environmental policies and regulations. Graduates with this concentration are well-prepared to enter the workforce or to pursue advanced degrees.

The Sustainable Engineering Design Focus: The Sustainable Engineering Design Focus incorporates the technical, economic, environmental and social requirements of the engineering design process.

The Dual MS in Integrated Science and Technology and Sustainable Environmental Resources Management: A fresh and innovative course of study that focuses on using analytical tools in a case study approach to address the key issues that define the future welfare of our global environment and the manner by which resources are utilized and managed. SERM integrates a strong and balanced technical program with policy and legal perspectives in exploring issues of agriculture and land, air and waste, water, energy, and marine and coastal resources. It reflects the impacts and potential of globalization through examples drawn from environmental issues across the Euro-Mediterranean region and, indeed, throughout the world.

The Undergraduate Certificate: The Advanced Manufacturing Certificate covers methodologies/principles that minimize the use of energy and waste throughout the life-cycle of a product. These principles include design for the environment, design for reuse, design for manufacturability, and design for disassembly. The courses highlight life-cycle assessment of the interaction of each manufacturing activity with the environment—from the creation of materials to product manufacture, distribution and use of products, disposal after use, and sometimes reincarnation.

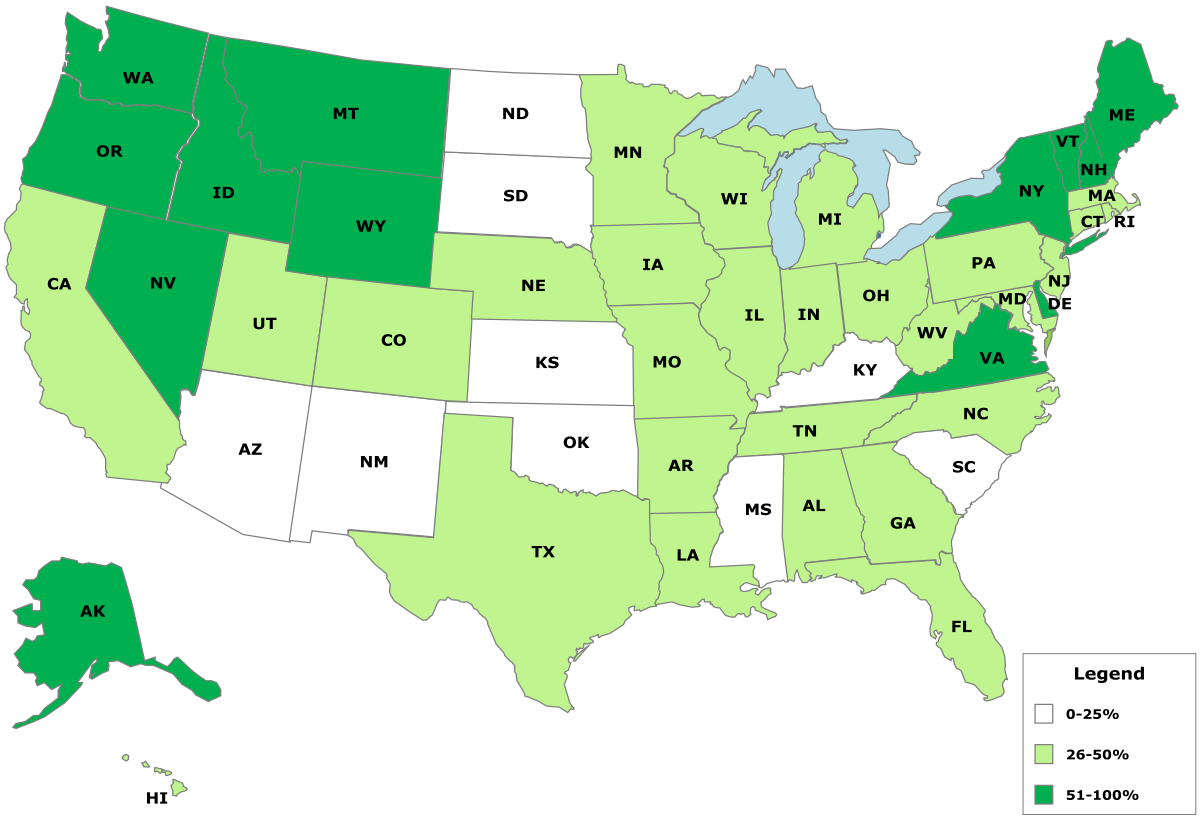
Section II – NCSE Study: IE Programs Overview

Colleges and Universities with IE Degree Programs

The information provided in this section and the next section on the key findings of the NCSE study is included to provide background and context for the remainder of the report.[2]

The NCSE's study of interdisciplinary environmental (IE) programs conducted a census of IE programs in the United States in 2008 which identified 840 IE programs offering 1,183 baccalaureate and graduate degrees located at 652 colleges and universities (Table 1). IE programs are offered in all 50 states, as well as Guam and Puerto Rico (Figure 1). Pennsylvania and New York boast the largest number of higher education institutions with IE programs—53 in PA and 60 in NY. On average, about 40% of the four-year institutions located in each state offer one or more IE degrees; the proportion for Virginia is higher at 52%. States in the Northeast and in the Northwest have the highest proportions.

Figure 1. Proportion of U. S. four-year institutions hosting IE programs



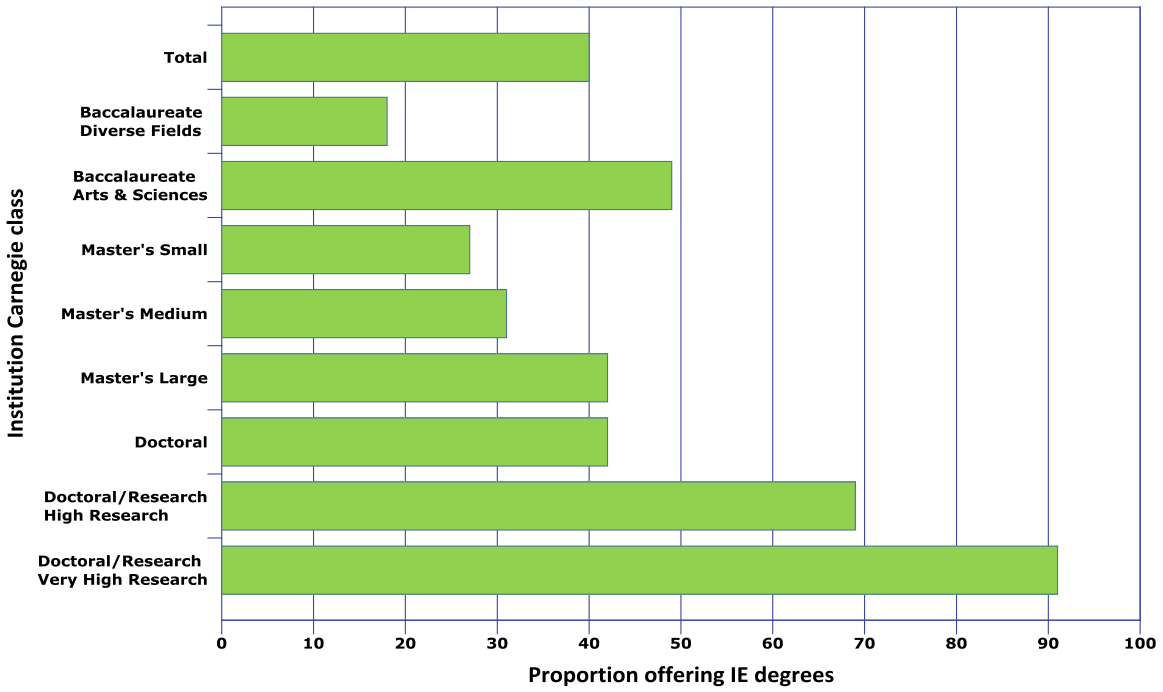
[2] The sample was representative based on four parameters (institution Carnegie class, control—public or private not-for-profit, census region, and degree name/level) and large enough to measure correlations between attributes with a power of 0.90 to detect a 0.20 (moderate) effect at α=0.05; statistical frequencies have a margin of error of ±5%.

Table 1. U.S. institutions with IE degree-granting programs by state

State/Territory	Number of IE degree-granting institutions	Proportion of all 4-year institutions	State/Territory	Number of IE degree-granting institutions	Proportion of all 4-year institutions
Alaska	5	100%	Montana	7	70%
Alabama	9	32%	North Carolina	22	44%
Arkansas	7	37%	North Dakota	2	20%
Arizona	4	24%	Nebraska	6	33%
California	41	39%	New Hampshire	9	53%
Colorado	11	44%	New Jersey	11	39%
Connecticut	9	43%	New Mexico	2	14%
District of Columbia	4	36%	Nevada	3	60%
Delaware	3	60%	New York	60	52%
Florida	19	38%	Ohio	27	44%
Georgia	11	26%	Oklahoma	5	24%
Guam	1	100%	Oregon	12	55%
Hawaii	3	38%	Pennsylvania	53	48%
Iowa	13	45%	Puerto Rico	6	17%
Idaho	4	57%	Rhode Island	3	38%
Illinois	25	46%	South Carolina	7	23%
Indiana	16	37%	South Dakota	2	15%
Kansas	6	23%	Tennessee	11	30%
Kentucky	5	19%	Texas	34	47%
Louisiana	7	33%	Utah	4	44%
Massachusetts	26	46%	Virginia	23	52%
Maryland	11	44%	Vermont	11	61%
Maine	13	81%	Washington	14	58%
Michigan	16	39%	Wisconsin	14	42%
Minnesota	15	41%	West Virginia	7	39%
Missouri	11	28%	Wyoming	1	100%
Mississippi	1	7%	**Total**	**652**	**40%**

The proportion of institutions offering IE programs differs by institutional type. Figure 2 illustrates that institutions classified as doctoral/research universities are much more likely to offer IE degrees than other types of institutions.

Figure 2. Proportion of institutions offering IE degree programs by institution Carnegie class



IE Degree Programs' Rapid Growth

Student demand for interdisciplinary environmental (IE) education has been growing rapidly since the 1990s and reached new heights in 2009-10. The escalating interest in environmental degree programs has been widely reported by the media including articles in the *Newsweek-Kaplan College Guide*, the *Princeton Review*, the *New York Times*, and *USA Today.* [3]

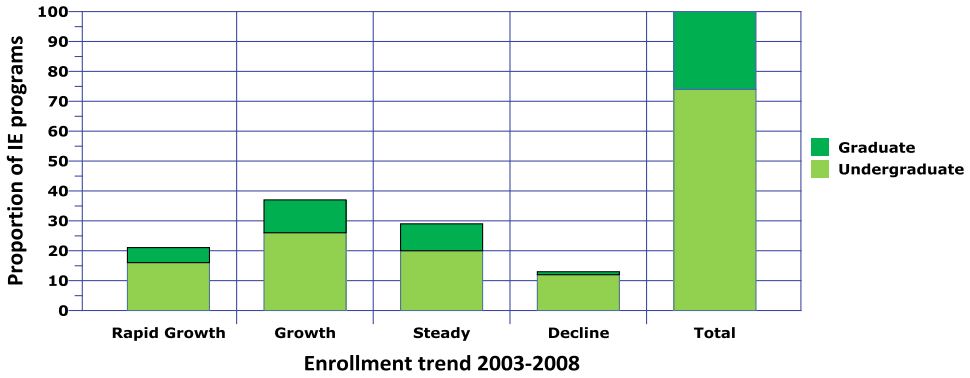
The growth in enrollment has been dramatic. The University of Michigan's Program in the Environment was initiated in 2003 with 35 students and today has 350 majors and 150 minors. The University of California at Los Angeles launched its Environmental Science program in 2006 with 10 students and three years later has 221 majors. Salisbury University founded its Environmental Studies program in 2004 and today has 93 majors. This level of growth is not unique to these three programs; the majority of IE programs are experiencing expanding enrollments.

A survey of 260 IE programs in 2008 found that two-thirds reported a growth trend from 2003 - 2008 (Figure 3). In addition, many programs that reported their enrollments as steady experienced a surge in

[3] "As Colleges Add Green Majors and Minors, Classes Fill Up," *USA Today*, December 28, 2009; "Sustainability Comes of Age," *New York Times*, December 29, 2009; "Green Degrees in Bloom," *Newsweek-Kaplan College Guide*, August 12, 2009; "Students Flocking to Sustainability Degrees, Careers," *USA Today*, August 3, 2009; "College Hopes and Worries Survey," *Princeton Review*, 2009.

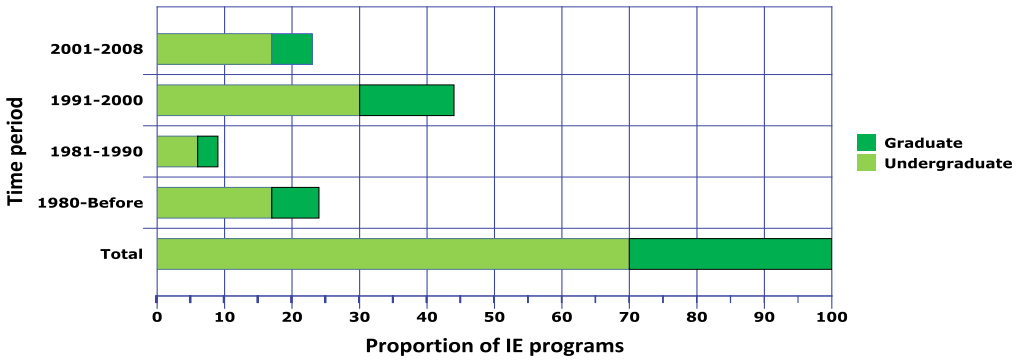
student interest in the semesters following the survey.[4] For example, Antioch University New England reports that applications for their Masters of Science programs in Environmental Studies and Resource Management and Conservation are up 42% from 2009. Similarly, the University of Vermont reports that between 2008 and 2010 the number of environmental science and environmental studies majors grew 37% from 495 to 679, and the number of degrees awarded rose 48% from 98 to an estimated 145.

Figure 3. IE program enrollment trends 2003-2008



Responding to this burgeoning student demand, universities and colleges have been initiating new IE degree programs. The 2008 survey revealed that two-thirds of existing IE programs were created after 1991, and almost a quarter since 2001 (Figure 4). The pace of creation of new IE programs is remarkable.

Figure 4. Time period IE programs established



Notably, growth in IE program enrollment is positively and significantly associated with four degree program objectives and with four forms of sustainability inclusion in program curricula (α=0.05; Table 2).

[4]Approximately 12% of undergraduate, 74% of masters, and 88% of doctoral programs report that they limit the numbers of students they admit to their degree programs based upon available positions and/or applicant qualifications. These constraints appear to negatively affect growth for some graduate programs; most of the graduate programs reporting declining or steady enrollments indicate they are unable to accept more students.

Table 2. IE degree program objectives, sustainability inclusion and enrollment trend

	Enrollment trend 2003-08 (proportion of programs in each growth category that share the objectives or include sustainability in their curricula)			
Program objective	Rapid growth	Growth	Steady	Decline
Preparing leaders & change agents (undergraduate)	78%	66%	54%	55%
Improving policy decisions (graduate)	77%	81%	77%	20%
Providing community service (undergraduate)	69%	61%	43%	43%
Advancing environmental research (undergraduate)	64%	48%	45%	33%
Sustainability inclusion				
Optional coursework	51%	28%	27%	23%
Core principle	47%	33%	30%	10%
Applied/service learning experiences	44%	35%	24%	18%
Research experiences	42%	22%	22%	5%

A positive five-year enrollment trend (2003-08) for undergraduate programs is associated with three program objectives—preparing students to be environmental leaders and change agents, providing community service, and advancing environmental research. Enrollment growth in graduate programs is significantly and positively associated with one program objective—improving policy decisions. Positive enrollment trends are also associated with inclusion of sustainability in the curriculum via coursework, as a core guiding principle, and through experiential research and applied/service learning opportunities. Table 2 illustrates that IE programs experiencing increasing enrollments are more likely to share these four objectives and include sustainability in their curricula.

IE Degree Programs' Diversity

The census count of IE degree programs reveals they exhibit an amazing variety of degree program names and focus areas. Many institutions offer more than one type of IE degree; for example, 12% of institutions offer both undergraduate environmental science(s) and environmental studies degrees. Other examples:

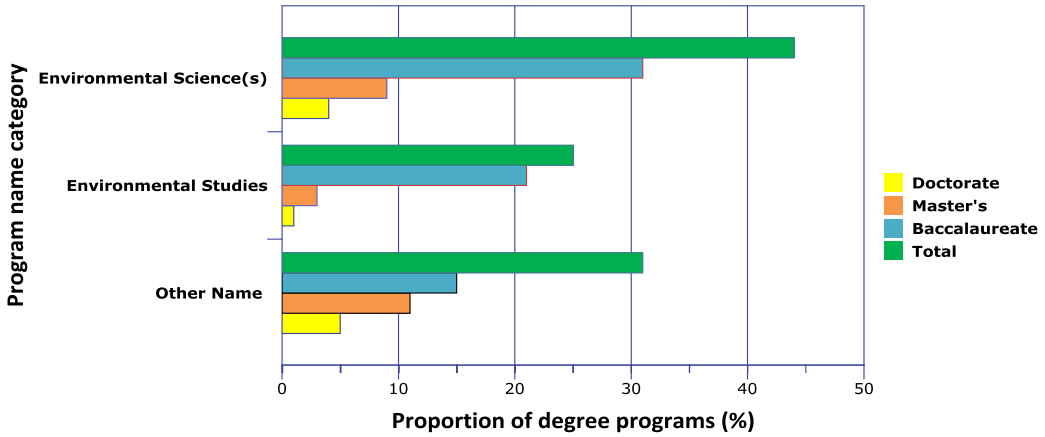
- Barnard College offers undergraduate degrees in Environmental Science and Environmental Policy.
- Purdue University offers undergraduate and graduate IE degrees with a focus on natural resources—undergraduate degrees in Natural Resources and Environmental Science or Natural Resources Planning and Decision Making, and graduate degrees in Natural Resource Social Sciences.
- The University of Wisconsin at Madison offers four graduate degrees in Environment and Resources, Conservation Biology and Sustainable Development, Energy and Environmental Policy, and Water Resources Management.

A large proportion of IE degree programs, (44% of 1183 IE programs), are named environmental science or sciences (Figure 5). Another 25% are named environmental studies. Degrees in environmental studies are awarded primarily at the baccalaureate level; only 3% of IE master's degrees and 1% of

doctoral degrees are named environmental studies. The remaining 31% of IE degree program names and focus areas vary widely, and include:

- Urban and Environmental Policy and Planning (Tufts University);
- Environmental Systems and Society (University of California at Los Angeles);
- Environmental Dynamics (University of Arkansas);
- Earth Systems Science and Policy (California State University at Monterey Bay);
- Watershed Science (Utah State University);
- Coastal and Marine Systems Science (Texas A&M University at Corpus Christi); and,
- Sustainability (Arizona State University).

Figure 5. IE degree program names and levels



Flexibility is a key attribute of IE degree programs. Many IE programs allow students to design their own concentrations to match their specific goals and interests and most offer an array of specialization options that reflect the expertise of their faculty and the mission and geographical location of their institution. Two examples are:

- California State University at Monterey Bay offers undergraduate degrees in Earth Systems Science and Policy with five specializations: Environmental Policy, Marine and Coastal Ecology, Watershed Systems, Science and Social Justice or Science Education.
- SUNY College of Environmental Science and Forestry offers graduate degrees in Environmental Science, also with five specializations: Environmental Communication and Participatory Processes, Environmental and Community Land Planning, Environmental Systems and Risk Management, Environmental Policy and Democratic Processes, and Water and Wetland Resource Studies.

Section III – NCSE Study: Key Findings[5]

Interdisciplinary Environmental Education: Definition of the Field

The NCSE study of IE programs was conducted in two phases. The first phase sought to determine how many perspectives exist concerning environmental program curriculum design, how they differ from each other, and what, if anything, they had in common. One of the major findings of this phase of the study was a consensus on IE field identity. The characteristics of this common view are summarized as follows:

The CEDD/NCSE study revealed that IE program leaders agree that:

1. IE programs should focus on the interfaces between human and natural systems (coupled human and natural systems).
2. IE programs should adopt a holistic, interdisciplinary educational approach that fosters synthesis and systems-thinking skills.
3. IE program curricula should include key concepts from the natural sciences, social sciences, applied sciences and humanities.
4. IE programs should promote understanding of the both the sociopolitical and natural aspects of environmental problems, the limits of technology and science, and the importance of acknowledging and reporting uncertainty.

This common view elucidates what IE programs study—the interfaces of coupled human-nature systems, and how they study the interfaces—via interdisciplinary knowledge and the insights gained from systems analysis and different epistemological viewpoints. It also clarifies the unique role of IE programs—why these programs are important and the distinctive role they fill in the higher education landscape. The goal of IE programs is to prepare students to be sustainability-oriented problem-solvers through interdisciplinary scholarship, research, practice and informed citizenship. Problem solving is conducted using a holistic systems approach rather than a traditional reductionist approach.

Although the concept of sustainability was not specifically included in the first phase of the study, the four-part consensus view of IE program identity aligns closely with the characteristics of sustainability-oriented environmental research and practice as it is commonly and widely described in the sustainability literature and in U. S. government documents pertaining to environmental education and research. For example, see the 2007 *Sustainability Research Strategy* proposed by the U.S. Environmental Protection Agency which states that effectively addressing environmental issues requires integrated, systems-based, sustainability-oriented approaches and the 2009 National Science Foundation Advisory Committee on Environmental Research and Education report *Transitions and Tipping Points in Complex Environmental Systems* that urges a shift toward societal needs-driven

[5] The data for graduate and undergraduate IE programs was initially analyzed separately; the results were almost identical so the data sets were combined to increase the sample size and the statistical validity of the results.

research exemplified by the emerging field of sustainability science: the study of complex and adaptive interactions between natural and social systems.[6]

Although all IE programs do not always self-identify sustainability as part of their mission, discussions at several formal discussion sessions and workshops held at environmental science and studies conferences confirm the broad agreement that IE programs share a normative commitment to sustainability and that the goal of IE degree programs is to prepare students to be sustainability-oriented, interdisciplinary problem solvers.[7] Sustainability in the context of these discussions and its use as a term of knowledge in the study's second phase is broadly interpreted as achieving resilient, sustainable relationships between actions taken to improve the human condition and the natural environment.

The results from the second phase of the study—a national survey of IE programs—confirm the centrality of the concepts of sustainability in IE programs. The importance of sustainability knowledge in program curricula has a mean rating of "moderate to high importance" across all IE degree program types, and the large majority of programs rate its importance in their degree curricula as either moderate or high (86% of undergraduate programs and 88% of graduate programs). In addition, almost all IE degree programs already include sustainability in their curricula (Table 3), with over half requiring coursework in sustainability.

Table 3. Sustainability inclusion by degree level and type

Sustainability inclusion	BS (*n*=148)	BA (*n*=102)	MS (*n*=43)	MA (*n*=9)	Other Masters (*n*=14)	PhD (*n*=25)	Total (*n*=341)
Required coursework	57%	62%	40%	56%	43%	36%	54%
Optional coursework	23%	44%	54%	44%	57%	44%	37%
Core principle	27%	38%	26%	89%	29%	16%	31%
Applied or service learning experiences	27%	36%	19%	33%	29%	4%	27%
Research experiences	20%	28%	28%	44%	43%	28%	26%
Not included	20%	13%	19%	0%	21%	28%	18%

In 2008, a third of IE programs considered sustainability as the core guiding principle in their curriculum design. An example is the Environmental Dynamics program at Arkansas State University that states its primary objective this way: "aid development of strategies for sustainable societies based on results of scientific research and respect for human cultures."

Since 2008 many more programs have adopted sustainability as a core principle. The new mission, vision and values statement for the Department of Environmental Studies at Antioch University New England is an example: **"**We train effective local, national, and international environmental leaders

[6] For a more thorough discussion on sustainability and its relationship to the consensus view of IE program identity see: Vincent, Shirley and Will Focht, 2010. In Search of Common Ground: Exploring Identity and the Possibility of Core Competencies for Interdisciplinary Environmental Programs. *Environmental Practice* 12(1):76-86.

[7] The National Council for Science and the Environment's Council of Environmental Deans and Directors Summer Meeting, Stevenson, Washington, July 15-17, 2008; the Third National Environmental Studies and Science Summit, Jonesboro, Arkansas, May 22-24, 2008; and the Second National Environmental Studies Summit, Syracuse, New York, June 8-10, 2007.

working to create a sustainable society that embodies respect and care for the community of life, ecological integrity, social and economic justice, democracy, nonviolence, and peace."

Taken together, the results from the perspectives phase of the study, the discussions at conferences, and the analysis of the national survey data indicate the field identity for interdisciplinary environmental programs is sustainability-oriented scholarship, research and practice with an emphasis on interdisciplinary problem solving.

In addition to the consensus on field identity, the perspectives study revealed three distinct perspectives on program design. These perspectives are oriented toward the type of graduates they aim to produce and were given descriptive names that referred to their educational objectives as expressed by the participants in the study. The three perspectives are: *Environmental Scientist, Environmental Citizen, and Environmental Problem Solver*.[8]

Analysis of the national survey data reveals these three perspectives align closely with three ideal curriculum models for IE education named *Systems Science*, *Policy and Governance*, and *Adaptive Management*. The convergence of the findings from the two studies with different samples and using different methods confirms the existence of three primary models for IE education aimed at preparing three distinct types of sustainability problem solvers. The three ideal curriculum models are discussed below.

Interdisciplinary Environmental Education: Knowledge and Skills Components

The second phase of the study analyzed data from a survey of 260 programs awarding 343 IE degrees to answer two primary research questions: (1) what are the components of knowledge and skills for ideal IE program curricula?, and (2) what are the ideal models for IE program curricula.

Competence in higher education is often defined as achieving specified learning outcomes that include theoretical and practical understanding, cognitive abilities, and techniques relevant to a specific field of study. Learning outcomes can also be expressed in terms of core competencies. Core competencies for IE programs serve several purposes:

- Provide a guide for curriculum development and, in a broader sense, for the overall development of the IE field of study;
- Promote recognition of the IE field and the expertise and qualifications of its graduates;
- Facilitate cooperation and communication among faculty from a wide range of disciplines; and
- Form a potential basis for IE program assessment, professional licensure, and perhaps degree program certification/accreditation.

The dimensions of knowledge and skills that may form core competencies or key learning outcomes for IE programs were determined from an analysis of IE program administrators' ratings of the importance of sixteen knowledge and twenty-three skills variables in an ideal curriculum for each of their program's

[8] For more information on the Phase I perspectives study see Vincent, Shirley and Will Focht. 2010. U. S. Higher Education Environmental Program Managers' Perspectives on Curriculum Design and Core Competencies: Implications for Sustainability as a Guiding Framework. *International Journal of Sustainability in Higher Education*. 10(2): 164-183.

degrees. Maximum likelihood factor analysis of these ratings revealed how IE program leaders group various knowledge areas and skills included in IE program curricula into five interdisciplinary IE knowledge factors and five integrated IE skills factors. These factors represent components of IE knowledge and skills; their composition provides a guide for the creation of interdisciplinary courses and curricula and their interrelationships provide a guide for structuring IE program curricula. They also provide a broad learning outcomes framework and may be considered as ten general core competencies for IE programs.

Although these ten knowledge and skills components are applicable to all IE programs, the emphasis placed on them varies significantly according to the educational approach adopted as discussed below.[9]

IE Interdisciplinary Knowledge Components

The five interdisciplinary IE knowledge components discovered are labeled *Natural Sciences, Natural Resources, Social Sciences, Humanities*, and *Economic Development.* Each is comprised of a subset of the sixteen knowledge variables with each variable contributing to the component to varying extents. For example, the *Natural Sciences* component includes concepts from three knowledge areas—life sciences, physical sciences and ecology[10]—with the life sciences the most prominent (Table 4).

Table 4 illustrates the relationships between the original sixteen knowledge variables and the five interdisciplinary IE knowledge components. The center column lists the five interdisciplinary knowledge components. The right column lists the knowledge areas that comprise the content of each knowledge component and the proportion each contributes to the component. The left column illustrates that the *Natural Resources, Social Sciences* and *Humanities* components are highly correlated with each other to create an interdisciplinary knowledge area labeled *Coupled Human-Nature Systems*.

The five component IE knowledge model is robust; all sixteen knowledge variables were significantly correlated with at least one knowledge component, the total variance explained was 64%, the goodness-of-fit test of the model was highly significant at $p>0.001$, and Cronbach's alpha scores confirm the reliability of the composition of each component.

[9] Although *factor* is the correct statistical term, the term knowledge and skills *component* is used hereafter as it is more descriptive of what the factors represent for IE program curriculum design.

[10] Ecology was included as a separate *interdisciplinary* knowledge area distinct from the life sciences because the study of ecosystem interactions within their physical environments often includes analysis of human system impacts.

Table 4. Interdisciplinary IE knowledge components (ideal curricula)

Interdisciplinary area	IE knowledge	Disciplinary knowledge areas (proportion of knowledge component)
Natural Sciences	Natural sciences	life sciences (60) physical sciences (27) ecology (13)
Coupled Human-nature Systems	Natural resources	natural resources management & agriculture (31) geography (20) sustainability (15) education (14) research methods (11) ecology (8)
	Social sciences	policy & public administration (42) economics (42) business (9) other social sciences (8)
	Humanities	history (48) literature & language arts (31) philosophy & ethics (21)
Economic Development	Economic development	engineering & built environment (73) business (27)

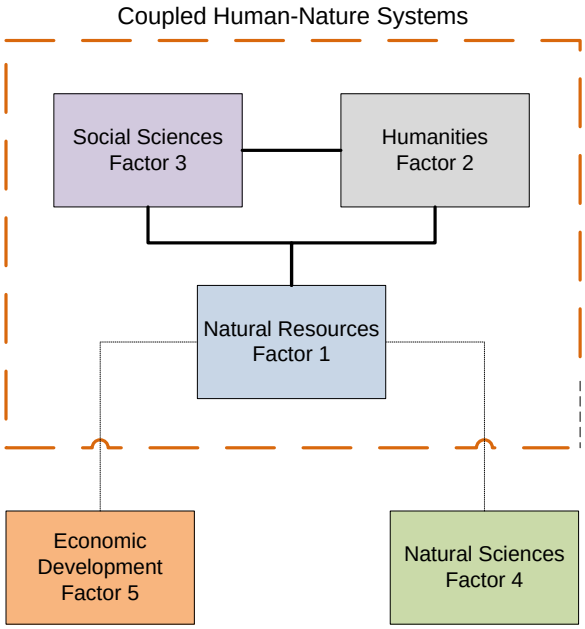
The *Natural Resources* component accounts for almost a third of the total variance explained by the model; this component best explains (predicts) how program administrators' importance ratings fall into the five components of interdisciplinary IE knowledge. In contrast, the other four components each account for only small proportions of the explained variance and therefore are less important predictors. Notably, the *Natural Resources* knowledge component is also significantly correlated with all four of the other knowledge components (Table 5). The *Natural Resources* component is highly correlated with the *Social Sciences* and *Humanities* factors, which are also highly correlated with each other, forming an integrated knowledge area named *Coupled Human-Nature Systems* (see Table 4 above). The *Natural Sciences* and *Economic Development* components are also moderately correlated with the *Natural Resources* component, but not with each other or with the *Social Sciences* or *Humanities* components.

Table 5. Knowledge component correlation matrix

Knowledge component	Natural resources	Humanities	Social sciences	Natural sciences	Economic development
Natural resources	1.000	.521	.545	.275	.303
Humanities		1.000	.636	.112	.103
Social sciences			1.000	.128	.149
Natural sciences				1.000	-.030
Economic development					1.000

Although IE programs combine and incorporate the five interdisciplinary knowledge components into their courses and curriculum designs in myriad ways, the knowledge model provides a shared framework for understanding how these components are structured in ideal IE degree curricula (Figure 6).

Figure 6. IE interdisciplinary knowledge model (ideal curricula)



Given the sustainability-oriented focus of IE programs, it is important to note that the sustainability knowledge variable is significantly associated with the *Natural Resources* knowledge component and therefore with the *Coupled Human-Nature Systems* knowledge area. This is another indication that sustainable stewardship of natural resources through understanding of coupled human-nature systems forms the central focus for all IE programs.

Analysis of the knowledge factor model informed by the IE program administrators' comments from the study indicates that:

- The sustainable stewardship of natural resources is the central focus for IE programs.
- Understanding of the natural sciences is essential foundational knowledge.
- Sustainable stewardship is realized through knowledge of coupled human-nature systems.
- The role of economic development—the business practices and technologies that together comprise the built environment and economic development—provides important context for understanding coupled human-nature systems.

IE Integrated Skills Components

The five integrated IE skills components discovered are labeled *Cognition, Technical Research and Analysis, Management, Community Engagement,* and *Public Communication*. Similar to the knowledge

components, each IE skills component is also an amalgam of various skills that contribute to the component to various extents. For example, *Cognition* includes five cognitive skills—synthesis, problem solving, analysis, creativity and critical thinking—with synthesis and problem solving most prominent (Table 6).

Table 6 shows the relationships between the skills variables and the five integrated IE skills components. The center column lists the five integrated skills components. The right column lists the skills variables that comprise the content of each skills component and the proportion each skill contributes to the component. The left column illustrates that two subsets of the skills components are highly correlated with each other to create two integrated skills areas: *Problem Analysis* and *Problem Solutions and Management*.

The five component IE skills model is robust; all but two of the twenty-three skills variables (literature and social research) were significantly correlated with at least one skills component, the total variance explained was 62%, the goodness-of-fit test of the model was highly significant at $p>0.001$, and Cronbach's alpha scores confirm the reliability of the composition of each component. The lack of a significant correlation for variables—in this case, literature and social research—with at least one component is not an indication of their value in the curriculum; it simply means their importance is not correlated with any of the components.

Table 6. Integrated IE skills components (ideal curricula)

Integrated area	IE skills	Skills sets (proportion of skills factor component)
Problem Analysis	Cognition	synthesis (25) problem-solving (23) analysis (19) creativity (17) critical thinking (16)
	Technical research & analysis	field research (26) laboratory research (23) mathematics (15) statistics (13) spatial analysis (11) technical & academic writing (8) oral communication (5)
Problem Solutions and Management	Cognition	(same as above)
	Management	personnel management (36) project management (27) leadership (17) decision science (10) information management (10)
	Community engagement	community relations (54) advocacy & outreach (35) leadership (11)
	Public communication	creative & journalistic writing (64) mass communications (28) creativity (10)

The *Technical Research and Analysis* component accounts for approximately a third of the total variance explained by the model; this component best explains (predicts) how program administrators'

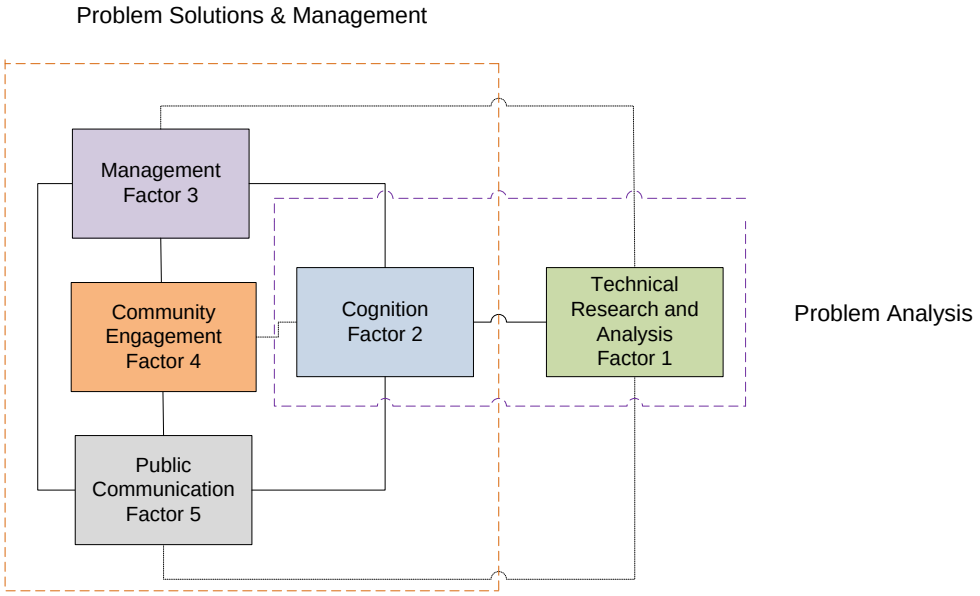
importance ratings fall into the five dimensions of integrated IE skills. In contrast, the other four components each account for only small proportions of the explained variance and therefore are less important predictors.

Subsets of the five skills components are highly correlated with each other forming two integrated sets—a *Problem Analysis* set and a *Problem Solutions and Management* set (Table 7). The *Cognition* and *Technical Research and Analysis* skills components are highly correlated, forming an integrated skills area labeled *Problem Analysis*. Note that the *Management* and *Public Communication* skills components are also moderately correlated with *Technical Research and Analysis*. The *Cognition, Management, Community Engagement* and *Public Communication* skills components are highly correlated with each other, forming a second integrated skills area named *Problem Solutions and Management*.

Table 7. Skills components correlation matrix

Skills component	Technical research & analysis	Management	Cognition	Public communication	Community engagement
Technical research & analysis	1.000	.323	.540	.294	.209
Management		1.000	.494	.534	.454
Cognition			1.000	.509	.417
Public communication				1.000	.544
Community engagement					1.000

Figure 7. IE interdisciplinary skills model (ideal curricula)



IE programs incorporate a diversity of skills into their program curricula in a multitude of ways, but the skills model structure indicates they share broad similarities in how skills are structured within IE degree

curricula (Figure 7). Analysis of the skills factor structure informed by program administrators' comments from the study indicates that:

- Problem analysis skills include technical and analytic research skills, plus management and public communication skills.
- Cognitive skills, with their emphasis on systems thinking and problem solving, are key elements for both the analysis of environmental problems and formulation of solutions.
- Devising solutions and implementing adaptive management plans for addressing environmental problems requires community engagement, management and public communication skills.

Interdisciplinary Environmental Education: Ideal Approaches/Models

The ideal models for IE programs were determined from an analysis of principal component scores derived from the program administrators' ratings of the importance of the thirty-nine knowledge and skills variables in an ideal curriculum for each of their program's degrees. Cluster analysis of the scores revealed three ideal approaches or models for IE education.

The three models are named *Systems Science*, *Policy and Governance* and *Adaptive Management.* Each model emphasizes different knowledge and skills components to prepare graduates for different types of sustainability-oriented problem solving. The models are characterized by their mean component scores (from the factor analyses described above) and by differences in the degree programs associated with each group: (1) the proportions of degree types (name and level), (2) certain degree program requirements, (3) specific degree program objectives, and (4) sustainability inclusion.

The three approaches represent the views of groups of program administrators that rate the ideal curricular components—the five interdisciplinary knowledge components and the five integrated skills components—in similar ways. Figures 8 and 9 illustrate how the mean importance ratings for each of the three ideal approaches—*Systems Science, Policy and Governance* and *Adaptive Management*—differ from the overall mean for all IE programs and from each other.[11] The importance rankings for two of the skills components—*Cognition* and *Public Communication*—are similar for all three approaches, but the ratings differ substantially for the other knowledge and skills components.

[11] The bars illustrate the mean factor scores for each of the components (factors) of the groups of programs aligned with the three approaches and their relationship to the mean factor score for all IE programs included in the survey which = 0.

Figure 8. IE knowledge component means by educational approach/model

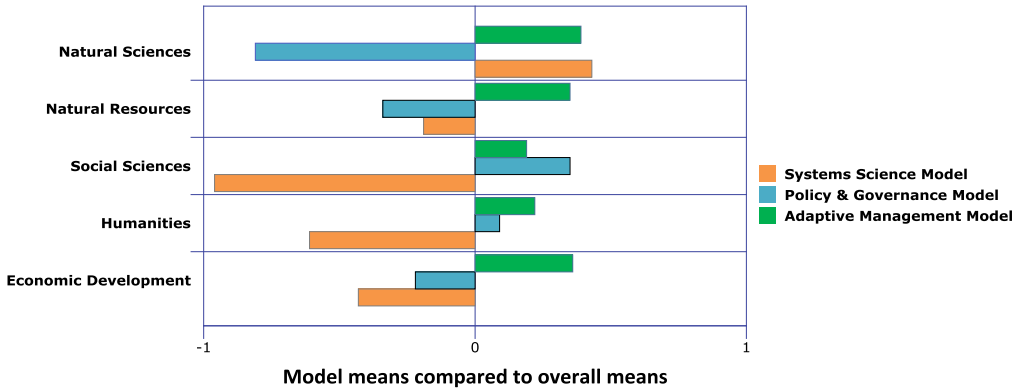


Figure 9. IE skills component means by educational approach/model

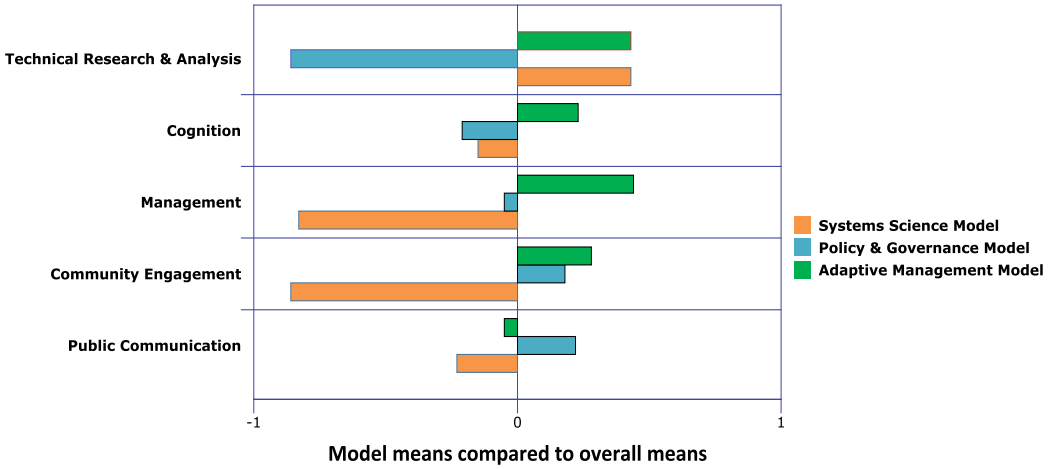


Figure 10 illustrates how the IE degree programs included in the survey aligned with the three models and the relationships between the models based on two dimensions that discriminate among the groups.

Discriminant analysis revealed two significant functions that explain the differences between the models. The first dimension (X axis) accounts for 64% of the variance between the model groups, and the second dimension (Y axis) 36%. Standardized correlation coefficients reveal that the *Social Sciences* and *Public Communication* components are positively associated with the first function while the *Technical Research and Analysis* and *Natural Sciences* components are negatively associated with this function (Table 8). The remaining components are positively associated with the second function, particularly *Management*, *Community Engagement*, and *Economic Development*.

Based on these associations the dimensions are given descriptive names: the first *Scientific Analysis versus Social and Institutional Change Focus*, and the second *Problems versus Solutions Focus*.

Table 8. Discriminant analysis correlation coefficients (ideal curricula)

	Scientific analysis vs. Societal change	Problem vs. Solutions focus
Technical research and analysis	-.493*	.337
Natural sciences	-.452*	.291
Social sciences	.360*	.311
Public communication	.124*	-.006
Management	.157	.497*
Community engagement	.255	.360*
Economic development	.002	.347*
Natural resources	-.091	.304*
Humanities	.155	.258*
Cognition	-.050	.195*

*Largest absolute correlation between each variable and any discriminant function.

Figure 10. IE degree programs plotted on two dimensions

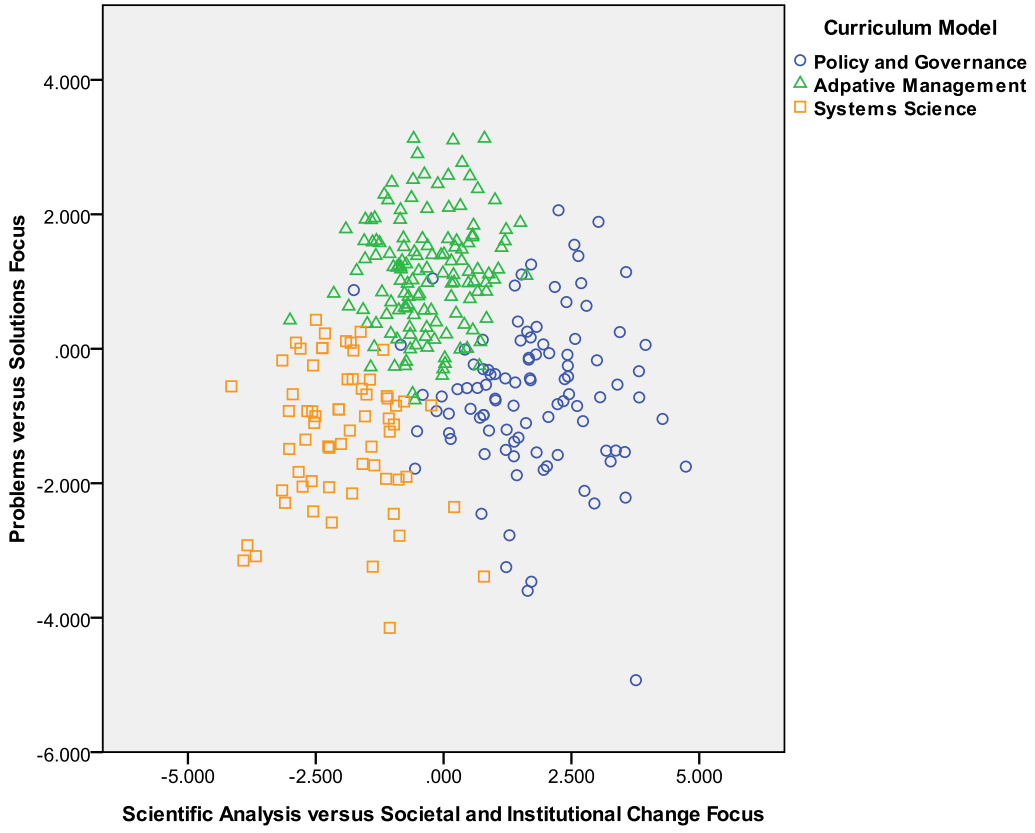
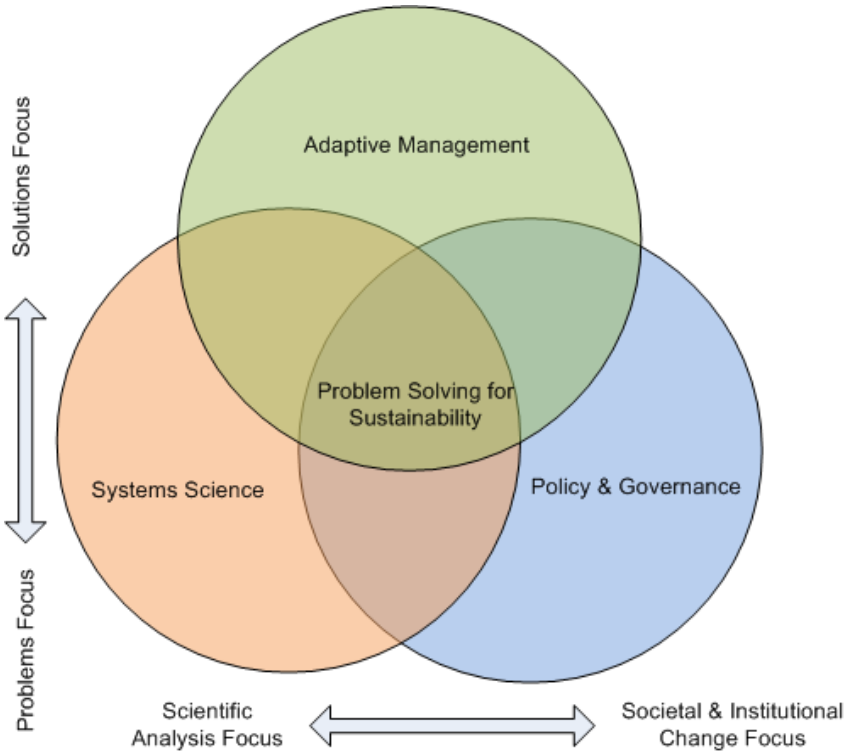


Figure 11 illustrates a unified framework for understanding IE programs in the United States based on the cluster and discriminate analyses. The three models are not opposed to each other; instead they overlap considerably so that some IE programs are situated on the boundaries of two or three models. The three models are oriented on two dimensions: (1) focus on analyzing environmental problems or implementing real world solutions, and (2) focus on understanding environmental problems using natural sciences-oriented scientific analysis or societal systems analysis.

Figure 11. A framework for understanding IE programs in the U. S.



Many degree-granting programs or higher education institutions offer degrees that align with more than one approach. Two examples:

- The Environmental Studies Program at Colby College offers an Environmental Studies BA that aligns with the *Policy and Governance* model and an Environmental Science BA that aligns with the *Systems Science* model.
- Cornell University has three different programs that offer degrees that align with each of the three models: Biology and Society BA/BS (*Policy & Governance*), Natural Resources BS/MS/PhD (*Adaptive Management*) and Science of Natural and Environmental Systems BS (*Systems Science*).

The Systems Science Approach/Model

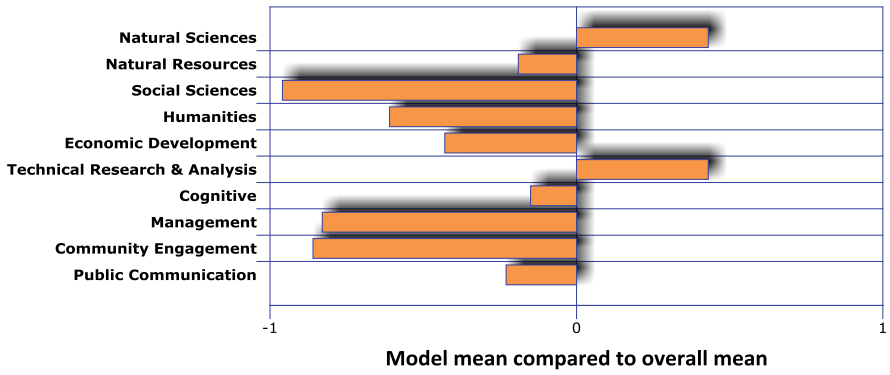
The *Systems Science* approach emphasizes in-depth knowledge of the natural sciences and technical research and analysis centered on laboratory and fieldwork skills. It has an analytic orientation that emphasizes traditional scientific skills and expertise in the natural sciences. *Systems Sciences* programs prepare students to conduct interdisciplinary analyses to develop understanding of the complexity of coupled human-nature systems.

This model places highest emphasis on the *Natural Sciences* knowledge component and the *Technical Research and Analysis* skills component (Figure 12).

Compared with the other two models, it places:

- Significantly lower emphasis on the *Social Sciences, Humanities* and *Economic Development* knowledge components.
- Significantly lower emphasis on the *Management* and *Community Engagement* skills components; lower emphasis on the *Public Communications* skills component.

Figure 12. IE knowledge and skills means for the Systems Science model



Degree programs associated with the *Systems Science* approach:

- Are more likely to be named environmental science(s) or have another science-focused name such as Science of Natural and Environmental Systems (Cornell University) or Earth System Science (University of Wyoming).
- Include a higher proportion of undergraduate programs compared with the other two models (85% undergraduate degree programs versus 68-70% for the other two approaches).
- Are more likely to be located within a traditional disciplinary department (43% versus 27-28% for the other two approaches).
- Are more likely to include the objective of preparing students for graduate and professional school (undergraduate programs) and preparing students to be environmental academics (graduate programs).
- Are significantly less likely to require students in graduate programs to participate in service learning projects than the other two models.
- Are significantly less likely to include the objectives of preparing students to be environmental leaders and change agents, and improving environmental policy decisions (undergraduate programs).
- Are significantly less likely to include sustainability in degree program curricula in any of the five ways measured—as a core guiding principle, required coursework, optional coursework, research experiences, or applied/service learning experiences.

The Policy and Governance Approach/Model

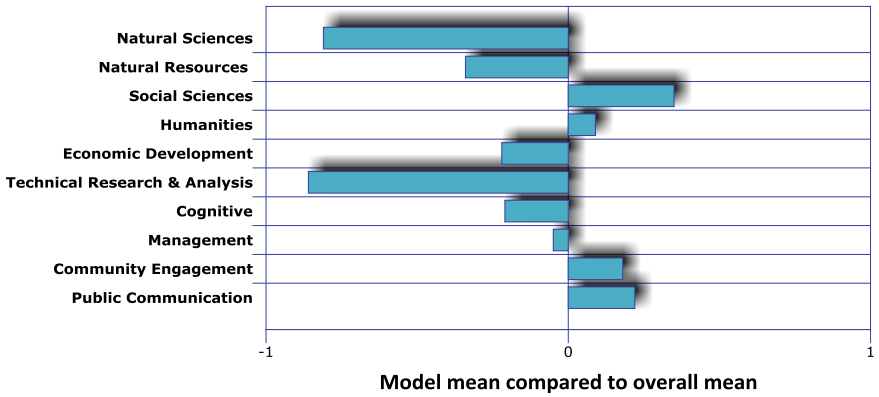
The *Policy and Governance* approach emphasizes the social sciences, humanities, and public engagement skills. The orientation for this model is societal and institutional change with a focus on public awareness and an emphasis on policy and governance processes. *Policy and Governance* programs prepare students to understand how political institutions, societal and industrial processes and individual choices contribute to practices that can either threaten or create resilient and sustainable human-nature interfaces.

This model places highest emphasis on the *Social Sciences* knowledge component and the *Public Communication* skills component (Figure 13).

Compared with the other two models, it places:

- Significantly lower emphasis on the *Natural Sciences* knowledge component; lower emphasis on the *Natural Resources* knowledge component.
- Significantly lower emphasis on the *Technical Research and Analysis* skills component.

Figure 13. IE knowledge and skills means for the Policy & Governance model



Degree programs associated with the *Policy and Governance* approach:

- Are more likely to be named environmental studies or have another policy-focused name such as Master of Public Affairs in Energy and Environmental Policy (University of Wisconsin at Madison) or Science, Technology and Policy (University of Minnesota at Twin Cities).
- Include a higher proportion of professional masters programs compared with the other two models.
- Are significantly less likely to require participation in a graduate research project (graduate degrees).
- Are most likely to include the objectives of preparing students to be environmental leaders and change agents, and improving environmental policy decisions (undergraduate degrees).
- Are most likely to include sustainability in degree program curricula in all five ways measured—as a core guiding principle, required coursework, optional coursework, research experiences, or applied/service learning experiences.

The Adaptive Management Approach/Model

The *Adaptive Management* approach emphasizes coupled human-nature systems knowledge and both problem analysis and solutions implementation skills. This approach has a professional orientation that emphasizes development of solutions through collaborative decision making processes (for example the development of watershed management plans, or the implementation of environmental management systems in private and public sector entities). *Adaptive Management* programs prepare students to solve complex environmental problems using integrated processes that directly inform policy and management decisions to effectively manage human-natural systems interfaces. These processes are iterative; management plans and policies are regularly assessed and adapted based on results, new knowledge and technical advances.

Compared to the overall mean for all IE programs this model places greater emphasis on all knowledge and skills components with the exception of *Public Communication* skills (Figure 14).

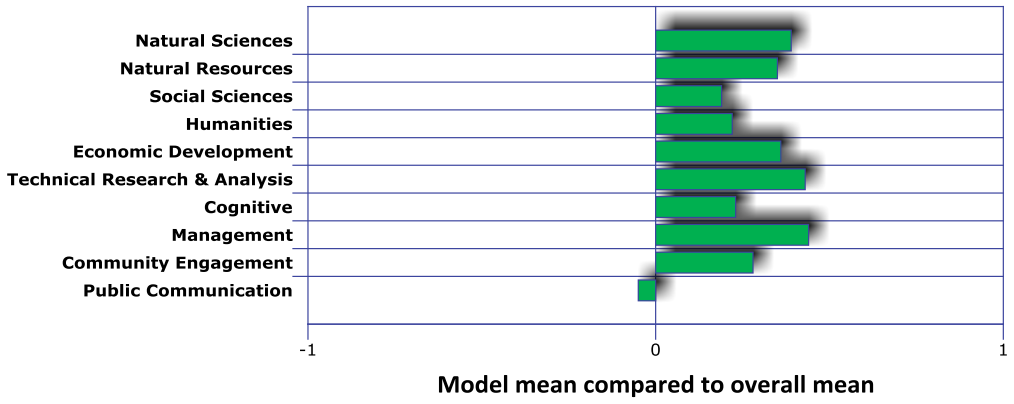
Compared with the other two models, it places:

- Higher emphasis on two of the correlated components that comprise the *Coupled Human-Systems Systems* knowledge area: *Natural Resources* and *Humanities.*
- Significantly higher emphasis on the *Natural Resource* and *Economic Development* knowledge components.
- Higher emphasis on three of the correlated components that comprise the *Problem Solutions and Management* IE skills area: *Cognitive*, *Management,* and *Community Engagement* skills components.
- Significantly higher emphasis on the *Cognitive* skills component (synthesis and problem solving).

Degree programs associated with the *Adaptive Management* approach:

- Are more likely to have a name other than environmental science(s) or environmental studies, such as Coastal Watershed Science and Policy (California State University - Monterey Bay) or a management-focused name such as Environmental Economics and Management (University of Rhode Island) or Environmental Resource Management (Pennsylvania State University).
- Includes a higher proportion of MS and PhD degree programs compared with the other two models.
- Are significantly more likely to require undergraduate participation in a research project (undergraduate degrees).
- Are more likely to include the objectives of preparing students to be environmental leaders and change agents, and improving environmental policy decisions (undergraduate degrees).
- Are more likely to include sustainability in degree program curricula in all five ways measured—as a core guiding principle, required coursework, optional coursework, research experiences, or applied/service learning experiences.

Figure 14. IE knowledge and skills means for the Adaptive Management model



Differences in the Popularity of the Three Approaches

The three different approaches to IE education reflect the views of IE program administrators regarding their preferences for each of the degree programs they offer. The most popular approach, representing 45% of the degree programs analyzed, is the *Adaptive Management* model (Figure 15). This is followed by the *Policy and Governance* model, the ideal for 33% of IE degree programs, and the *Systems Science* model, the least popular approach, representing 22% of IE degree programs included in the survey.

The three models also differ significantly on enrollment trend. Although most IE degree programs report positive enrollment trends, those associated with the *Systems Science* model have the highest proportion of degree programs experiencing declining enrollments, while the *Adaptive Management* model has the highest proportion of degree programs with growing enrollments. In the *Policy and Governance* model, the proportion of programs experiencing growing enrollments fell between the other two models and was not significantly different from either (Table 9).

Figure 15. Proportion of Degree Programs Associated with Three Approaches/Models

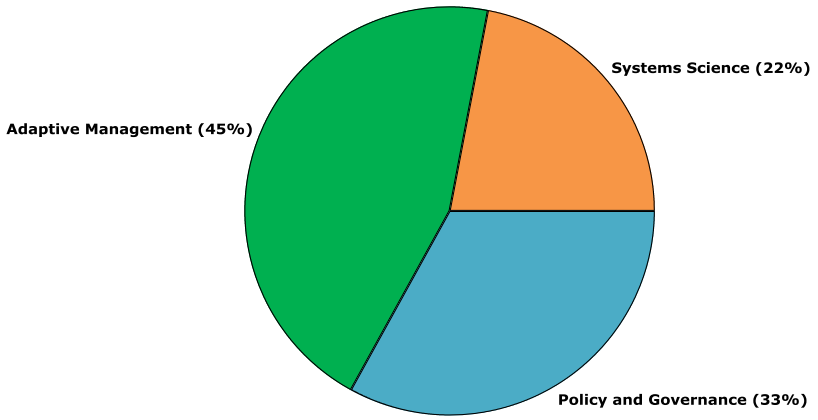


Table 9. Ideal curriculum models and enrollment trends

Ideal curriculum model	Rapid growth (*n*=63)	Growth (*n*=113)	Steady (*n*=88)	Decline (*n*=37)
Systems Science	16%	32%	35%	17%
Policy and Governance	19%	40%	31%	10%
Adaptive Management	24%	39%	25%	12%

A possible explanation is suggested by the degree program attributes positively associated with program growth—sustainability inclusion and four program objectives. The three program objectives positively associated with undergraduate program growth are: (1) preparing students to be environmental leaders and change agents, (2) providing community service, and (3) advancing environmental research. The program objective of improving environmental policy decisions is positively associated with graduate program growth. These relationships suggest why more programs in the *Systems Science* model are declining since this model, in contrast with the other two models, was significantly less likely to include sustainability in the curriculum or share two of these four program objectives—preparing students to be environmental leaders and change agents and improving environmental policy decisions.

Program administrators' educational preparation was shown to vary significantly between the three ideal IE educational approaches. Degree programs associated with the *Systems Science* model have the least diversity in program administrators' educational preparation and the highest proportion of program administrators whose educational preparation is exclusively in the natural sciences. Although the majority of the administrators associated with all three models hold degrees exclusively in the natural sciences, the programs associated with the other two models exhibit more diversity in administrators' educational preparation. The *Policy and Governance* approach has the highest proportion of administrators with degrees in the social sciences and humanities, and the *Adaptive Management* approach the highest proportion of those with interdisciplinary preparation (Table 10).

Table 10. Program administrator educational preparation and ideal curriculum models

	Ideal curriculum model		
Educational preparation category	Systems Science (*n*=66)	Policy & Governance (*n*=101)	Adaptive Management (*n*=137)
Natural sciences	68%	48%	52%
Applied sciences or professional	12%	22%	20%
Social sciences or humanities	9%	16%	6%
Interdisciplinary	11%	14%	22%

Mann Whitney tests (non-parametric *t*-test) Science/Governance U=1947, z=-2.13, p<.05; Science/Management U=2742, z=-2.02, p<.05.

The lower diversity of program administrators' educational preparation in the *Systems Science* model is due partly to a higher proportion of these degree programs located within traditional natural science departments. However, the differences are also due to dissimilarity in the way program administrators with different educational backgrounds rate the importance of the ten IE knowledge and skill components of ideal curricula.

Three knowledge components (*Natural Sciences, Natural Resources,* and *Economic Development*) and one skills factor (*Management*) exhibit significant differences in mean scores based on administrators' educational preparation. Administrators with interdisciplinary or applied/professional degrees rated the importance of the *Natural Resources and Economic Development* knowledge components and the *Management* skills component higher than those whose educational preparation was in the natural sciences or in the social sciences/humanities. Those with degrees in the natural sciences rated the importance of the *Natural Sciences* component higher than the other groups, and those with degrees in the social sciences/humanities placed significantly lower importance on *Economic Development* knowledge component and the *Management* skills component.

Section IV – Comparison of JMU Environmental Program Administrative Attributes with NCSE Study Findings

Competing Programs: Programs at Peer Institutions

JMU identified eight universities as peer institutions for the purpose of this report. Table 11 lists the degree programs at these institutions with an explicitly interdisciplinary (coupled human-nature systems) environmental focus as well as discipline or professional field degree programs with an environmental focus or concentration.

Six of the eight institutions offer undergraduate interdisciplinary environmental degree programs in the following areas: Environmental Science, Environmental Studies, Environmental Policy and Planning, and Environmental Management and Protection. The University of North Carolina-Wilmington also offers a Master of Arts in Environmental Studies. Appalachian State also offers degrees and concentrations in sustainable development and sustainable technology and the University of North Carolina-Wilmington awards an MS in interdisciplinary Marine Science. Only two of the eight do not offer interdisciplinary environmental degrees—the Virginia Military Institute and Georgia Southern University.

Four of the eight offer minors or certificates in environmental studies or environmental sustainability and six award baccalaureate and/or graduate degrees in a variety of disciplines with environmental concentrations. The Virginia Military Institute doesn't offer any environmental programs.

Four of the interdisciplinary environmental degree programs were included in the representative sample that participated in the 2008 NCSE survey and study—the Environmental Studies BA, BS and MA programs at the University of North Carolina-Wilmington and the Environmental Management and Protection BS at California Polytechnic State University-San Luis Obispo. Two of these were aligned with the *Adaptive Management* model—the Environmental Studies BS at North Carolina and the Environmental Management and Protection BS at Cal Poly. The other two were associated with the *Policy and Governance* model.

Of the six institutions offering interdisciplinary environmental degree programs, five have programs located in interdisciplinary departments—the Department of Natural Resources Management, (California Polytechnic State University-San Luis Obispo), the Department of Geography and Environment (Rowan University), the Department of Earth and Environmental Sciences (University of Mary Washington), the Department of Environmental Studies (University of North Carolina-Wilmington), and the Department of Environmental Sciences (University of Virginia). Three have degree-granting programs administratively housed in a traditional college—the Interdisciplinary Studies Program in the University College (Appalachian State University), the Environmental Science Program in the College of Arts and Sciences (Appalachian State University), and the Environmental Studies Program in the School of Arts and Sciences (University of Richmond).

Five of eight have centers or institutes focused on the environment and sustainability in regional studies energy, environmental economics, coastal resources, urban forestry, marine science, sustainability, and environmental law.

Table 11. Peer institutions' environmental and sustainability degree programs

Institution	Carnegie Class; Control	Administrative Location	Degrees and Institutes
Appalachian State University, NC	Master's Large; Public	Appalachian Studies Program; Center for Appalachian Studies; University College	• Appalachian Studies: Sustainable Development MA
		Environmental Science Program; College of Arts and Sciences	• Environmental Science BS
		Interdisciplinary Studies Program; University College	• Interdisciplinary Studies: Environmental Policy and Planning BA
		Sustainable Development Program; University College	• Sustainable Development BA • Sustainable Development: Environmental Studies BS • Sustainable Development: Agroecology and Sustainable Agriculture BS • Sustainable Development UG Minor
		Department of Anthropology; College of Arts and Sciences	• Anthropology: Sustainable Development BS
		Department of Biology; College of Arts and Sciences	• Biology: Ecology, Evolution and Environmental BS
		Department of Chemistry; College of Arts and Sciences	• Chemistry: Environmental BS
		Department of Economics; College of Business	• Economics: Environmental Economics and Policy BA
		Department of Government and Justice Studies; College of Arts and Sciences	• Political Science: Environmental Politics and Policy MA
		Department of Geology; College of Arts and Sciences	• Geology: Environmental BS
		Department of Technology and Environmental Design; College of Fine and Applied Arts	• Appropriate Technology BS • Technology: Renewable Energy Engineering MS
		Institutes and Centers	• Center for Appalachian Studies • Energy Center • Research Institute for Environment, Energy and Economics
California Polytechnic State University-San Luis Obispo, CA	Master's Large; Public	Department of Natural Resources Management; College of Agriculture, Food and Environmental Sciences	• Environmental Management and Protection BS • Forestry and Natural Resources BS • Agricultural and Environmental Plant Sciences BS • Agriculture: Environmental Horticultural Science MS
		Institutes and Centers	• Urban Forest Ecosystems Institute • Coastal Resources Institute

Institution	Carnegie Class; Control	Administrative Location	Degrees and Institutes
Georgia Southern University, GA	Doctoral; Public	Center for Sustainability	• Environmental Sustainability Concentration (UG Minor) • Sustainability Advisor Certificate (Professional)
		College of Public Health	• Public Health: Environmental Health Sciences MPH
		Institutes and Centers	• Center for Sustainability • Coastal Georgia Center
Rowan University, VA	Master's Large; Public	Department of Geography and Environment; College of Liberal Arts and Sciences	• Environmental Studies BA • Geography: Environmental Studies BA • Geography: Environmental Science BA • Planning: Environmental Studies BS • Planning: Environmental Science BS • Environmental Studies UG Minor
		Department of Biological Sciences; College of Liberal Arts and Sciences	• Biology: Environmental Studies BS
Virginia Military Institute, VA	Baccalaureate Arts and Sciences; Public		None
University of Mary Washington, VA	Master's Large; Public	Department of Earth and Environmental Sciences; College of Arts and Sciences	• Environmental Science BA/BS/BLS • Environmental Geology BS • Environmental Sustainability UG Minor
University of North Carolina-Wilmington, NC	Master's Large; Public	Department of Environmental Studies, College of Arts and Sciences	• Environmental Studies BA/BS/MA • Environmental Studies UG Minor • Environmental Studies Certificate (professional)
		Department of Geography and Geology; College of Arts and Sciences	• Marine Science MS
		Institutes and Centers	• Center for Marine Science
University of Richmond, VA	Baccalaureate Arts and Sciences; Private Not-for-profit	Environmental Studies Program; School of Arts and Sciences	• Environmental Studies BA/BS • Environmental Studies UG Minor
		School of Law	• Law: Environmental Law JD
		Institutes and Centers	• Center for Environmental Studies; School of Law

Administrative Location

The JMU environmental programs are for the most part administratively housed within their host departments and school; three of the four minors are coordinated through the Office of Cross Disciplinary Studies and Planning.

The majority of interdisciplinary environmental (IE) degree programs at large master's institutions are administratively located within academic units or programs that offer undergraduate IE degrees (60%). The remaining 40% are evenly split between those that offer both undergraduate and graduate IE degrees and those that award only graduate degrees. Undergraduate-only and combined undergraduate-graduate programs are most often administratively housed within a program than spans one or more traditional colleges, while graduate-only programs are most often located within a traditional department (Table 12). Most IE programs, including those administratively located within traditional departments, draw upon faculty and courses outside the home department but the extent of cross-departmental and cross-college involvement varies considerably.

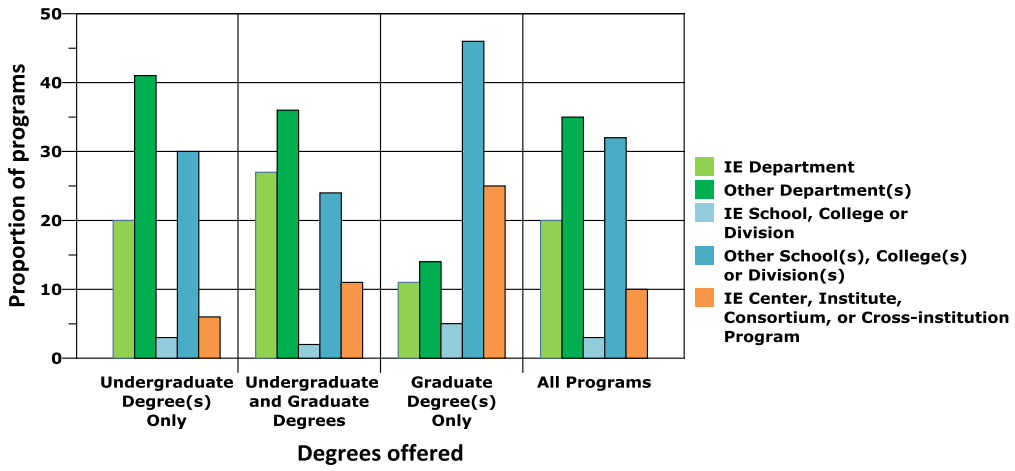
Table 12. Administrative location for IE degree programs*

Program Type	IE Department	Other Department	IE College or School	Other College(s) or School(s)	IE Center or Institute
Undergraduate only (*n*=36)	22%	28%	0%	42%	8%
Undergraduate & graduate (*n*=12)	25%	25%	0%	50%	0%
Graduate only (n=12)	25%	58%	0%	17%	0%

*Programs at large master's institutions that participated in 2008 NCSE survey

Overall, about a third of all IE degree-granting programs are located within their own interdisciplinary autonomous administrative units—an IE department (23%), an IE school or college (4%), or a degree-granting IE institute, center or institution-spanning program (11%). The remaining two-thirds of IE programs are located within or across one or more traditional departments (31%), or within a program that spans one or more colleges (31%; Figure 16).

Figure 16. IE degree program administrative locations



Effect of Program Administrative Location on Ability to Manage the Factors that Contribute to Success

A program administrative location with a traditional department was revealed by the NCSE study to be the least desirable for IE programs. IE degree programs located within their own IE academic unit (department, school, college, center, etc.) appear to have important advantages over programs in other locations. Administrative agency (autonomy and capacity to direct resources) is the key component that allows interdisciplinary environmental programs to fully attain their educational, research and service missions. Administrative independence and the capacity to obtain and direct resources are intimately tied to the three other key elements related to effective program design: adopting an overall vision/goal, implementing truly interdisciplinary curricula, and the capacity to involve students in real world interdisciplinary knowledge-production and decision-making processes. In addition, administrative agency (i.e. tenure-track faculty lines) can go a long way to ameliorate the tenure and promotion challenges often cited as problematic for interdisciplinary scholars.

The administrators of programs located within their own autonomous IE administrative units report statistically significant higher levels of satisfaction with their programs' ability to strategically manage the factors that influence program success. The NCSE survey asked program administrators to gauge the importance of various factors on the success of IE programs in general and the level of their satisfaction with how their own program addressed or utilized each factor in its own success (Table 13). Five groups of influencing factors were rated: (1) curriculum factors, (2) institutional factors, (3) graduate employment factors, (4) external support factors, and (5) partnership factors.

The factors in three of the groups—curriculum, institutional and graduate employment factors— were all rated of high or moderate importance for the success of IE programs while the factors in the other two groups—external support and partnership factors—were all rated of mean low importance. Four factors were rated as highly important: developing courses, incorporating real world problems into courses, program leadership, and faculty support.

The result of how satisfied the administrators were with how their own programs addressed or utilized each factor reveal significant differences in levels of satisfaction with a number of factors depending upon their programs' administrative locations. Not surprisingly, the levels of satisfaction with various factors that influence program success are generally higher for programs within their own IE administrative units. The majority of the programs located within their own autonomous IE academic units are highly satisfied with their administrative location in contrast to less than a third of programs in other departments or those that cross other academic units (Table 13). Programs located in their own IE environmental academic units are also significantly more likely to be highly satisfied with their ability to offer relevant degrees and specializations, provide effective program leadership, prepare students for employment, compete for funding and public support, and participate in partnerships with other educational institutions and organizations.

Table 13. Effect of program administrative location on satisfaction

Influencing factor	IE department (*n*=50)	Within other department(s) (*n*=88)	IE school, college, or institute/center (*n*=32)	Within or across other academic unit(s) (*n*=76)
	Proportion highly satisfied			
Curriculum factors (moderate to high importance)				
Incorporate real world problems	71%	72%	65%	72%
Offer relevant degrees	63%	41%	52%	40%
Develop courses	54%	42%	35%	35%
Sequence courses	33%	34%	32%	32%
Institutional factors (moderate to high importance)				
Program leadership	72%	44%	66%	62%
Program location	55%	27%	59%	32%
Faculty support	54%	38%	53%	53%
Compete w/other academic units	22%	8%	34%	23%
Institutional support	29%	16%	22%	20%
Graduate employment factors (moderate importance)				
Prepare graduates for local/regional employment	49%	49%	65%	38%
Prepare graduates for national employment	38%	21%	45%	19%
External support factors (low importance)				
Compete for foundation & private funding	27%	9%	22%	11%
Compete for federal funding	16%	8%	31%	11%
Compete for state and local funding	14%	7%	6%	4%
Win public support	12%	2%	22%	11%
Win political support	9%	1%	9%	6%
Partnership factors (low importance)				
Participate in governmental agency partnerships	27%	15%	20%	18%
Participate in NGO partnerships	25%	7%	25%	14%
Participate in educational institution partnerships	24%	11%	22%	16%
Participate in private sector partnerships	21%	17%	10%	11%
Participate in professional society partnerships	11%	4%	10%	4%

Administrators of IE programs housed within their own departments are most satisfied with their ability to offer relevant degrees, develop courses, provide effective program leadership, compete for some types of external funding (foundation and other private, state and local) and participate in some types of partnerships (governmental agencies, private sector; Table 13). Administrators of programs located in an IE college, school or institution spanning institute, center or program had highest levels of satisfaction with their programs' administrative location, their ability to compete with other academic units, their ability to prepare students for employment opportunities, their ability to compete for federal

funding, and their ability to win public support (Table 13). Most importantly, these programs were also the most successful at offering ideal IE curricula (Tables 14 and 15).

Effect of Program Location on Ability to Provide Ideal Degree Curricula

Programs located within their own autonomous IE units are also the most successful in providing curricula that ensures an appropriate level of exposure to the core knowledge and skills required for student competency (Tables 14 and 15). Comparing how closely the ideal emphases on 39 knowledge and skills areas in an ideal curriculum match the actual emphases reveals influences based upon program location.[12] IE degree programs located within their own environmental school or college are most likely to provide curricula with ideal levels of emphases on knowledge and skills areas, meeting or exceeding the ideal mean emphases in all but three skills areas—community relations, synthesis and analysis. In contrast, IE degree programs located within traditional departments were clearly at a disadvantage, meeting or exceeding the ideal emphases for only 9 of the 39 areas.

Table 14. Effect of program location on the ability to provide ideal emphases on knowledge areas in IE degree program curricula

Knowledge area	Mean ideal emphasis (*n*=246)	IE department (*n*=50)	Other department(s) (*n*=88)	IE school, college (*n*=7)	Other schools, colleges (*n*=76)	IE center, institute, or equivalent (*n*=25)
		Mean curriculum emphasis				
Natural sciences knowledge						
Physical sciences	2.5	2.1	2.4	2.5	2.3	2.3
Life sciences	2.5	2.3	2.4	2.5	2.4	2.3
Social sciences knowledge						
Policy, planning & administration	2.3	2.2	1.7	2.3	2.1	2.2
Economics	1.8	2.5	1.4	2.2	2.0	1.9
Other social sciences	1.7	2.2	1.4	1.9	2.0	1.6
Humanities knowledge						
Philosophy & ethics	1.8	2.3	1.6	1.8	1.8	1.7
History	1.3	1.7	1.3	1.5	1.3	1.2
Literature & language arts	1.2	1.6	1.2	1.9	1.2	1.1
Applied sciences & professional knowledge						
Research methods	2.3	2.5	2.2	2.6	2.4	2.2
Business	1.4	1.7	1.0	1.7	1.4	1.3
Engineering & built environment	1.2	1.6	1.0	1.6	1.2	1.5
Education	1.1	1.7	0.9	1.3	1.3	1.2
Interdisciplinary knowledge						
Ecology	2.6	2.6	2.5	2.6	2.6	2.5
Sustainability	2.2	2.3	1.8	2.1	2.2	2.2
Natural resources mgmt.. & agriculture	2.0	2.5	1.7	2.3	1.8	2.2
Geography	1.9	2.1	1.6	2.0	2.0	1.8
Knowledge area emphases met/exceeded (within 0.1)		14/16	6/16	16/16	13/16	14/16

[12] Rated on a four point importance scale; 3=high importance, 2=moderate, 1=low, 0=minimal/no)

Table 15. Effect of program location on the ability to provide ideal emphases on skills areas in IE degree program curricula

Skills area	Mean ideal emphasis (*n*=246)	IE department (*n*=50)	Other department(s) (*n*=88)	IE school, college (*n*=7)	Other schools, colleges (*n*=76)	IE center, institute, program (*n*=25)
		Mean curriculum emphasis				
Cognitive skills						
Problem solving	2.8	2.6	2.4	2.8	2.7	2.8
Critical thinking	2.7	2.5	2.4	2.7	2.6	2.8
Synthesis	2.6	2.4	2.1	2.4	2.4	2.5
Analysis	2.4	2.2	2.0	2.2	2.3	2.4
Creativity	2.3	2.4	1.8	2.7	2.2	2.5
Communication skills						
Technical & academic writing	2.7	2.5	2.4	2.7	2.5	2.4
Oral communication	2.6	2.4	2.3	2.6	2.3	2.4
Creative & journalistic writing	1.4	1.7	1.2	1.6	1.5	1.3
Mass communication	1.5	1.5	1.2	1.6	1.6	1.4
Research skills						
Field research	2.4	2.6	2.4	2.8	2.4	2.8
Literature research	2.2	2.3	2.0	2.3	2.1	2.1
Laboratory research	2.2	2.4	2.2	2.5	2.3	2.8
Social research	1.9	2.2	1.6	2.4	2.0	2.1
Computational skills						
Statistics	2.4	2.5	2.2	2.9	2.2	2.5
Spatial analysis	2.2	2.6	2.0	2.2	2.4	2.3
Mathematics	2.1	2.1	2.0	2.6	2.0	2.4
Decision sciences	1.6	1.6	1.2	1.8	1.6	1.6
Information management	1.6	1.9	1.3	1.7	1.8	1.4
Managerial skills						
Community relations	1.8	1.7	1.3	1.3	1.8	1.7
Leadership	1.7	1.7	1.2	2.7	1.8	1.5
Advocacy & outreach	1.6	1.6	1.3	1.7	1.8	1.6
Project management	1.3	1.3	0.9	2.0	1.4	1.5
Personnel management	1.1	1.0	0.7	1.3	1.2	1.3
Skills area emphases met/exceeded (within 0.1)		17/23	3/23	20/23	19/23	19/23
Knowledge and skills area emphases met/exceeded (within 0.1)		31/39	9/39	36/39	32/39	33/39

Leadership and Faculty

The JMU environmental programs are all led by volunteer coordinators. The minors have designated coordinators that report to the Vice Provost for Cross-disciplinary Programs but do not have specified FTE appointments for serving as the coordinators. The concentrations, sustainable engineering design focus and certificate program are administered by the relevant department heads or school directors. The dual Master of Science in Sustainable Environmental Resources Management and Integrated Science and Technology program is co-directed by professors at JMU and the University of Malta.

The majority of the IE degree programs at master's universities have program directors (45%) or department chairs or heads (37%) as the primary administrator. The department chairs/heads are most often sole administrators, but 17% have additional program co-administrators (Table 16). Program leadership was one of four factors rated of high importance for program success in the NCSE survey. Given the importance of program leadership, the JMU programs may have strategic disadvantages compared with programs with more robust program leadership.

Table 16. IE program administrator appointments at master's large universities

Appointment Type	Department Chair or Head *n*=18	Program Director, Chair or Coordinator *n*=22	Administrator Title College Dean, Associate Dean, or Assistant Dean *n*=2	Other* *n*=7	Total *n*=49
Full-time sole Administrator	44%	41%	50%	71%	47%
Part-time Sole Administrator	17%	36%	50%	0%	25%
Full-time Co-Administrator	17%	0%	0%	0%	6%
Part-time Co-Administrator	11%	5%	0%	0%	6%
Other	0%	14%	0%	0%	6%
No Official Administrator	11%	4%	0%	29%	10%
Total	37%	45%	4%	14%	100%

*Chair of advisory committee, primary advisor, etc.

Many IE programs, even those located within their own autonomous IE units, do not have tenure-track faculty appointed within the program. Altogether, 37% of IE programs report they have no full time faculty appointments, and another 20% have one or two who most often serve as the program administrator(s) (Table 17). The majority of programs, especially those without their own administrative units, rely primarily on part time faculty and volunteer faculty from other academic units. However, there is a trend toward more programs located in units with the ability to hire interdisciplinary faculty. The 2012 NCSE survey will elucidate the parameters of this trend.

The JMU programs do not have the capacity to offer interdisciplinary environmental faculty appointments or joint appointments; it relies solely on faculty whose tenure tracks reside within their individual departments.

Table 17. IE Faculty by program location

Faculty appointed in program	Number	IE department (*n*=50)	Other department(s) (*n*=89)	IE school, college (*n*=8)	Other schools, colleges (*n*=80)	IE center, institute, program (*n*=25)
Full-time	0	8% (new)	35%	37%	54%	36%
	1-2	24%	20%	13%	16%	20%
	2+	68%	45%	50%	30%	44%
Part-time (joint, contract)	0	18%	42%	25%	38%	24%
	1-2	20%	27%	38%	23%	32%
	2+	62%	31%	37%	39%	44%
% = adjuncts		60%	44%	37%	39%	52%
Volunteer (affiliated)	0	26%	24%	13%	20%	12%
	1-2	16%	9%	13%	9%	0%
	2+	58%	67%	74%	71%	88%

Resources

Funding Sources

The JMU environmental programs' budgets are unclear. Some of the concentrations reported that their budgets were equivalent to similar programs (Integrated Science and Technology, Geographic Science, Advanced Manufacturing) but the other programs indicated they had no official funds allocated to the program, were unsure, or that the funding was less than that provided to similar other programs.

Undergraduate IE programs at master's universities are roughly split between programs that report their operating budgets are equivalent or greater than programs with similar numbers of students (45%) and those who report their budgets are less than other programs of similar size (33%). The remaining programs were unsure how their budget compared with other programs (8%) or had no dedicated budget (14%).

On average, undergraduate programs at master's universities receive approximately 86% of their funding from non-directed funds (institutional appropriations, tuition and fees), 8% from long-term directed funds (endowments, facilities, contracts) and 6% from short-term directed funds (grants, contracts, earmarks, donations; Table 18).

Table 18. IE Program funding sources

Source	Undergraduate programs (*n*=45) Mean proportion of funding from source*
Non-directed (i.e. tuition, institutional funding)	86%
Long-term directed (i.e. endowment, contracts)	8%
Short-term directed (i.e. grants, contracts)	6%

Program Specific Funding and Resources for Curricular Use

The JMU environmental programs do not have centralized specialized computer centers, research or teaching laboratories designed specifically for environmental research and study, however, these facilities are available to students through their respective academic units. In addition, the curricula include the use of field sites at the Edith Carrier Arboretum, the JMU Farm and other local parks and reserves.

A number of IE programs at large master's institutions do not utilize specialized environmental facilities that support student education and professional skills development in their curricula; most use specialized computer facilities, but less than half have specialized laboratories, or utilize institutional sites or other facilities (Table 19).

Table 19. Environmental facilities used in IE program curricula

Type of facility	Undergraduate programs (*n*=50)
IE computer centers	68%
Specialized IE laboratories	40%
Nature center or protected area	40%
Field station or campus	36%
Other facilities*	20%

*Collaborative arrangements with government agencies/independent laboratories/other university and college departments; national and international field sites; campus sustainability/environmental centers.

The environmental programs at JMU have differing capacities to provide resources for students given that some are concentrations or focus areas in departmental or school degree programs while others are minors or certificates.

About half of IE undergraduate programs at large master's institutions provide students assistance in participating in external learning opportunities and travel support for conferences and scholarly activities. Less than half provide student scholarships, internal research grants, or student service awards. A majority of programs provide faculty members with travel support; about half provide access to internal research grants and program-specific resources for teaching and course development; a third offer faculty service awards. Less than a fifth support outreach activities (Table 20).

Table 20. IE programs' student and faculty resources

Program-specific resource	Programs (*n*=50)
Student external learning opportunities (study abroad, internships)	52%
Student scholarships or fellowships	38%
Student travel support	50%
Student research grants	38%
Student service awards	22%
Faculty travel	60%
Faculty research grants	48%
Faculty teaching or course development support	46%
Faculty service awards	32%
Outreach activities	18%

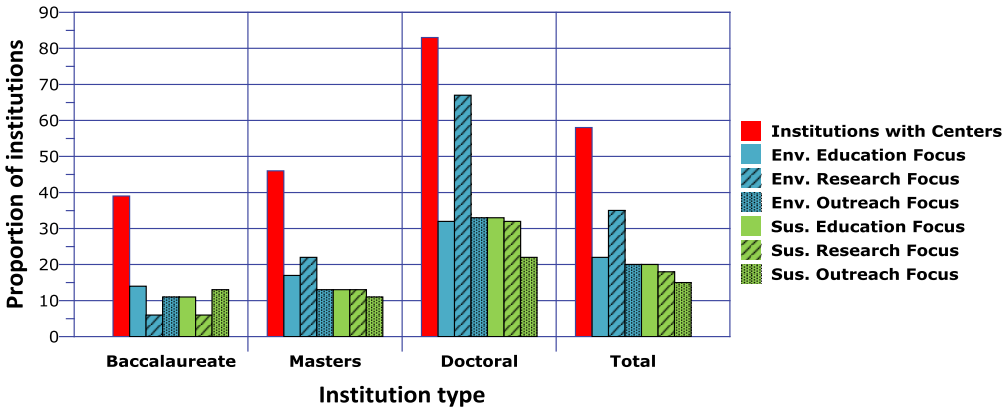
Engagement with Campus Institutes/Centers and External Partners

Campus Environmental/Sustainability Institutes/Centers

JMU hosts several centers with a primary focus on the environment and sustainability, including the Institute for Stewardship of the National World; the Institute for Energy and Environmental Research; the Institute for Health and Environmental Communication; the Center for Environment, Health and Safety; the JMU Farm; the Carrier Arboretum and the Arboretum Collaborative program. Other centers that may include activities relevant to the JMU's environmental programs are the Center for Materials Science, the Gilliam Center for Ethical Business Leadership, the Madison Institutes, the Nelson Institute, and the Institute for Conflict Analysis and Intervention. Currently, the JMU environmental programs do not have defined ways in which these centers are utilized in the curricula, however students do benefit from educational and other opportunities provided primarily through faculty participation in the centers.

About 45% of master's institutions have one or more centers dedicated to environmental and/or sustainability issues that focus on facilitating environmental and sustainability education, research and/or outreach (Figure 17).

Figure 17. Institutions hosting environmental and/or sustainability centers

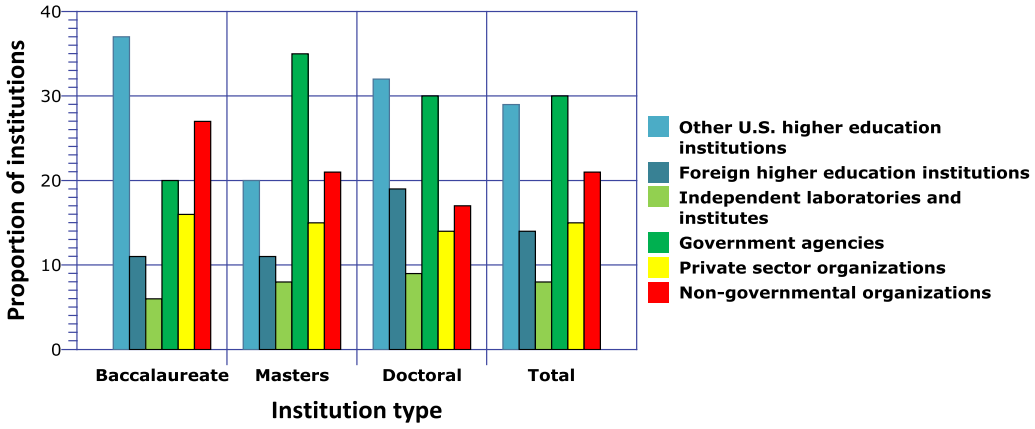


External Partnerships

Several of the JMU environmental programs report formal relationships with external partners. The Integrated Science and Technology department has partnerships with two foreign higher education institutions, the University of Malta and the Hochschule für Technik und Wirtshaft des Saarland in Germany. In addition to the dual MS degree program offered with the University of Malta, students also participate in cooperative research programs, jointly offered courses, and field work opportunities. The Department of Geology and Environmental Science also has an agreement with a foreign institution—the National University of Ireland-Galway—as well as relationships with several governmental agencies. These relationships provide students and faculty with opportunities to participate in joint research projects and utilize partner facilities and internships for students.

Nationally, external partnerships are increasingly viewed as important venues to provide enhanced and/or unique educational and experiential opportunities for students and faculty. Affiliated and partner organizations contribute to IE program curriculum by providing additional resources and opportunities for students and faculty that include shared educational programs, collaborative research projects, and participation in applied and community-based service learning initiatives. The most prevalent types of external partnerships, reported by about a third of all IE programs nationwide, are with other domestic higher education institutions and/or government agencies (Figure 18). Baccalaureate colleges and doctoral institutions are more likely to partner with other higher education institutions to offer transferable coursework, shared degree programs and specialized educational and research courses (including online courses).[13] Masters and doctoral institutions are more likely to have partnerships with governmental agencies. The third most prevalent type of partnership is with non-governmental organizations, which are also more frequent at baccalaureate colleges.

Figure 18. External affiliates and partners



At larges master's institutions, participation in research projects, internships and other applied learning opportunities are the most common form of cooperative opportunities for students; participation in joint research is the most common form of collaboration for IE program faculty (Table 21). A few programs offer shared educational programs and collaborative service learning or outreach experiences.

Table 21. Opportunities for IE students and faculty provided through external affiliates and partnerships

Opportunities	Programs (*n*=50)
Students participate in field/internship/applied learning experiences	36%
Students participate in research programs	32%
Students participate in education programs	22%
Students participate in service learning/outreach	22%
Faculty participate in research programs	28%
Faculty participate in education programs	26%
Faculty participate in service learning/outreach	20%
Faculty participate in field/internship/applied learning experiences	18%

[13] For an innovative example, see the Great Plains Interactive Distance Education Alliance http://www.gpidea.org.

Assessment

IE programs use a variety of metrics to evaluate the effectiveness of their educational programs including enrollment trends, graduation rates, program graduates' job placement, student scholarship, internal and external reviews, and surveys that gauge student, alumni and faculty satisfaction.

An increasing number of programs have developed assessment processes that include achievement of specified learning outcomes. Most college and university accrediting agencies require that all undergraduate degree programs have defined learning outcomes and methodologies for evaluating student achievement of the outcomes. Achievement of the outcomes for student learning are often assessed by evaluating course syllabi to ensure core concepts and skills are included in required coursework, performance of students in key courses and on assessment exams, and by feedback from students via exit interviews, surveys or focus groups.

The JMU environmental programs vary substantially in use of assessment tools (Table 22). Two of the concentrations and three of the minors do not assess defined learning outcomes. The biology concentration has no formal assessment, although it may be included in program reviews. The other concentrations report that the concentrations are specifically reviewed as a part of their program reviews.

The four minors, three of the concentrations—Geographic Science: ECSD, Geology: EEG, and Integrated Science and Technology: ENV—and the Sustainable Engineering Design program require a synthesis capstone course. Student performance in capstone courses are the most popular form of assessment for IE programs and for higher education programs in general.[14] Two of the concentrations survey students at graduation on their employment status and plans for graduate school and alumni on how well the program prepared them for their professions—Geographic Science: ECSD and Integrated Science and Technology: ENV. The Sustainable Engineering Design program employs a range of assessment procedures including employer surveys and tracking student scholarship, leadership and service. The Sustainable Engineering Design program and the Integrated Science and Technology: ENV program also align their programs with ABET standards in Leadership and Quality Assurance in Applied Science, Computing, Engineering, and Technology Education.

Other recommended assessment tools for IE programs include structured student portfolios evaluated by the students and faculty in an ongoing process, and research processes that formally assess alumni survey responses to align curricula to better serve the needs of graduates in the workforce.[15] Internal (representatives from relevant units across the campus, students) and external advisory groups (partner organizations, alumni, employers, governmental representatives) can also serve as important partners in evaluating and revising curricula to ensure relevance to workforce needs and students' interests.

[14] National Institute for Learning Outcomes Assessment. 2011. *Down and In: Assessment Practices at the Program Level.*

[15] Wright, W., Knight, P., and N. Pomerleau. 1999. Portfolio people: teaching and learning dossiers and innovation in higher education. *Innovations in Higher Education* 24(2):89-103. Also see the portfolio process used by the Oklahoma State University Environmental Science Graduate Program. Hansmann, R. 2009. Linking the components of a university program to the qualifications profile of its graduates. *Journal of Research in Science Teaching* 46(5):537-569.

Table 22. JMU environmental program assessment tools*

	Assess Learning outcomes	Student surveys	Alumni surveys	Employer surveys	Student Portfolios	Student scholarship or service	Capstone Course	Program reviews
Environmental Science Minor							✓	
Environmental Studies Minor	✓						✓	
Environmental Management Minor							✓	
Environmental Information Systems Minor							✓	
Biology: EEB Concentration								
Economics: ENRE Concentration								✓
Geographic Science: ECSD Concentration	✓	✓	✓				✓	✓
Geology: EEG Concentration	✓						✓	✓
Integrated Science & Technology/ ENV Concentration	✓	✓	✓				✓	✓
Engineering/ Sustainable Design Focus	✓	✓	✓	✓		✓	✓	✓
Advanced Manufacturing Certificate	✓							✓

*Data provided by program administrators

Section V – Comparison of JMU Environmental Programs' Attributes with NCSE Study Findings

Enrollment, Objectives and Requirements

Program Enrollment Compared with Similar Degree Programs

Table 23 illustrates the average enrollment for the 5-year period 2003-2008 (academic years) for the representative sample of undergraduate environmental science programs, environmental studies programs, and programs classified as policy, planning and management that participated in the NCSE study as compared to the current enrollment for three similar JMU minors.

Table 23. IE undergraduate degree program enrollment at master's institutions compared with JMU minors

Degree Program	2003-2008* Mean	Min/Max	JMU Minors
Environmental Science(s) BS *n*=29	23	1/100	10
Environmental Studies BA/BS *n*=27	32	2/165	45
Environmental Policy, Planning & Management BA/BS *n*=10	41	2/130	5

*Average over five academic years

Table 24 illustrates the enrollment data for the JMU environmental programs. Some programs have seen little growth over time, while others have experienced substantial growth. The environmental concentrations comprise from 6-60% of their respective majors.

Table 24. JMU environmental programs enrollment

Program	2003-06*	Current
Environmental Science Minor	11**	10
Environmental Studies Minor	-	45
Environmental Management Minor	2	5
Environmental Information Systems Minor	8	5
Biology: EEB Concentration	-	60 (<10%)
Economics: ENRE Concentration	-	1-2 (<10%)
Geographic Science: ECSD Concentration	15	66 (60%)
Geology: EEG Concentration	-	13 (19%)
Integrated Science & Technology: ENV Concentration	27	75 (25%)
Engineering: Sustainable Design Focus	-	110
Advanced Manufacturing Certificate	-	6

*Average over three academic years - data from JMU 2007 Report of the Environmental Science/Studies Work Group; ** The current Environmental Studies minor was established in 2010; the original Environmental Studies minor was redesigned to become the current Environmental Science minor.

Many of JMU's environmental programs are new or redesigned and thus have short histories. The three original minors have all experienced low, but steady enrollment. The new Environmental Studies minor established in 2010 has a far larger number of students. Two of the original concentrations in Geographic Science and Integrated Science and Technology have experienced substantial growth; the third, in Economics, has consistently attracted very few students. The Geology and Biology concentrations attract relevant numbers of students within their majors. The environmental concentrations vary in popularity within their majors, comprising less than 10% of the majors in Biology and Economics, about a fifth of majors in Geology, a fourth of majors in Integrated Science and Technology, and more than half of Geographic Science majors. The new engineering program with a focus on sustainable design has experienced rapid growth since its inception and is the JMU environmental program with the highest enrollment. The undergraduate certificate in advanced manufacturing has only attracted a handful of students.

The majority of environmental programs across the United States are growing rapidly; many programs are reporting extraordinary growth. Some of the largest include the programs at the University of Vermont which have over 400 students enrolled in the Environmental Studies program and over 300 in the Environmental Science program, and the University of Michigan's Program in the Environment (which has science and studies tracks) with over 350 majors and 150 minors. In contrast, only a few of JMU's environmental programs are growing—the Environmental Studies minor, the engineering program, and the concentrations in Geographic Science and Integrated Science and Technology.

Enrollment Trends Vary Based on Degree Program Name

The NCSE study revealed that the average number of students enrolled in undergraduate IE programs varied significantly based on program name type.[16] Undergraduate programs named environmental science(s) average fewer students compared with IE degree programs named environmental studies or those with other names. The mean number of students enrolled in undergraduate programs named environmental science(s) was 29 versus 52 for environmental studies and 64 for programs with other names. The average number of graduate students enrolled in IE programs range from 22-28 and did not vary significantly based on program name.

For undergraduate programs located at large master's colleges and universities the differences in average enrollment based on degree program names are similar. The mean number of students enrolled in undergraduate programs named environmental science(s) is lower than the mean for programs named environmental studies or those classified as policy, planning and management (Table 25).

Enrollment trends are Significantly Associated with Ideal Educational Approach/Model

As discussed previously in this report, the NCSE study revealed differences in enrollment trends associated with the three ideal curriculum models. The *Adaptive Management* approach has a significantly higher proportion of programs experiencing growing enrollments compared to the *Systems*

[16] Analysis of variances tests, $p \geq .05$.

Science model which has the lowest proportion. The proportion for the *Policy and Governance* model is in between the other two models and not significantly different from either. The popularity of the ideal approaches among IE program leaders follows the same trend—the *Adaptive Management* model is the most popular ideal for IE programs (45%), the *Systems Science* model the least popular (22%), and the popularity of the *Policy and Governance* model falls in between (33%).

The overall trends are consistent with IE programs at large master's institutions. The majority of environmental science programs are aligned with the *Adaptive Management* model, the majority of environmental studies programs are aligned with the *Policy and Governance* model, and lower enrollments are associated with the *Systems Science* model (Table 25).

Table 25. Program enrollment by model at large masters institutions*

	Policy & Governance		Adaptive Management		Systems Science	
Degree Program Type	Mean	Min/Max	Mean	Min/Max	Mean	Min/Max
Environmental Science BS	*n*=5		*n*=15		*n*=6	
	23	8/40	22	1/100	11	2/25
Environmental Studies BA/BS	*n*=11		*n*=5		*n*=4	
	44	10/165	35	3/100	25	5/50
Environmental Policy, Planning & Management BA/BS	*n*=4		*n*=5		*n*=0	
	30	5/75	31	2/50	-	-

* The names of degree programs were associated with the three ideal approaches, although not significantly.

Enrollment trends are Significantly Associated with Program Objectives and Inclusion of Sustainability

As discussed previously in this report, the NCSE study revealed that growth in IE program enrollment is positively and significantly associated with four degree program objectives and the inclusion of sustainability in program curricula.

The objectives associated with program growth are:

- Preparing students to be environmental leaders and change agents (undergraduate degree programs);
- Providing community service[17] (undergraduate degree programs);
- Advancing environmental research[18] (undergraduate degree programs); and
- Improving environmental policy decisions[19] (graduate degree programs).

Sustainability inclusion includes:

- Sustainability as a core educational principle (undergraduate and graduate programs);
- Sustainability focused coursework (undergraduate and graduate programs);
- Sustainability oriented research experiences (undergraduate and graduate programs); and,
- Sustainability oriented applied/service learning experiences (undergraduate and graduate programs).

[17] Student participation in community-based applied or service learning experiences or internships.
[18] Student participation in environmental or sustainability research.
[19] Student participation in policy-oriented research or applied learning experiences.

The JMU environmental programs vary in terms of sharing these objectives and inclusion of sustainability in the curricula. Table 26 illustrates which programs share the three objectives correlated with undergraduate program growth and include sustainability as a core principle, in coursework, in research opportunities and in applied learning opportunities. The findings for the JMU programs are consistent with the national findings; programs that share the three objectives and include sustainability tend to be more popular with students (see enrollment data above).

Table 26. Program objectives and sustainability inclusion in JMU programs*

	Program Objectives			Sustainability Inclusion			
Program	Leaders & change agents	Community service	Research opportunities	Core principle	Coursework	Research	Applied projects
Environmental Science Minor	✓						
Environmental Studies Minor	✓				✓		
Environmental Management Minor	✓				✓		
Environmental Information Systems Minor	✓				✓		
Biology: EEB Concentration			✓				
Economics: ENRE Concentration					✓		
Geographic Science: ECSD Concentration	✓	✓	✓	✓	✓	✓	✓
Geology: EEG Concentration	✓	✓	✓				
Integrated Science & Technology: ENV Concentration	✓	✓	✓	✓	✓	✓	✓
Engineering: Sustainable Design Focus	✓	✓	✓	✓	✓	✓	✓
Advanced Manufacturing Certificate	✓			✓	✓		

*Data provided by program administrators

Degree Requirements

Table 27 illustrates the degree requirements for the IE undergraduate programs that participated in the study. The majority of IE undergraduate programs require students to complete an advanced level synthesis or capstone course, and about a third of programs require substantial coursework in another major and/or completion of a formal written research report. Participation in a research project, a formal external internship, and/or an applied or service learning project are also fairly common requirements, especially for BA programs, although the majority of programs offer these experiences as options.[20]

Table 27. IE Degree program requirements

Bachelor of Science (*n*=149)	Always required	Required in certain cases*	Option
Formal written research/review report	33%	13%	-
Substantial coursework in a traditional major	35%	3%	-
Participation in a research project	26%	10%	63%
Formal external internship	20%	11%	64%
Applied or service learning project	14%	5%	60%
Advanced level synthesis/integration (capstone) course	69%	0%	11%
Bachelor of Arts (*n*=102)	**Always required**	**Required in certain cases***	**Option**
Formal written research/review report	38%	14%	-
Substantial coursework in another major	30%	8%	-
Participation in a research project	32%	5%	57%
Formal external internship	24%	6%	66%
Applied or service learning project	17%	2%	66%
Advanced level synthesis (capstone) course	75%	2%	9%

[1]Required for honors, some degree tracks or specializations, and some degree options (other options may include internship, capstone course, senior seminar, study abroad, creative project, thesis, professional paper, qualifying exam or professional experience).

Table 28 illustrates the degree requirements for JMU's environmental programs. All require substantial coursework in another major given that the programs are either a minor, concentration, certificate, or focus area. Consistent with the NCSE study findings, most require students to complete an advanced level synthesis or capstone course and three require a formal written report equivalent to a senior thesis. Four require participation in a research project. Internships and study abroad are options for completing an experiential requirement for several programs.

[20] Other requirements and options include participation in a design studio, study abroad, seminar courses, coursework at another institution, field research, formal presentations, professional certification, or participation in an integrated first year interdisciplinary learning community.

Table 28. JMU environmental program requirements*

	Synthesis course	Field research	Individual research	Team research	Applied project	External internship	Senior thesis	Study abroad
Environmental Science Minor	✓							
Environmental Studies Minor	✓	**		✓		**		**
Environmental Management Minor	✓							**
Environmental Information Systems Minor	✓							**
Biology: EEB Concentration		**	**	**	**	**	**	**
Economics: ENRE Concentration		**	✓	**	**	**	**	**
Geographic Science: ECSD Concentration	✓	**	**	**	**	**	**	**
Geology: EEG Concentration	✓	✓	✓	✓		**	✓	**
Integrated Science & Technology: ENV Concentration	✓	**	**	**	**		✓	**
Engineering: Sustainable Design Focus	✓			✓	✓		✓	**
Advanced Manufacturing Certificate								

*Data provided by program administrators; ** an option to fulfill requirements

Curriculum Design

A universal core curriculum with multiple options is the most prevalent type of curriculum design for IE undergraduate programs, followed by broad exposure to a wide range of environmental topics (Table 29). BS programs are more likely than BA programs to focus on depth in a disciplinary area, although the proportion of programs using this model is low, representing only about a sixth of all BS programs.

Table 29. Undergraduate IE programs curriculum design

Curriculum design	BS (*n*=148)	BA (*n*=102)
Universal core with multiple options	39%	41%
Broad exposure to a wide range of environmental topics	26%	32%
Depth in a particular disciplinary area	16%	8%
Multiple options with different core requirements	8%	8%
Focus on a particular environmental/sustainability theme	6%	6%
Other*	5%	5%

*Broad core with depth via concentration, minor or dual major.

All but one of the JMU environmental programs are aligned with the three most prevalent IE curriculum design models (Table 30). The Integrated Science and Technology: ENV concentration and the two minors affiliated with the Integrated Science and Technology department have a universal core with multiple options. The economics, geology and engineering programs focus on disciplinary depth. The environmental science and studies minors, and the biology and geographic science concentrations focus more on breadth. The advanced manufacturing certificate program is designed to focus on a particular theme.

Table 30. JMU environmental programs' curriculum design

	Universal core	Broad exposure	Disciplinary depth	Focus on a theme
Environmental Science Minor		✓		
Environmental Studies Minor		✓		
Environmental Management Minor	✓			
Environmental Information Systems Minor	✓			
Biology: EEB Concentration		✓		
Economics: ENRE Concentration			✓	
Geographic Science: ECSD Concentration		✓		
Geology: EEG Concentration			✓	
Integrated Science & Technology: ENV Concentration	✓			
Engineering: Sustainable Design Focus			✓	
Advanced Manufacturing Certificate				✓

Alignment with IE Field Identity

In this section the JMU environmental programs are compared with the four key characteristics of IE program field identity. This section and the next two sections together address the question of how the curricular content of the JMU environmental programs compare with all IE programs.

The NCSE study revealed a consensus field identity for IE programs based on sustainability-oriented scholarship, research and practice with an emphasis on systems-based, interdisciplinary problem solving as described in the key findings section of this document. The four key characteristics of IE program field identity are:

- *Focus of Study.* The interfaces between human and natural systems (coupled human-nature systems).
- *Educational Approach.* A holistic educational approach that focuses on interdisciplinary knowledge and insights gained from systems approaches and diverse epistemological viewpoints to understand environmental problems and devise solutions. Includes key concepts from the natural sciences, the social sciences, the applied sciences and the humanities.
- *Key Learning Outcomes.* Disciplinary synthesis and system-thinking cognitive skills. Knowledge of the sociopolitical and natural aspects of environmental problems, understanding of the limits of technology and science for solving environmental problems, and the importance of acknowledging and reporting uncertainty.
- *Goal.* To prepare graduates to be sustainability-oriented problem solvers through scholarship, research, practice and informed citizenship.

Table 31 illustrates how well the JMU programs align with the four key characteristics of IE field identity based on an analysis of the program descriptions on the JMU website and catalogs, and the responses of the program administrators to questions about their programs.

Table 31. JMU environmental programs' alignment with key characteristics of IE field identity

	Focus	Approach	Outcomes	Goal
Environmental Science Minor	*	*		*
Environmental Studies Minor	*	*		✓
Environmental Management Minor	*	*		*
Environmental Information Systems Minor	*	*		*
Biology: EEB Concentration	*			
Economics: ENRE Concentration	*			
Geographic Science: ECSD Concentration	✓	*		✓
Geology: EEG Concentration		*		
Integrated Science & Technology: ENV Concentration	✓	✓	✓	✓
Engineering: Sustainable Design Focus	✓	✓	✓	✓
Advanced Manufacturing Certificate	*			*

*Partial alignment

Several of JMU's environmental programs align well or fairly well with the key characteristics of the IE field. The Integrated Science and Technology: ENV and the Sustainable Engineering Design Focus programs are well-aligned with the national consensus on IE program field identity. The Geographic Science: ECSD program is well-aligned except for a clear emphasis on synthesis and systems-thinking as key learning outcomes. Although not included in this report, the dual master's degree program in Sustainable Environmental Resources Management/Integrated Science and Technology offered through a partnership with University of Malta is also well aligned with the key characteristics of the IE field.

The minors are fairly well-aligned but do not have a clear focus on the interactions of coupled human-nature systems and instead seem to focus primarily on either natural or social systems rather than use these as a perspective lens for focusing on the interfaces. They vary in their inclusion of sustainability, although all stress problem-solving as a goal. Three share a capstone course but the focus appears to be on differing perspectives on an issue rather than synthesis and systems thinking for solutions development. Since these programs are minors, students' degrees will align with the interdisciplinary environmental field more or less depending upon their majors.

The remaining programs align more closely with their disciplines and professional fields than with IE programs. The Biology: EEB, Economics: ENRE, and Geology: EEG programs do not include sustainability and focus primarily on either natural systems or social systems rather than the interactions of coupled human-nature systems. They also stress disciplinary depth rather than synthesis and systems-thinking. The Advanced Manufacturing Certificate focuses on life cycle analysis, a defined set of methodologies and principles for sustainable manufacturing.

Alignment with Ideal Educational Approaches

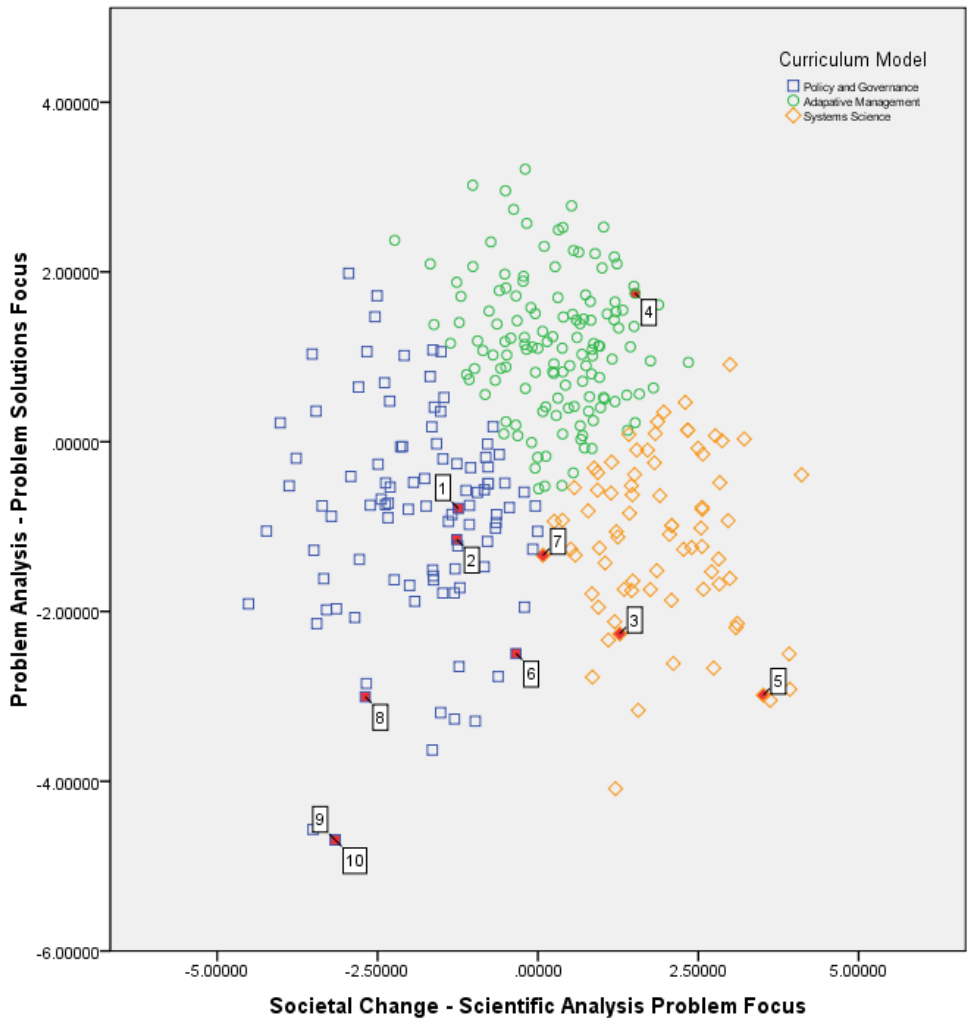
Recall that discriminant analysis revealed two significant functions that explain the differences between the three ideal approaches to IE education (based on the factor scores for the five interdisciplinary knowledge components and the five integrated skills components). The first dimension (illustrated on the X axis) accounts for the majority of the variance (64%) between groups; the second dimension (Y axis) accounts for the remaining 36% (Figure 20). The first dimension is characterized by an emphasis on natural sciences knowledge and technical research and analysis skills versus an emphasis on social sciences knowledge and community engagement skills. The second dimension is characterized by a higher or lower emphasis on managerial and community engagement skills, and resource management and social sciences knowledge.

Figure 19 illustrates where the JMU environmental programs all when plotted together with the 304 IE degree programs from the original NCSE study.[21]

[21] The Advanced Manufacturing Certificate is not included because the data needed was not provided.

Figure 19. JMU programs plotted on two dimensions that distinguish approaches

1=Integrated Science and Technology: ENV
2=Geographic Science/ECSD
3=Geology: EEG
4=Engineering/Sustainable Design
5=Biology: EEB
6=Economics: ENRE
7=Environmental Science Minor
8=Environmental Studies Minor
9=Environmental Management Minor
10=Environmental Information Systems Minor



Only two of the JMU environmental programs align with one of the three models—the Geographic Science: ECSD and the Integrated Science and Technology: ENV degrees fit within the *Policy and Governance* model. These two programs are the most interdisciplinary degrees of the JMU environmental programs and therefore it makes sense that they would be the ones that fit within the framework. They are near the center of this model group indicating a strong association with this

model. These programs have a balanced approach focused on understanding problems and devising solutions with more emphasis on societal systems (including policy, business and technology) and less on natural systems analysis.

The others JMU programs are located on the periphery of one of the models or are located near the center of all three indicating weak associations with the models. This is not surprising given that the framework is based on interdisciplinary environmental degree programs and the JMU programs are primarily discipline-based degrees or minors/certificates.

The Sustainable Engineering Design program is associated with the most popular approach for IE degree programs—*Adaptive Management*—because of its strong solutions orientation and applied sciences approach to problems. It fits within the framework but on the periphery due to its identity as an engineering program that incorporates technical, economic, environmental and social principles into engineering design.

Three minors—Environmental Studies, Environmental Management and Environmental Information Systems—and the Economics: ENRE are located on the periphery of the *Policy and Governance* model. These programs have a weak association with this model and are primary focused on the analysis of societal systems' roles and impacts on environmental and sustainability issues.

The remaining three programs are classified as *Systems Science*, although the Environmental Science minor is located near the center of all three approaches indicating scores close to zero on both dimensions which is interpreted as an undefined approach. The other two programs—Biology: EEB and Geology: EEG—are oriented toward problem understanding using natural sciences analytical approaches. This reflects their identities as primarily focused within their respective disciplines.

Section VI – Environmental Workforce Overview

Job opportunities for the graduates of IE programs are rising rapidly. The 2008 *Jobs and Environment Initiative* study analyzed the environmental job market nationally and in nine states (Arizona, California, Connecticut, Florida, Michigan, Minnesota, North Carolina, Ohio and Wisconsin).[22] The size of the environmental industry in the nine states comprised from 2.6% to 3.9% of state GDP corresponding to 2.9% to 4.9% of total state jobs. A significant proportion of the environmental-related jobs market is in the public administration sector (38-47%); another 16-29% is in private sector professional, scientific and technical services. The remainder is spread across all sectors. Since the variation between states was relatively small, Virginia and other states are likely to have similarly sized and structured environmental industry and environmental-related jobs markets.

The United States Department of Labor predicts a 28% increase in the number of environmental scientist and specialist positions between 2008 and 2018, a growth rate much faster than most occupations. About 37% of environmental scientists and specialists were employed in state and local governments; 21% in management, scientific, and technical consulting services; 15% in architectural, engineering and related services; and 7% in the Federal Government, primarily in the Environmental Protection Agency (USEPA) and the Department of Defense. Job growth for environmental scientists and specialists is expected to be strongest in private sector consulting firms, but job prospects are also especially favorable for environmental health positions in state and local governments.

Other emerging opportunities for IE program graduates include planning-oriented jobs in public administration (environmental policy and planning, urban development), sustainability (private and public sector sustainability management, sustainable community development, international sustainable development), environmental management (private and public sector environmental management systems, water management, energy management, greenhouse gas accounting and management, materials and waste management) and natural resources management (watershed systems, ecosystems, coastal and marine systems, land use planning).

Environmental protection expertise and sustainability knowledge are increasingly applicable across a wide spectrum of jobs, creating demand for IE degree programs as well as minors, certificates, and professional continuing education programs.

Evolution of the IE Workforce

The IE workforce develops in response to the evolving environmental movement and its influence on the sociopolitical and economic milieus of the United States and other developed and developing countries. Sherburne Abbott, the Associate Director for Environment and Energy in the federal Office of Science and Technology Policy, has identified five waves of the environmental movement that have influenced IE workforce needs: (1) the preservation movement 1850-1890, (2) the natural resources

[22] Bezdek, R. H., R. M. Wendling, and P. DiPerna. 2008, Environmental Protection, the economy, and jobs: National and regional analyses. *Journal of Environmental Management* 86: 63-79.

management movement 1890-1950, (3) the ecological movement 1950-1970, (4) the regulatory movement 1970-1990, and (5) the sustainability movement 1990-present.

The current sustainability movement began following the publication in 1987 of the United Nations World Commission on Environment and Development report *Our Common Future* which brought the concept of sustainability into public discourse. The sustainability movement is characterized by a new approach to solving complex environmental problems through solutions that integrate ecological heath, social justice and economic security over varying temporal and spatial scales.

Each of the four waves preceding the current sustainability wave produced laws, regulations, technical and scientific approaches, professions, and institutions appropriate to the missions and goals of the time. Each subsequent wave was built upon the foundations that preceded it while adding new approaches, objectives and career paths. Today, some environmental jobs are recognizable as modern versions of long-established professions, such as those in natural resources management and regulatory compliance, while others are newly emerging career paths. Sustainability is driving a wave of new policies, methods for problem solving, and careers for environmental professionals. Taken together, the professions created during the waves constitute a complex array of interrelated environmental jobs that evolve over time.

The emergence, growth, and decline of environmental careers also follow cycles driven by policy and technological changes. Political demands that manifest during environmental movements influence government policies that in turn drive new investment, research and development, environmental career creation, expansion, and decline. Kevin Doyle, the president of Green Economy, a Boston-based training, research, and consulting firm, and former National Program Director for the Environmental Careers Organization, describes three factors that influenced the evolution of careers from the 1970s to the present:

• *Industry maturation*. As environmental industry sectors respond to changing market demands, specific career sectors explode, mature, consolidate, and decline. Some professions that were established during the 1970s matured and are now stagnant or declining, while emerging sectors are expanding.

•*Technology cycles*. Technology increases the need for some types of environmental professionals and decreases the need for others. Field monitoring, hazardous materials management and geographic information system mapping are examples of areas where the need for specialists has declined with technological improvements.

• *Declining power of the federal government as employment driver*. Although the federal government remains the largest single employer of environmental professionals, two trends are emerging. Under political pressure to shrink the size of the federal workforce, many programs are being devolved to state and local governments, and jobs are being outsourced to private contractors.

A recent analysis of the environmental labor market in the European Union similarly describes an environmental employment life cycle tied to environmental policy changes and subsequent demands for new technologies and services. The study, based on 16 reports of the European Union's ESSENCE network, found that the demand for environmental professionals described as either "specialists" or "generalists" fluctuated following changes in government policies and investments in environmental

technology. Demand for specialists—scientists, technologists and engineers—rises immediately following the implementation of new government policies, which drives spending on new technologies, which is then followed by a shift to demand for more generalists—managers and administrators. The market becomes saturated after a period of time, until new political demands or technological innovations stimulate the development of new policies or technologies, which again drive an increase in demand for new types of specialists and generalists.

Trends Driving Evolution of the Environmental Workforce

The federal government formally shifted its environmental focus to sustainability in the 2007 national *Sustainability Research Strategy* which states: "The focus on sustainability research recognizes the changing nature of environmental challenges that society faces today. In the past the United States Environmental Protection Agency focused its actions more directly on specific pollutants, their sources and their causes. More recently, and into the future, the Agency must provide information that will address a broader set of environmental issues involving population and economic growth, energy use, agriculture and industrial development. Capably addressing these questions and the tradeoffs they will entail requires new systems-based focus on science and analysis."[23]

In December 2010 USEPA Administrator Lisa Jackson announced that sustainability is the goal for agency reforms. The National Academy of Sciences released its report, *Sustainability and the U.S. EPA*, in September 2010 on how to make sustainability operational throughout the agency. The USEPA also emphasizes sustainability in its newly released FY 2011-2015 Strategic Plan.[24] The concepts of sustainability and sustainable development are invoked throughout the plan's five strategic goals and five cross-cutting fundamental strategies. Programs and research are grouped into four key areas: 1) Safe and Sustainable Communities, 2) Sustainable Water, 3) Air, Climate and Energy, and 4) Safer Products for a Sustainable World.

The 2009 National Science Foundation Advisory Committee on Environmental Research and Education (NSF AC-ERE) report titled *Transitions and Tipping Points in Complex Environmental Systems also* urges a shift toward societal needs-driven education and research exemplified by the emerging field of sustainability science.[25] The report emphasizes the need for environmental education and research to "strengthen our understanding of the links between human behavior and natural processes" by integrating the behavioral sciences, life sciences, earth and atmospheric sciences, social sciences, mathematics, physical sciences, engineering and information sciences.

The USEPA shift in focus and the recommendations of the NSF AC-ERE illustrate two trends that influence the evolving roles for graduates of interdisciplinary environmental programs and indicate how the three ideal IE educational approaches may prepare students for emerging environmental careers. The first is the need for the participation of most, if not all, fields in solving complex and interrelated

[23] United States Environmental Protection Agency Office of Research and Development. 2007. *Sustainability Research Strategy*. http://www.epa.gov/Sustainability/pdfs/EPA-12057_SRS_R4-1.pdf.
[24] http://www.epa.gov/ocfo/plan/plan.htm.
[25] National Science Foundation AC-ERE. 2009. *Transitions and Tipping Points in Complex Environmental Systems*. Washington, DC: National Science Foundation.

global environmental problems. In 1998, Jane Lubchenco, writing on behalf of the board of the American Association for the Advancement of Science, challenged all scientists to rethink the way science is deployed to meet the challenges of the future.

> The concept of what constitutes "the environment" is changing rapidly. Urgent and unprecedented environmental and social changes challenge scientists to define a new social contract….The new and unmet needs of society include more comprehensive understanding and technologies for society to move toward a more sustainable biosphere—one which is ecologically sound, economically feasible and socially just.

In response, the Federal government, institutions of higher education, non-profit and for-profit organizations, and thousands of individual scientists have realigned research priorities, instituted new funding programs, and designed new interdisciplinary structures to facilitate interdisciplinary coupled human-nature systems research, assist in the development of new sustainability policies, and support action aimed at solving pressing environmental problems. The national *Sustainability Research Strategy,* USEPA strategic plan, and the strategies recommended by the National Science Foundation's Advisory Council for Environmental Research and Education elucidate how the federal government is working to engage many disciplines and entities in working toward enhanced understanding of complex environmental systems, promoting a higher level of public environmental literacy, and providing a foundation for informing policy decisions.

The second trend is the increasing importance placed on new modes of research, knowledge production, and education that transcend disciplinary boundaries and address scientific and societal problems using systems thinking and analysis. The literature discussing the theories, mechanisms, methods, and challenges of these new integrative modes of inquiry and decision making is vast and growing and there is substantial terminological ambiguity concerning the various terms describing interdisciplinary processes, as well as considerable diversity in how these new processes are structured, implemented, and evaluated.

In spite of the terminological diversity used to describe these new forms of knowledge production and decision-making, two terms are used most often: interdisciplinary or transdisciplinary processes. The most frequently cited distinctions between these two forms are based on the actors included in the process and the primary purpose of the process. Interdisciplinary processes are most often described as those undertaken by academics and other scientific and technological experts to gain understanding of complex environmental systems and phenomena.[26] Transdisciplinary processes include other types of actors in addition to scientific and technological experts, including environmental practitioners, policymakers, economic sector representatives, and public stakeholders.[27] These processes are explicitly designed to solve societal problems, linking the results directly to policy and adaptive management decisions. Knowledge integration and mutual learning are key goals for both

[26] The Oxford Handbook of Interdisciplinarity, 2009, edited by Frodeman R., Thompson Klein J., and Mitcham, C. Oxford University Press, Oxford.

[27] *Handbook of Transdisciplinary Research*, 2008, edited by G. Hirsch Hadorn, H. Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacker-Mansuy, D. Joye, C. Pohl, U. Wiesmann, and E. Zemp. Dordtecht: Springer.

interdisciplinary and transdisciplinary processes, explicitly acknowledging and incorporating different value rationalities and forms of knowledge relevant to the problem or issue under consideration.

Linking science, policy and management is an important component of these new interdisciplinary and transdisciplinary processes; this linkage has been identified as one of the critical unmet needs of society and highlights the need for "translators" trained to work at the policy-science and management-science interfaces to help bridge science and policy.

These two trends highlight the important roles for students prepared within ideal IE programs and how they are uniquely qualified to participate in the new integrative and systems-based research, knowledge production, and decision making processes. They also highlight that professional competence in the context of IE education is not narrowly defined vocational training or skills acquisition, but rather the development of holistic understanding and abilities that are flexible and adaptable and that foster reflexive life-long learning. A competence approach for IE education must prepare students to creatively address problems in different contexts, continuously reflect upon their own perspectives and practices, and adapt to rapidly changing contemporary societies where narrowly-defined traditional competencies may quickly become obsolete.

Environmental professionals point to the relevance of sustainability-oriented integrative processes in their work, particularly the need for professional skills related to context-specific problem solving that engages a variety of public and private entities. They emphasize that professional competence is linked to problem solving in specific contexts—working with environmental issues in the interplay of companies, consultants, regulatory authorities, local communities and non-governmental organizations. They conclude that environmental professionals' education should be structured more along thematic guidelines that provide students with a set of problem-solving strategies, and integrate general management principles and organizational theory.

An analysis by Brand and Karvonen (2007) argues that an "ecosystem of expertise" is needed to effectively develop, implement, and manage sustainability projects. This expertise should include: (1) an "outreach expert who communicates effectively to non-experts," (2) an "interdisciplinary expert who understands the overlaps of neighboring disciplines," (3) a "meta-expert who brokers the multiple claims of relevance between different forms of expertise," and (4) a "civic expert who engages in democratic discourse with experts and non-experts". [28] These forms of expertise align well with the three IE programs' ideal approaches to curriculum design: *Systems Science* (interdisciplinary expert), *Policy and Governance* (outreach expert and civic expert), and *Adaptive Management* (meta-expert).

The *Systems Science* model can prepare scientists who, through their combination of breadth of understanding of sustainability and interdisciplinary processes and disciplinary depth in an area of the natural sciences or in a thematic area such as biodiversity can effectively participate in interdisciplinary research to inform knowledge production and decision-making processes.

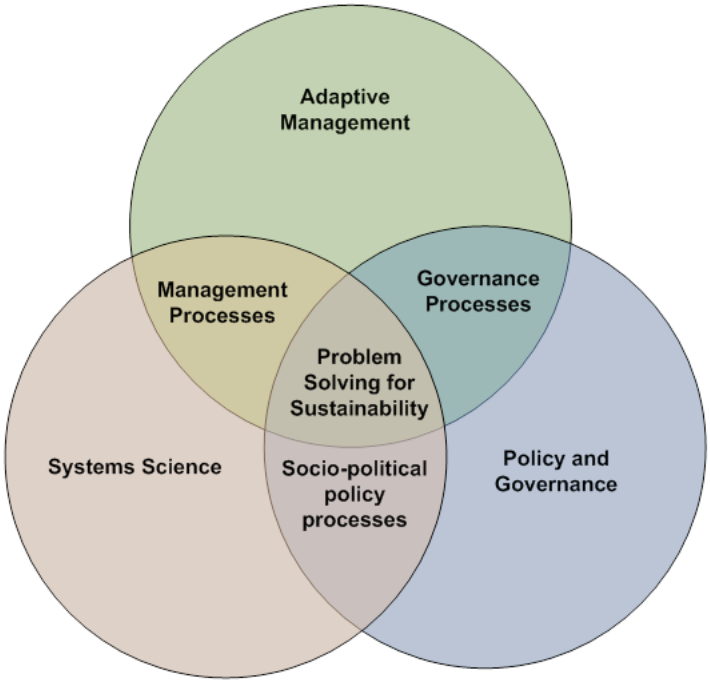
[28] Brand, R., and A. Karvonen. 2007. The Ecosystem of Expertise: Complementary Knowledges for Sustainable Development. *Sustainability: Science, Practice & Policy* 3(1): 21-31.

The *Policy and Governance* model can prepare policy and administration professionals to serve as critical policy actors within transdisciplinary processes as well as translators working at the policy-science and policy-management interfaces.

Professionals prepared in programs embracing the *Adaptive Management* model can serve as the "meta-experts" and decision process managers who understand the relevance of various expertise and knowledge claims in interdisciplinary and transdisciplinary processes and therefore can construct, facilitate, and manage these processes.

Figure 20 illustrates how the three ideal curricula models/approaches to sustainability are related to management, sociopolitical policy making and solutions development and management processes. The science approach develops knowledge that informs management and policy decisions; the governance approach informs the development of appropriate policy mechanisms and governance systems; and the management approach implements management plans and participates in and complies with governance processes (decision making organizations) and mechanisms (regulatory requirements, standards, economic mechanisms)

Figure 20. Framework for Integrated Approaches to Sustainability Problem Solving



The Sustainability Workforce

Sustainability-related employment is difficult to quantify since the field is new, rapidly evolving, and encompasses a wide variety of professional areas. However, there are strong indictors of a significant and growing demand for sustainability professionals. Sustainability sectors that are especially strong are the traditional environmental professions, sustainability enterprise management (private and not-for-

profit companies and organizations), sustainability-oriented urban and land use planning, green built environment, and clean energy.

What is clear is the rising demand for sustainability education; the first sustainability degree programs were launched in 2006-07 and today there are over one hundred. Student demand for sustainability programs has been widely reported by the media. A survey of New Jersey high school teachers and college students conducted by the Richard Stockton College confirmed high levels of interest in sustainability degree programs in the mid-Atlantic region.[29]

Problem-solving for sustainability is the key educational goal for interdisciplinary environmental (IE) education programs as discussed above and is a goal increasingly being adopted by a number of other educational fields including planning, policy and administration, architecture and landscape design, civil engineering, and business administration.

A study by the MIT Sloan School of Management and the Boston Consulting Group found that companies they define as "sustainability embracers" outperform "cautious adopters."[30] A report prepared for the U.S. Mayors Conference estimates that "green" jobs could be the fastest growing segment of the U.S. economy over the next few years.[31] The Clean Tech Job Trends report predicts that clean energy jobs will offer some of the largest growth opportunities and the Greenhouse Gas Management Institute reports that their survey of employers and greenhouse gas (GHG) professionals predict that the majority of publically-traded companies will require GHG management professionals and that there is an insufficient supply of qualified GHG practitioners.[32]

The International Society of Sustainability Professionals 2010 survey of 379 professionals working in sustainability identified two prevalent job types—Corporate Sustainability Manager and Sustainable Community Development Director.[33] Higher education is another sector where demand for sustainability professionals is high.[34]

Patrick Hossay and Tait Chirenje (Richard Stockton College) reviewed multiple jobs reports and employment data as well as hundreds of mid-Atlantic job postings on eight major internet employment sites. They found 116 jobs in New Jersey, Delaware, New York and Pennsylvania that would be suitable for graduates of their new sustainability degree. Their analysis of job postings regionally and nationally determined some of the most notable and frequently-found positions are: business sustainability officers and managers, sustainability consultant, planner or municipal sustainability official, nonprofit management, policy advocate, sustainability auditors, sustainability educator, and regulatory agent.

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[29] Hossay, P. and T. Chirenje, 2011. *Proposal for a Sustainability Degree Program,* The Richard Stockton College of New Jersey.
[30] MIT Slocan Management Review and the Boston Consulting Group. 2011. Sustainability: The 'Embracers' Seize Advantage. *MIT Sloan Management Review*.
[31] United States Conference of Mayors. 2008. *Current and Potential Green Jobs in the U.S. Economy*. Global Insight, Lexington, MA.
[32] Pernick, R. C Wilder, and T. Winnie. 2010. *Clean Tech Job Trends 2010*. Clean Edge, Inc. Portland, OR; Greenhouse Gas Management Institute. 2010. *The 2010 Greenhouse Gas and Climate Change Workforce Needs Assessment Survey Report.*
[33] Willard, M., et al. 2010. *The Sustainability Professional: 2010 Competency Survey Report*. International Society of Sustainability Professionals.
[34] Association for the Advancement of Sustainability in Higher Education. 2010. *Higher Education Staffing Survey*. AASHE.

These results are consistent with the findings of the other sources illustrating that sustainability-oriented job opportunities are similar to environmental jobs in that they are most prevalent in the governmental and consulting sectors, but with increasing opportunities in sustainability enterprise management in a wide range of for-profit and non-profit organizations.

Review of Surveys of Employees and Practitioners about Expectations of Graduates

Although the number of graduates from interdisciplinary environmental programs has increased and the demand for environmental jobs is growing, few studies have examined whether the education and preparation that graduates receive adequately prepare them for successful environmental careers. The studies to date—though few in number and most from outside the US—indicate that employers seek graduates with communication, analytical, problem solving, and managerial skills, as well as a broad understanding of environmental issues and decision-making contexts.

The USEPA's Workforce Assessment Project completed in 1999 stressed that the environmental workforce of the future should have sustainability expertise, multifaceted knowledge with an emphasis on broad understanding of environmental problems, leadership and management skills, and multi-dimensional, audience-customized communication skills.[35] Environmental experts should be "multifaceted" such that they have deep enough knowledge of a variety of fields to know where to look outside and inside the agency for expertise relevant to solving sustainability-oriented problems.

John Esson, director of the U.S. Green Careers Center, reports that the results of annual national environmental employment surveys suggest that the two most important characteristics in employee candidates are written and verbal communication skills and a willingness to take responsibility. Other desirable skills are the ability to work effectively as part of a team and technical expertise and knowledge related to specific jobs.

A 1992 study found that environmental employers in Australia particularly value graduates who can function as "environmental integrators" by managing or coordinating groups of people or projects, participating in multidisciplinary teams, and integrating people and information effective networking. A survey of Australian employers conducted in 2003 found that employers want workplace experience (internships), adaptability, and flexibility. Attributes of particular concern to employers are awareness of environmental issues and their social aspects, as well as understanding political and business processes.

A 2003 survey of employers of interdisciplinary environmental science master's and doctoral degree graduates in Italy found that employees are expected to take leadership roles in influencing environmental management and policy. They found that employer preferences indicate a shift away from detailed technical abilities to broader analytical and problem-solving skills in management, financial analysis, communications, and teamwork. They also found that these masters and doctoral level graduates obtained jobs that require managerial skills, skills in interacting with experts from different disciplines to find operative—defined as practical, measurable, policy relevant—solutions, and

[35] United States Environmental Protection Agency Office of Administration and Resource Management. 1999. *Workforce Assessment Project: Executive Summary and Tasks 1-4 Final Reports*. http://www.epa.gov/epahrist/workforce/wap.pdf.

a broad educational background that embraces the socioeconomic disciplines as opposed to expertise in performing specific technical tasks. This study concluded that "The environmental labor sector is seeking graduates with a broad educational basis who also embrace the socioeconomic disciplines, as opposed to a highly specialized person whose skills can already be found in other more traditional scientific disciplines."

Environmental professionals also stress broad skills. A 2009 study of IE program graduates in the Netherlands found that graduates are employed in a wide range of sectors from universities to consultancy agencies, governmental and non-governmental organizations, and private sector industries. These IE professionals and their employers both view their key strengths as broad practical and professional knowledge and skills in building bridges across disciplines (stressing communication and intellectual skills). A recent study of 600 respondents working in environmental professions in Australia found that a high level of competency in general skills (including written and oral communication, critical thinking/judgment, leadership, planning/organizing projects, teamwork, and facilitation) and practical work experience are cited most often as requirements for success.

A 2009 article authored by a consultancy agency leader on the transition from student to employee argues that knowledge of basic science, ecosystem interactions, and policy are all important for professional success, but organizational abilities and creative problem-solving skills are essential. Similarly, an environmental practitioner with over 25 years of experience identifies four key skills essential for environmental professionals—communication, collaboration, team learning, and stewardship (defined as the willingness to be accountable for the larger whole). These studies indicate that employers of IE program graduates most value the skills associated with interdisciplinary teamwork, critical thinking, problem solving, communication, planning, and management. These skills may actually be more important than substantive knowledge, though knowledge of environmentally relevant natural sciences and sociopolitical disciplines are undoubtedly important.

Section VII – Summary

Overview of Environmental and Sustainability Education at JMU

James Madison University is a leader and innovator in sustainability in higher education; the university is a signatory of the Talloires Declaration and the American College and University Presidents' Climate Commitment and is recognized as a "green college" by the Princeton Review.[36] President Rose formed the Commission on Environmental Stewardship and Sustainability in 2007 which led to the establishment of the Institute for the Stewardship of the Natural World (ISNW) to coordinate environmental stewardship efforts across the campus. In 2009 the university adopted environmental stewardship as a defining characteristic of the university—"The university will be an environmentally literate community whose members think critically and act, individually and collectively, as model stewards of the natural world." Student learning outcomes related to this strategic goal are: (1) recognize the interdependence of humans and the environment, (2) understand the health, socio-economic and ecological dimensions of environmental stewardship, (3) understand how environmental problems are explored, and how solutions are developed and implemented, and (4) understand how environmental stewardship is and can be integrated into our lives.

The ISNW Environmental Stewardship Action Plan 2011-2015 includes "advancing environmental literacy and engagement through research, education and community programs" as one of three primary goals. Institutional objectives include: 1) enhancing environmental stewardship education with an emphasis on interdisciplinary work (via continuation of the Arboretum Collaborative and assessing students' environmental literacy), and 2) enhancing the quantity of and participation in environmental scholarship (via support for faculty research).

A signature initiative to advance environmental literacy at JMU is the Arboretum Collaborative, a Presidential Initiative established in 2010. The Collaborative is a faculty professional development program designed to facilitate curricular innovation that in turn will advance students' environmental literacy. Competitively selected faculty attend a series of sessions that present content related to environmental stewardship and pedagogy during the spring semester and work collaboratively during the summer to develop course re-design proposals that include environmental learning outcomes. Two faculty cohorts have completed the program and the third cohort will complete the program in the summer of 2012.

The impact of the Arboretum Collaborative program in advancing environmental stewardship education at JMU is unclear. A January 2012 survey of JMU faculty conducted by the ISNW indicates a decrease of 6-8% in the number of faculty participating in teaching and research related to environmental stewardship. Since the survey is a convenience sample it is difficult to ascertain the relevance of the decrease which may simple be a reflection of the sample of faculty participating. An assessment process that evaluates the impact of the Arboretum Collaborative program would be beneficial for demonstrating its value and enhancing the benefits of the program.

[36] The Princeton Review's Guide to 322 Green Colleges 2012. http://www.princetonreview.com/green-guide.aspx

JMU's environmental stewardship education efforts led by the ISNW are focused on literacy for all students. The Office of Cross-disciplinary studies coordinates the interdisciplinary minors; the other environmental programs are administered by their respective departments or schools. JMU does not current offer interdisciplinary degree programs in environment or sustainability.

The JMU environmental and sustainability focused education programs include four minors, five concentrations in different disciplines, an undergraduate certificate, a dual MS degree program with the University of Malta, and the Sustainable Engineering Design program. All of the environmental programs at JMU were established 1999-2010—part of the rapid expansion of interdisciplinary environmental and sustainability education programs in higher education that began around 2000 and continues today.

The majority of environmental programs across the United States are growing rapidly; many programs are reporting extraordinary growth. In contrast, only four of JMU's environmental programs are growing—the Geographic Science: ECSD and Integrated Science and Technology: ENV concentrations, the Environmental Studies minor, and the Sustainable Engineering Design program. Four of the five concentrations are doing well, with ~6-60% of students choosing the environmental concentration in their respective major. The fourth, the Economics: ENRE concentration attracts very few students. The other three minors and the undergraduate certificate in Advanced Manufacturing are not faring as well; all have ≤10 students; the Environmental Sustainability/Business Sustainability Certificate was discontinued. The dual MS degree offered by ISAT and the University of Malta was not included in this report but appears to also be doing well. It is interesting to note that the Environmental Studies minor attracts more women students; the Environmental Science minor, the Biology: EEB and Geology: EEG concentrations report a balance between women and men; the remaining environmental programs have primarily men enrolled. This may be a reflection of their respective academic units rather than the environmental programs, but it should be noted that the environmental programs overall are skewed toward men.

The NCSE study found a number of factors that correlate positively and significantly with enrollment trends in IE degree programs. In the case of undergraduate programs, the program name is a factor with programs named environmental sciences having fewer students on average than programs named environmental studies or program with other names such as environmental policy and management or environmental systems. Three program objectives were positively correlated with undergraduate program growth: preparing students to become leaders and change agents, providing community service, and advancing environmental/sustainability research. One program objective was positively correlated with graduate program growth: improving environmental/sustainability policy decisions. Both undergraduate and graduate program growth was positively correlated with inclusion of sustainability in the curricula (as a core principle, in focused coursework, through research experiences, and through applied/service learning opportunities). Finally, degree programs aligned with one of the three ideal approaches to IE education identified by the NCSE study—the *Adaptive Management* model—were more likely to exhibit a growth trend than the other two models.

These trends are apparent as well for the JMU environmental programs, the programs that include sustainability and share the programs objectives correlated with undergraduate enrollment growth are

thriving—the Geographic Science: ECSD and Integrated Science and Technology: ENV concentrations, the Sustainable Engineering Design program and the Environmental Studies minor. The only JMU environmental program associated with the *Adaptive Management* approach—the Sustainable Engineering Design program—is the program with the highest enrollment.

The majority of the JMU environmental programs require a synthesis capstone course, the most common requirement for IE programs. Many of the programs also require an experiential component—an important requirement since experiential experience is highly desired and valued by students, employers and educational experts.

The NCSE study revealed a consensus field identity for IE programs based on sustainability-oriented scholarship, research and practice with an emphasis on interdisciplinary problem solving as described in the key findings section of this document. Several of JMU's environmental programs align well or fairly well with the key characteristics of the IE field. The Integrated Science and Technology: ENV and the Sustainable Engineering Design programs are well-aligned with the national consensus on IE program field identity. The Geographic Science: ECSD program is well-aligned except for a clear emphasis on synthesis and systems-thinking as key learning outcomes. Although not included in this report, the dual master's degree program in Sustainable Environmental Resources Management/Integrated Science and Technology offered through a partnership with University of Malta appears to also be well aligned with the key characteristics of the IE field.

The minors are fairly well-aligned but do not have a clear focus on the interactions of coupled human-nature systems and instead seem to focus primarily on either natural or social systems rather than the interfaces of coupled human-nature systems. They vary in their inclusion of sustainability, although all stress problem-solving as a goal. Three share a capstone course but the focus appears to be on exploring differing perspectives on an issue rather than synthesis and systems thinking for solutions development. Since these programs are minors, students' degrees will align with the interdisciplinary environmental field more or less depending upon their majors.

The remaining programs align more closely with their disciplines and professional fields than with IE programs. The Biology: EEB, Economics: ENRE and Geology: EEG programs do not explicitly include sustainability and focus primarily on either natural systems or social systems rather than the interactions of coupled human-nature systems. They also stress disciplinary depth rather than synthesis and systems-thinking. The Advanced Manufacturing Certificate focuses on life cycle analysis, a defined set of methodologies and principles for sustainable manufacturing.

The NCSE study revealed three ideal approaches to IE education that prepare students for three broad categories of IE careers: the *Systems Science* model that prepares students for careers as environmental research scientists and technicians, the *Policy and Governance* model that prepares students for careers as specialists and citizens involved in environmental policy, planning, administration and governance; and the most desirable IE model (most popular among program administrators, students and employers), the *Adaptive Management* model, that prepares students for careers as environmental and sustainability management and decision making professionals.

Two of the JMU environmental programs align with one of these three models—the Geographic Science: ECSD and the Integrated Science and Technology: ENV degrees fit within the *Policy and Governance* model. These two programs are the most interdisciplinary degrees of the JMU environmental programs and therefore it makes sense that they would be the ones that fit within the IE framework. They are near the center of this model group indicating a strong association with this model. These programs have a balanced approach focused on understanding problems and devising solutions with more emphasis on societal systems (including policy, technology and business) and less on natural systems analysis.

The other JMU programs are located on the periphery of one of the models or are located near the center of all three indicating weak associations with the models. This is not surprising given that the framework is based on IE degree programs and the JMU programs are primarily discipline-based degrees or minors/certificates.

The Sustainable Engineering Design program is weakly associated with the most popular approach for IE degree programs—*Adaptive Management*—because of its strong solutions orientation and applied sciences approach to problems. It lies on the periphery of the model due to its identity as an engineering program that incorporates technical, economic, environmental and social principles into engineering design.

Three of the minors—Environmental Studies, Environmental Management and Environmental Information Systems—and the Economics: ENRE are located on the periphery of the *Policy and Governance* model. These programs have a weak association with this model and are primary focused on the analysis of societal systems' roles in and impacts on environmental and sustainability issues.

The remaining three programs are classified as *Systems Science*, although the Environmental Science minor is located near the center of all three approaches indicating scores close to zero on both dimensions which is interpreted as an undefined approach. The other two programs—Biology: EEB and Geology: EEG—are oriented toward problem understanding using natural sciences analytical approaches. This reflects their identities as primarily focused within their respective disciplines.

The JMU environmental programs aligned best with IE workforce needs are also the most popular with students—Geographic Science: ECSD, Integrated Science and Technology: ENV, and Sustainable Engineering Design. Although all three ideal approaches to IE education are equally relevant, the *Adaptive Management* model is best aligned with emerging workforce needs as described by the USEPA and other employers as well as IE professionals. Employers are also seeking discipline-focused specialists with broad understanding of sustainability and collaborative decision making processes; increasingly natural and applied science disciplines and many professional disciplines (such as engineering, public health, business management, architecture, landscape design, public policy, public administration, and urban planning and community development) are focused on problem solving for sustainability and interdisciplinary collaborative processes in the context of their own disciplines/professions. Two prominent areas of growth in sustainability-oriented jobs are in sustainable enterprise management and sustainable community planning and development.

In addition to the ISNW initiatives and the JMU environmental programs, students also have opportunities to work with faculty on regional initiatives focused on renewable energy and applied environmental research through the Institute for Energy and Environmental Research (IEER). Initiatives include Valley 25x'25 (promotes energy conservation and renewable energy), Virginia Wind Energy Collaborative, and the Virginia Coastal Energy Research Consortium. The Office of Outreach and Engagement works with community partners to provide a variety of professional development and life-long learning educational opportunities that include environmental and sustainability education programs primarily offered for K-12, adult, and community learners.

JMU Institutional Strengths in Environmental and Sustainability Education

JMU has four distinctive environmental programs that differentiate the university in the national environmental and sustainability education landscape. The School of Engineering program in Sustainable Engineering Design is a pioneering and exemplary model for engineering. The program prepares students to be flexible and adaptive integrators with the skills and knowledge that will enable them to contribute crucial expertise toward achieving a sustainable future. The two environmental concentrations and the Dual MS in Integrated Science and Technology and Sustainable Environmental Resources Management offered by the Department of Integrated Science and Technology are innovative programs that are well aligned with 21st century environmental and sustainability workforce needs and student interests. The engineering program and the concentrations in Integrated Science and Technology: ENV and Geographic Science: ECSD are well-aligned with the national consensus on IE program field identity and with the two most popular ideal approaches to IE education—*Adaptive Management* and *Policy and Governance*. The dual major was not included in this analysis. Very few universities offer programs as cutting edge as the new School of Engineering program in Sustainable Engineering Design or programs similar to those offered by the Department of Integrated Science and Technology.

Only two other large master's institutions offer similar applied science and technology programs: Marshall University in West Virginia and Rochester Institute of Technology in New York. Rochester Institute of Technology is one of four master's universities whose Carnegie profiles most closely align with JMU (the other three are included in the peer universities covered in this report—Appalachian State University, California Polytechnic State University-San Luis Obispo, and the University of North Carolina-Wilmington).

Marshall University offers a BS in Integrated Science and Technology: Environmental Assessment and Policy through the Department of Integrated Science and Technology in the College of Science. This department is also home to Marshall's BS in Environmental Science and BS in Natural Resources and Recreation Management programs. Marshall also offers a MS in Environmental Science through the Division of Applied Science and Technology in the College of Information Technology and Engineering. The Rochester Institute of Technology offers a MA in Science, Technology and Public Policy through the Department of Science, Technology, and Society/Public Policy in the College of Liberal Arts. Rochester also awards BS and MS degrees in Environmental Science though the Environmental Science Program in the College of Science; a MS in Sustainable Systems and a PhD in Sustainability through the Golisano Institute for Sustainability; and a BS in Environmental Management and Technology through the

Department of Civil Engineering Technology, Environmental Management and Safety, College of Applied Science and Technology.

The concentrations in Biology, Economics and Geology are closely aligned with their respective disciplines and have a traditional educational approach, stressing depth in their respective disciplines. The Biology: EEB and Geology: EEG concentrations are solid concentrations with a number of students selecting these options within their majors. The Economics: ENRE concentration is less successful but has high potential given the new global focus on the importance of the economics of sustainability. New approaches to economics and business management that decouple economic growth from resource consumption is an emerging area of research and professional practice and has been called potentially "one of the biggest sources of future success for business" as well being identified as the most urgent challenge facing global societies by the United Nations Environmental Programme.[37]

The four minors are coordinated through the Office of Cross-Disciplinary Studies and can be taken in conjunction with any degree program. Two of the minors—Environmental Management and Environmental Information Systems—are closely affiliated with the Department of Integrated Science and Technology and serve primarily as minors for departmental majors. The undergraduate certificate in Advanced Manufacturing is offered by the College of Business and is also primarily earned by business majors, although it may also be combined with any major. Three of the minors—Environmental Science, Studies and Management—share a capstone course which investigates a particular environmental topic using a case-study, team-teaching approach. The course is designed to involve students in problem-solving, using cross-disciplinary communication and teamwork, hands-on experiences, and applied research techniques. A synthesis capstone course requirement for minors is unusual and is an important strength of these three programs.

National Trends in IE and Sustainability Education

This section summarizes national trends in IE and sustainability education. It provides perspective on how JMU is currently positioned in the national higher education landscape and how it may build upon its institutional strengths in IE and sustainability education.

Rapid Rise in the Number of IE and Sustainability Degree Programs

The majority of institutions of higher education offer IE and/or sustainability degree programs. All but a handful of research institutions offer IE or sustainability degrees; larger universities often offer multiple interdisciplinary degree programs as well as multiple concentrations in disciplines and professional fields. The NCSE 2012 census indicates a sharp increase of 33% in the proportion of higher education institutions offering IE and/or sustainability degrees. The proportion of large master's institutions offering IE/sustainability degrees is 57%; an increase of 36% over 2008.[38] Environmental science(s) and studies programs are most prevalent, but an increasing number of schools are offering sustainability or themed degree programs that focus on specific environmental systems or issues; graduate degrees in these areas are also becoming more common (Table 32).

[37] KPMG 2012 Expect the Unexpected: Building Business Value in a Changing World.
[38] Public and not-for-profit large master's institutions in the U.S.

Table 32. IE degree types offered by large master's institutions

Degree Type	UG Degrees n=270	GR Degrees n=93
Environmental Science(s)	46%	40%
Environmental Studies	28%	15%
Environmental Theme/Sustainability*	11%	29%
Environmental Policy/Planning/Management	9%	11%
Environmental Technical/Applied	3%	4%
Natural Resources Management	2%	1%

* For example, Regenerative Studies, Marine Science, Environmental Marine & Estuarine Science, Environmental Science and Health, Environmental Sustainability, Sustainability Science, Sustainable Development, etc.

The number of sustainability degrees in the U.S. is rising rapidly; increasing from a handful in 2008 to over one hundred today. Table 33 lists the sustainability programs offered by large master's institutions. Analysis of the results from the NCSE 2012 survey will provide guidance on the characteristics and curricula of these programs and how they compare with IE programs.

Table 33. Sustainability degree programs offered by large master's institutions

Undergraduate Programs		
Baldwin-Wallace College Berea, OH	Sustainability Programs; Division of Business Administration	Sustainability BA
Bentley University Waltham, MA	Department of Natural and Applied Sciences and the Office of Sustainability	Earth, Environment and Global Sustainability BLS
College of Notre Dame of Maryland Baltimore, MD	Environmental Sustainability Program; Women's College	Environmental Sustainability BA
Creighton University Omaha, NE	Department of Physics; College of Arts and Sciences	Sustainable Energy BA
Daemen College Amherst, NY	Interdisciplinary Programs, Division of Arts and Sciences	Global and Local Sustainability BA
Kean University Union, NJ	Center for Sustainability Studies; College of Natural, Applied and Health Sciences	Sustainability Science BS
Lipscomb University Nashville, TN	Institute for Sustainable Practice	Sustainable Practice BS
Maharishi University of Management Fairfield, IA	Department of Sustainable Living	Sustainable Living BS
Marylhurst University Marylhurst, OR	Department of Interdisciplinary Studies	Interdisciplinary Studies: Sustainability Studies BA
Philadelphia University Philadelphia, PA	Environmental Sustainability Program; College of Science, Health and the Liberal Arts	Environmental Sustainability BS
Tennessee Technological University Cookeville, TN	Environmental and Sustainability Studies Program; College of Arts and Sciences	Environmental and Sustainable Studies BS
University of Baltimore Baltimore, MD	Division of Science, Information Arts and Technologies; College of Arts and Science	Environmental Sustainability and Human Ecology BA
Wilkes University Wilkes-Barre, PA	Institute of Environmental Sciences and Sustainability, Environmental Engineering & Earth Sciences	Environmental Sciences and Sustainability BA/BS

Graduate Programs		
Chatham College Pittsburg, PA	School of Sustainability and the Environment	Sustainability MS
CUNY City College New York, NY	Spitzer School of Architecture; Grove School of Engineering and Division of Science	Sustainability in the Urban Environment MS
Lipscomb University Nashville, TN	Institute for Sustainable Practice	Sustainable Practice BS, MS
Long Island University-C. W. Post Brookville, NY	Department of Earth and Environmental Science, College of Liberal Arts and Sciences	Environmental Sustainability MS
National University La Jolla, CA	Department of Applied Engineering; School of Engineering, Technology and Media	Sustainability Management MS
Rochester Institute of Technology Rochester, NY	Golisano Institute for Sustainability	Sustainable Systems MA Sustainability PhD
Saint Edward's University Austin, TX	Graduate College	Environmental Management and Sustainability PSM
Slippery Rock University of Pennsylvania Slippery Rock, PA	Department of Geography, Geology, and the Environment; College of Health, Environment, and Science	Sustainable Systems, MS

The majority of IE BA programs at larger universities are aligned with the *Policy and Governance* model. Most IE BS programs are aligned with the *Adaptive Management* model. Many of the programs aligned with the *Systems Science* model are based in traditional departments and often emphasize a discipline-focused approach to environmental science; however others are organized around a theme such as watershed management or coastal science. Although all three ideal approaches are equally relevant for IE education, the *Adaptive Management* model is best aligned with emerging workforce needs as described by the USEPA and other employers as well as IE professionals and is the most popular model for students and IE program administrators.

Recent surveys indicate that majorities (up to 80%) of IE program graduates plan to continue their education and many IE programs are developing five-year accelerated degree programs. Professional Science Masters which combine studies in science and business are increasingly in demand.[39] About a quarter of large master's institutions offer IE and/or sustainability graduate degrees.

An increasing number of IE programs are offering dual majors—these options are attracting increasing numbers of students, providing evidence of students' interest in programs that fuse environmental/sustainability and other disciplines/professions. A range of dual degree options should be considered and encouraged for students since sustainability and environmental expertise is increasingly applicable across a spectrum of professions and disciplines. Continuing education options, such as the executive degree program offered by Duke University's Nicholas School of Environmental Leadership Program, can bring in revenue and enhance external partnerships.

Rapid Rise in Interdisciplinary Academic Units

Administrative agency (autonomy and capacity to direct resources) is the key component that allows IE programs to fully attain their educational, research and service missions. Administrative independence and the capacity to obtain and direct resources are intimately tied to the three other key elements

[39] See http://www.sciencemasters.com for more information.

related to effective program design: adopting an overall vision/goal, implementing truly interdisciplinary curricula, and the capacity to involve students in real world inter- and transdisciplinary knowledge-production and decision-making processes. In addition, administrative agency ameliorates the tenure and promotion challenges often cited as problematic for interdisciplinary scholars.

A traditional department was revealed by NCSE study to be the least desirable for IE programs both in terms of providing ideal curricula and in satisfaction with the factors that contribute to program success. For larger universities, a college, school or degree-granting institute or center is an optimal structure for IE programs because it confers the required administrative agency and has the capacity to fulfill a number of interrelated institutional goals. The NCSE survey found that the administrators of programs located in an IE college, school or institute had the highest levels of satisfaction with their programs' administrative location, their ability to prepare students for employment opportunities, compete for federal funding, and win public support. Most importantly, these programs were also the most successful at offering ideal IE curricula. Leadership capacity and core faculty resources are significant competitive factors for IE programs.

Of the eight JMU peer institutions offering IE and/or sustainability degrees, five award these degrees through interdisciplinary environmental departments and three through degree granting programs than span one or more colleges. The NCSE 2012 census of IE and sustainability degree programs indicates these are the two most prevalent degree-granting units for IE and sustainability degrees at large master's institutions (65%); another quarter of programs are offered through traditional departments (Table 35).

Table 35. Location of IE units at large master's institutions

Administration location	Proportion of programs *n*=262
IE Department	27%
Traditional Department	25%
IE College/School/Division	3%
Program Spanning Traditional College(s)	38%
IE Center or Institution	3%
Other*	4%

* Graduate College, Honors College, University Studies, Office of the Provost, Continuing Studies.

One of the key advantages of an IE college, school or degree-granting institute is that it can support an explicitly interdisciplinary environmental faculty while also drawing upon related strengths across the university. An IE college, school or institute can provide the capacity to cope with burgeoning student interest and employer demand for environmental and sustainability education by offering its own interdisciplinary environmental majors as well as general education classes in environmental issues and sustainability for all students; certificates, minors and dual majors for students in disciplinary and professional programs; and continuing education certificates, courses and degree options for career professionals.

Increasing recognition of the importance of IE programs for sustainability-oriented problem solving centered on understanding and managing complex linked environmental, social and economic challenges is leading to a steady stream of new colleges, schools, divisions, institutes and campuses

dedicated to the study of the environment and sustainability. Examples at large master's institutions include the School of Sustainability and the Environment at Chatham University (housed on its own campus), the School of Earth and Environmental Sciences at CUNY-Queens College, the Golisano Institute for Sustainability at the Rochester Institute of Technology, the School of Earth and Environmental Sciences at Chapman University, the Center for Earth and Environmental Science at SUNY-Plattsburg, the Center for Sustainability Studies at Kean University, the Institute for Sustainable Practice at Lipscomb University, the Institute of Environmental Sciences and Sustainability at Wilkes University, the Institute of Environmental Sciences at Creighton University, the College of Environmental Design at California State Polytechnic University-Pomona, the Division of Environmental Science at Stephen F. Austin State University, and the Division of Environmental Studies and Geology at Alfred University.

Representatives of newly instituted interdisciplinary academic units describe the benefits/goals as: (1) the creation of a highly visible academic unit dedicated to the environment that can draw upon related strengths across the university, (2) the ability to offer a variety of interdisciplinary environmental and sustainability educational programs (degrees, dual-degrees, minors, certificates, executive/professional programs); (3) the capacity to support the incorporation of environmental and sustainability content into general education requirements and other degree programs; (4) the capability to facilitate collaborative, interdisciplinary and transdisciplinary research and campus sustainability initiatives, increasing the competitiveness of the faculty in winning funding for interdisciplinary research and education initiatives; and (5) an enhanced ability to work effectively with intercampus and external partners to implement and enhance outreach and applied research programs that serve society and drive economic development.

IE and sustainability schools, colleges and institute/centers exhibit a variety of structures. The School of Sustainability at Arizona State University has eight core interdisciplinary faculty members solely appointed within the school, sixteen with joint appointments in the school and other academic units, and forty affiliated faculty. The School of Natural Resources and Environment (SNRE) at the University of Michigan and the SUNY Southampton campus organize their faculty around interdisciplinary majors rather than by departments or groups. The SNRE also collaborates with other faculty across the institution through a number of Centers of Excellence that expand interdisciplinary research and educational opportunities for students and faculty. The College of Sustainability at Dalhousie utilizes term appointments of faculty (FTE .33-.50, term 3-5 years) from across the university to develop and teach courses for an interdisciplinary major in Environment, Sustainability and Society. Some schools provide a hub for collaborative education programs and research initiatives for faculty tenured in other academic units. Three that share this model are the School for Global Environmental Sustainability at Colorado State University, the Institute for Sustainable Solutions at Portland State University, and the School of Global Sustainability at the University of South Florida. Still others are structured like traditional colleges where the faculty members are organized in departments or divisions. These include the Nicholas School of the Environment at Duke University, the Huxley College of the Environment at Western Washington University, and the College of the Environment at Washington State University.

Two recent articles offer insights on the process of developing an IE school, college or center: (1) "Institutional innovation to deliver post-secondary education for sustainability" provides an in-depth discussion of the process used to create the College of Sustainability at Dalhousie University, and (2) "Transforming knowledge for sustainability: towards adaptive academic institutions" discusses how academic structures can support the production of knowledge for sustainability.[40]

Although each institution structures their unit differently, representatives of newly instituted IE schools, institutes/centers and colleges agree that three key elements must be effectively addressed in implementing a successful new IE school, college or institution spanning center or institute: (1) a shared vision for the unit with support from across the campus, especially from top administrators (including funding support mechanisms), (2) clearly defined procedures for faculty appointments that include specific responsibilities for participating faculty and consideration of tenure and promotion issues (especially for jointly appointed junior faculty), and (3) clearly delineated leadership and reporting responsibilities and roles; a streamlined reporting structure is best.

Expansion of Partnerships that Enhance Educational Opportunities

Nationally, formal external partnerships are increasingly viewed as important venues to provide enhanced and/or unique educational and experiential opportunities for students and faculty. Affiliated and partner organizations contribute to IE program curriculum by providing additional resources and opportunities for students and faculty that include shared educational programs, collaborative research projects, and participation in applied and community-based service learning initiatives.

Students and faculty engage with external partners in a number of ways including participating in shared and specialized educational programs, working on collaborative research projects, conducting service learning and community outreach activities, and taking part in applied learning experiences through fieldwork and internships.

An emerging trend is innovative campus-community sustainability partnerships. An example is the University of Oregon and Portland State University Sustainable Cities Initiative. Over the course of a year, courses from a variety of departments and programs work collaboratively on sustainability-oriented projects. Another example is the Community Sustainability Partnership formed by three local higher education institutions—Grand Valley State University, Aquinas College and Grand Rapids Community College—and the City of Grand Rapids. The concept has expanded to include two hundred partner organizations, ten academic institutions and eight communities. Grand Valley State also has an campus-community partnership with an international focus—the Applied Global Innovation Initiative.

Academic institutes and centers are also increasingly participating in a variety of internal campus and external campus-public-private partnerships. The University of Michigan provides an example of an institution that coordinates and supports research and educational programs via two sustainability institutes in conjunction with the School of Natural Resources and Environment, the undergraduate

[40] Buszard, D. and J. Kolb. 2011. Institutional innovation to deliver post-secondary education for sustainability. *Sustainability: The Journal of Record* 4(2):80-84. Miller T., Mũnoz-Erickson, T. and C. Redman. 2011. Transforming knowledge for sustainability: toward adaptive academic institutions. 2011. *International Journal of Sustainability in Higher Education* 12(2):177-192.

Program in the Environment and other academic units across campus. The ERB Institute for Global Sustainability Enterprise and the Graham Sustainability Institute provide a variety of research, learning and skills development opportunities for students and faculty. Both facilitate collaborative research and applied initiatives across campus and with external partners, but they also integrate educational opportunities for both undergraduate and graduate students.

The ERB Institute offers an undergraduate course on Global Enterprise and Sustainable Development and is actively developing additional undergraduate courses and action-based learning experiences. The Institute also provides undergraduate student scholarships to support experiential experiences. At the graduate level, the Institute coordinates an MBA/MS program focused on Global Sustainable Enterprise which involves a blend of coursework, projects and research related to business, the environment, and sustainability. Students enrolled in the three-year program earn two degrees: a Master of Business Administration from the Stephen M. Ross School of Business, and a Master of Science from the School of Natural Resources & Environment. The Institute also works closely with doctoral students from the School of Natural Resources and Environment.

The Graham Sustainability Institute oversees an interdisciplinary Doctoral Fellowship program, a new 10-credit Undergraduate Sustainability Scholars Program, the Student Sustainability Initiative, and the university's Sustainability Courses and Faculty Databases. It fosters professional education, public outreach, and scientific scholarship to support the development of leaders and change agents in moving societies toward more sustainable futures.

Innovative Assessment/Professional Development Processes

There is an apparent correlation between assessment and program success at JMU—the programs using the most assessment tools and providing the most student professional development services tend to be the most successful in terms of enrollment—the Environmental Studies minor, the Geographic Science: ECSD and Integrated Science and Technology: ENV concentrations, and the Sustainable Engineering Design program.

Many IE programs are using new forms of assessment tools that include advisory groups, structured student portfolios evaluated by the students and faculty in an ongoing process, and research processes that formally assess alumni survey responses to align curricula to better serve the needs of graduates in the workforce.[41] Portfolios can be very useful tools for both IE students and programs by providing a roadmap for developing an interdisciplinary plan of study that meets each individual student's goals, providing evidence of the student's progress in growth in competence and skills, demonstrating professional accomplishment to prospective employers, and serving as an important assessment tool. Internal (representatives from relevant units across the campus, students) and external advisory groups (partner organizations, alumni, employers, governmental representatives) can also serve as important partners in evaluating and revising curricula to ensure relevance to workforce needs and students' interests.

[41] Wright, W., Knight, P., and N. Pomerleau. 1999. Portfolio people: teaching and learning dossiers and innovation in higher education. *Innovations in Higher Education* 24(2):89-103. Also see the portfolio process used by the Oklahoma State University Environmental Science Graduate Program. Hansmann, R. 2009. Linking the components of a university program to the qualifications profile of its graduates. *Journal of Research in Science Teaching* 46(5):537-569.

Section VIII - NCSE Affiliate Member Benefits and Resources

The National Council for Science and the Environment has been working since 1990 to improve the scientific basis for environmental decision-making. We envision a society where environmental decisions are based on an accurate understanding of the underlying science, its meaning and limitations, and the potential consequences of action or inaction.

NCSE specializes in bringing together the communities creating and using environmental knowledge, including research, education, environmental and business organizations, as well as governmental bodies at all levels. While an advocate for the use of science, NCSE does not take positions on environmental outcomes. NCSE operates programs in five strategic areas: Strengthening Education and Careers; Communicating Science to the Public; Organizing the National Conference on Science, Policy and the Environment; Providing Science Solutions; and Advancing Science Policy at the National Level.

The NCSE is dedicated to:

- Supporting the advancement of degree-granting environmental programs on the nation's campuses;
- Promoting federal funding for environmental and energy research and education at colleges and universities;
- Educating policymakers and the public about the value of environmental science to society;
- Providing objective, science-based information through the online *Encyclopedia of Earth*, a comprehensive resource developed by an international collaboration of experts; and
- Facilitating solution-oriented collaborations among scientists, educators, policymakers, and corporate and civic leaders through NCSE events and programs.

Exclusive benefits for NCSE Affiliates and resources for environmental faculty and students include:

The National Conference on Science, Policy and the Environment. The NCSE convenes an annual national conference that brings together more than 1,000 academic, government, business, science, and civil society leaders to address a global environmental challenge. The 13th National Conference on Science, Policy and the Environment, "Environmental Disasters: Science, Preparedness and Resilience," will be held January 15-17, 2013, in Washington, DC. The conference will address the increasing occurrence of environmental disasters and the science, technology, and decision making needed to more effectively prepare, respond and make our communities more resilient. University Affiliate schools receive free conference registrations for up to five faculty or students (valued at $495 per participant). Faculty and students will have the opportunity to organize a symposium or workshop as well as participate in poster sessions and an exhibition. The conference offers exceptional networking opportunities and student mentoring tables at the luncheon. **www.environmentaldisasters.net**

Council of Environmental Deans and Directors. A premier benefit of University Affiliate membership is representation on NCSE's Council of Environmental Deans and Directors (CEDD)—the organization for environmental program leaders. The Council of Environmental Deans and Directors (CEDD) works to advance the quality and effectiveness of environmental education and scholarship on the nation's campuses. Each University Affiliate school designates a representative to serve on CEDD. The group

currently includes more than 160 members representing academic environmental programs of all sizes and types. CEDD supports improved management of academic programs, promotes leadership development, and facilitates collaborative program opportunities. Government agencies, national and international organizations, and business groups seek out CEDD as a gateway to working with the academic environmental community and accessing its expertise.

The CEDD meets twice annually. The 2012 Summer Meeting, "Leadership of Diverse Environmental Programs," will be held June 18-20, 2012, in San Jose, California. The Winter Meeting will be held January 18, 2013, in Washington, DC. These meetings are exclusive to CEDD representatives. **www.ncseonline.org**

Council of Energy Research and Education Leaders. The Council of Energy Research and Education Leaders (CEREL) is an organization for the leaders of academic energy research and education centers, institutes, and programs. It provides the means for leaders in energy research, education, and communication to collaboratively use knowledge about energy to improve education, decision-making, and, more generally, the well-being of society. The Association of Public and Land-grant Universities is a collaborating partner in CEREL and will assists with government relations and other services. **www.ncseonline.org**

Research on Interdisciplinary Environmental and Sustainability Education Programs and Program Graduates. The NCSE conducted the first landmark study of interdisciplinary environmental and sustainability programs in the United States. The initial census, survey and analysis of findings revealed important insights into the environmental education landscape in the United States. The results, published in 2010, have been used by hundreds of colleges and universities to enhance their environmental programs. A new census, survey and analysis are being conducted in 2012. Findings to date indicate a large increase in the number of IE programs and growth in sustainability programs from a handful to over one hundred today. NCSE Affiliate institutions receive a trends report on the census results, a summary of the finding and analysis of the survey and have exclusive access to the census data and discounted customized analysis and program evaluation services. The CEDD also conducts an annual survey of IE program graduates to learn more about their career preparation, pathways and plans for the future. **www.ncseonline.org**

Funding for Environmental Research and Education. Member institutions benefit from NCSE's connections with federal officials and funding agencies. The NCSE is a leading national voice in support of extramural funding for environmental science and assists its member universities in competing for these resources. Through NCSE events faculty have the opportunity to engage with federal officials regarding agency program priorities and funding opportunities. Currently, NCSE is partnering with more than 20 member universities on major grant proposals to the National Science Foundation (NSF) and other agencies. **www.ncseonline.org**

Handbook of Federal Funding for Environmental R&D. NCSE affiliate members receive exclusive access to the *Handbook of Federal Funding for Environmental R&D.* The handbook provides a comprehensive survey of $10 billion in federal funding, including budget tables, programmatic descriptions, and hyperlinks to federal environmental programs and funding opportunities. **www.ncseonline.org**

Free Online Subscriptions to Leading Environmental and Energy Publications. Member schools receive complimentary campus-wide subscriptions to E&E Publishing's *E&E Daily, Greenwire, Land Letter,* and *E&ENews PM*—leading online publications on environment and energy news, policy, and politics. These highly regarded publications provide timely and objective coverage of today's critical issues, including climate policy, energy, air and water quality, public lands, agriculture, technology, and markets. The subscriptions are valued at $4,000 for educational institutions. **www.ncseonline.org**

Interdisciplinary Hiring, Tenure and Promotion: Guidance for Individuals and Institutions. A special report authored by CEDD members, offers guidance on dealing with the entire pre- and post-tenure experience. **www.ncseonline.org**

The Encyclopedia of Earth. A free, fully searchable online resource on the Earth, its natural environments, and their interaction with society. A global community of over 1,400 scholars, educators and professionals from 60 countries collaborate to produce quality and reliable environmental information for the web. Information includes articles, books, reports and curriculum resources that are written in non-technical language and available in various media formats, which are accessible and useful to students, educators, professionals, and policy makers as well as the general public. **www.eoearth.org**

Climate Adaptation and Mitigation E-Learning Initiative (CAMEL). A free, comprehensive, interdisciplinary, multi-media resource for educators to teach, create and share curricular resources on climate change. CAMEL provides syllabi, teaching modules, lab and field exercises, lectures, and case studies, among other resources, to assist in teaching about climate change. Free weekly seminars are held on specific curricular resources. **www.camelclimatechange.org**

Environmental Internship Clearing House. The new online environmental internship clearinghouse provides hundreds of environment-related internship opportunities throughout the year. The clearinghouse features internships at federal agencies, such as the USDA, NASA, and the National Park Service, nonprofits such as National Wildlife Federation and Environmental Law Institute, and businesses. **www.environmentalinterns.org**

Appendix A – NCSE Study: Methodology

The NCSE IE programs study addressed four broad research questions designed to inform and facilitate discussion on IE program field identity and essential knowledge and skills:

1. What are the perspectives among IE program leaders regarding curriculum design? What do they have in common and how do they differ?
2. What dimensions underlie the inclusion of various knowledge and skill areas in IE program curricula? How are these areas related and how may they be combined into interdisciplinary knowledge and skills areas?
3. What types of ideal models of IE program curricula exist? What are the characteristics of each model?
4. How are administrative and degree program attributes related to ideal curriculum types? What do these relationships indicate concerning program structure and evolution?

A combination of qualitative and quantitative statistical methods were used to answer these questions including: qualitative emergent theme analysis, Q methodology, multiple regression, maximum likelihood factor analysis, principal components analysis, SPSS two-step cluster analysis, Ward's cluster analysis, discriminant analysis, analysis of variance (ANOVA) and Kruskal-Wallis analysis of variance by ranks (KWANOVA).

The study was conducted in two phases: (1) an initial online survey and Q methodology analysis with a sample comprised of 61 NCSE Council of Environmental Deans and Directors (CEDD) members, and (2) a nationwide online survey and data analysis with a sample of 260 IE program administrators representing IE programs awarding 343 degrees (see the list of participating institutions and programs for both phases of the study in Appendix B).

Phase I – Perspectives on Interdisciplinary Environmental Program Curricula

The first phase of the curriculum study sought to answer the first research question about the number of perspectives on environmental program curriculum design that program administrators hold, how these perspectives differ, and what they have in common.

Q methodology is a technique for systematically revealing subjects' perspectives. It has been used widely as a research tool for empirically determining the perspectives of participants in a variety of policy development and decision-making processes. It can be used to identify various viewpoints and perceptions about a particular situation, provide insight into the attributes of each perspective, explicitly outline areas of consensus and conflict, and assist in developing a common view. This method was used to discern the various perspectives regarding environmental program curriculum design held by the administrators of IE programs at institutions that participate in the CEDD.

The Q methodology study was conducted in three steps: (1) an online survey to obtain individuals' opinions on curricular design and program characteristics, (2) an online Q sorting exercise to ascertain individual and community perspectives on curricular design and to assess conflicts and characterize the nature of debate, and (3) data analysis to investigate relationships between the perspectives and IE program attributes (multiple regression, descriptive statistics).

Sample. This first phase of the study was conducted in 2003 with volunteer participants from the CEDD membership who identified themselves as administrators of IE programs. Respondents included 61 CEDD members representing IE programs at 57 institutions of higher education. A subset of the respondents—44 CEDD members representing 42 institutions—participated in the Q sorting exercise.

The representativeness of the sample was assessed by comparing four defining program attributes between the Q survey sample and the national survey target population at $\alpha=0.05$ (two-tailed test): institution control (public or private-not-for-profit), institution basic Carnegie classification category,[42] institution location (U.S. census division), and program degree type (name/level). The sample was found to be representative for all four parameters.

Phase II - National Survey of Interdisciplinary Environmental Programs

The second phase of the curriculum study was designed to answer the remaining three research questions: (1) the identity of the dimensions that underlie the inclusion of knowledge and skill areas in IE program curricula, (2) the number and characteristics of ideal curricular models for IE education; and (3) how administrative and degree program attributes may be related to the ideal curriculum types and what these relationships indicate concerning program structure and evolution.

This phase of the study was conducted in three steps: (1) identification of all U. S. programs awarding baccalaureate and graduate level IE degrees, (2) an online survey to obtain IE program administrators' views on program structure and curriculum design, and (3) data analyses appropriate for each of the three research questions.

Several statistical methods were used to analyze the data gathered by the survey. First, descriptive statistics appropriate to each question were calculated and responses to the open-ended questions coded according to emergent themes. Second, exploratory factor analysis (maximum likelihood method) was used to determine the factors (dimensions) underlying the importance ratings of 16 knowledge areas and 23 skills in ideal IE program curricula. Third, principal component analysis followed by SPSS two-step method cluster analysis was used to reveal groups of administrators who prefer similar ideal curricular models. Fourth, discriminant analysis was used to confirm the cluster solution and aid in interpretation of the results. Finally, two types of analysis of variance tests were used to explore relationships among the three ideal curriculum models, the IE knowledge and skill factors, and other program and degree program features: one-way analysis of variance (ANOVA) for scale variable data and Kruskal-Wallis one-way analysis of variance by ranks (KWANOVA) for ordinal and categorical variable data. The significance level was set at $\alpha=0.05$ for all analyses.

Sample. The online survey of U.S. interdisciplinary environmental program administrators was conducted during January-May 2008. Program administrators were targeted because not only are they expected to be most familiar with their programs but also because fewer than half of IE programs have their own faculty.

[42] The Carnegie Foundation for the Advancement of Teaching Basic Carnegie Classification is a framework developed by the foundation for classifying higher education institutions. For more information see http://classifications.carnegiefoundation.org/.

The survey was limited to U. S. baccalaureate and graduate degree-granting programs that focus on the human-nature interface from a broad interdisciplinary perspective. This population included all degree programs named environmental science(s) or environmental studies as well as other broadly interdisciplinary IE degree programs with names such as sustainability, environmental policy, environmental management and natural resources management.

The survey sample excluded degree programs that offer: (1) only associate degrees, minors or certificates, (2) professional degrees in allied fields such as environmental engineering, environmental law, environmental health and safety, and (3) other discipline-oriented degrees in environmental fields such as environmental chemistry/toxicology, environmental geology/hydrology, conservation biology, sustainable agriculture, forestry/rangeland management, environmental economics, or environmental statistics.

Several sources were used to identify institutions hosting programs that met the survey population criteria. An initial list was generated from a search of the U. S. Department of Education Integrated Postsecondary Data System (IPEDS at http://nces.ed.gov/ipeds/) to identify institutions that granted at least one degree in selected Classification of Instructional Programs (CIP) areas during 2002-2006. The program areas selected from the CIP schema developed by the National Center for Education Statistics were: 03.0103 Environmental Studies (new in 2003), 03.0104 Environmental Science (new in 2003), 03.0102 Environmental Science/Studies (replaced in 2003), 03.0101 Natural Resources/Conservation, General, and 03.0201 Natural Resources Management and Policy.

Additional sources were used to supplement the initial IPEDS-generated list because: (1) the available CIP areas do not accurately reflect the content and/or the range of IE programs, (2) all 4-year institutions do not provide data to the IPEDS system (only those that participate in the federal financial assistance programs are required to participate), and (3) the accuracy of the data is unclear (the institutional representative assigned with completing the IPEDS survey may not understand how the CIP areas align with their institution's degree programs).

The five additional sources used were: (1) the 2007 Council of Environmental Deans and Directors membership list, (2) survey data from the online report "Not all are created equal: an analysis of the environmental programs/department in U.S. academic institutions from 1900 until May 2005," (3) institutions that participated in a American Association for the Advancement of Science (AAAS) sustainability program survey, (4) programs at institutions listed in the Association for the Advancement of Sustainability in Higher Education's AASHE Digest 2006, and (5) searches for environmental undergraduate and graduate programs listed in Peterson's guide.

The selection of programs not named environmental science or environmental studies for inclusion or exclusion in the survey population required the subjective judgment of the researcher. Decisions were based upon an examination of the descriptive information and degree requirements provided on program websites and in course catalogs. Following review of institution and program websites, a total

of 840 IE programs at 652 institutions awarding 1183 degrees were identified as meeting the selection criteria (the census was conducted in fall 2007).[43]

Completed survey responses were received from administrators of 260 of the 840 programs (addressing 343 degrees)—a response rate of 31% (see the list of participating institutions at the end of the report). This sample was sufficient to measure correlations between attributes with a power of 0.90 to detect a 0.20 (moderate) effect at $\alpha=0.05$; statistical frequencies have a margin of error of ±5%. See Appendix B for a list of participating institutions and programs.

The representativeness of the sample was assessed by comparing four defining program attributes between the sample and target population at $\alpha=0.05$ (two-tailed test): institution control (public or private-not-for-profit), institution basic Carnegie class, institution location (U.S. census division), and program degree type (name/level). The sample was found to be representative for all four parameters.

***Exploratory Factor Analysis*.** Exploratory (maximum likelihood method) factor analysis was used to explore administrators' judgments of the importance (using a 4-point Likert scale from minimal, to low, to moderate, to high) of 16 knowledge areas and 23 skills in an ideal curriculum for each degree offered (these knowledge areas and skills were vetted by program administrators at a workshop conducted before the survey was administered). A total of 308 knowledge and 304 skill sets were obtained for analysis. Factor analysis reduced the thirty-nine knowledge and skill ratings into dimensions representing groups of similarly rated sets. These factors represent potential broad interdisciplinary core competency areas and reveal how the disciplinary knowledge areas and skills are related to each other in idealized IE program curricula.

Maximum likelihood factor extraction was used because it includes a statistical goodness-of-fit test and allows generalizations from an unbiased sample to a population of either subjects or variables. The validity of the factor structure and model is established by the maximum likelihood goodness-of-fit test and by testing the reliability of each factor using Cronbach's alpha reliability coefficient (value ≥ 0.7 indicates that the variables loading on the factor are sufficiently similar). Model goodness-of-fit tests for both the knowledge factor solution and skill factor solution are highly significant at $p<0.001$; all of the factors were shown to be reliable.

Five criteria can be considered when determining the number of factors to retain for interpretation. All five criteria were evaluated; the popular Kaiser criterion was selected, which recommends retaining all factors with eigenvalues ≥ 1.

Factor rotation is used to simplify data structures by rotating factor axes so that the variables are loaded maximally on only one factor (minimizes unexplained variance). Orthogonal rotation maintains factor independence while oblique rotation allows factors to correlate. Oblique rotation should be used if factors are believed to be related. Since it was suspected that some knowledge and skills factors are related, an oblique (Promax) rotation method was employed for the primary analysis and then compared the results to an orthogonal (Varimax) rotation.

[43] For additional information on the survey sample selection see Vincent, Shirley. 2010 A Search for Identity: Exploring Core Competencies for Interdisciplinary Environmental Programs. PhD diss., Oklahoma State University.

The meaning of each factor is interpreted using factor loadings. A factor loading is the Pearson correlation coefficient of the original variables (in this study, the importance ratings of knowledge and skill areas) with a factor. Factor loadings indicate an association of the variable with a factor and ranges from 1 (perfect positive association) to -1 (perfect negative association). The relative importance of each variable is indicated by the magnitude of the squares of the factor loadings. In social science research 0.32 is cited as a conservative value for the minimum loading of a variable on a factor because it equates to approximately 10% overlapping variance. This value was used as the critical value for this study.

Cluster Analysis. Principal component analysis, followed by SPSS two-step clustering method was used to identify groups of program administrators who prefer similar ideal curriculum models. Cluster analysis is used to combine or classify objects into groups using a predetermined selection criterion. The resulting clusters will exhibit high internal (within cluster) homogeneity and high external (between-cluster) heterogeneity. It allows the researcher to cluster cases into similar groups.

In cluster analysis, multicollinearity results in a weighting process that affects the analysis; multicollinear variables are implicitly weighted more heavily. Since several of the importance-rated variables exhibited multicollinearity, principal components analysis was used to group similarly rated variables prior to clustering. Reducing the original importance rating variables into sets of knowledge and skill components eliminated multicollinearity while retaining all variables and their variances in the analysis.

The SPSS two-step method was selected as the most appropriate clustering method for this study because of the characteristics of the clustering algorithm and because it provides statistical and graphical outputs that aid interpretation.

Because cluster analysis involves a subjective judgment on an optimal cluster solution, it is important to validate the solution. Four methods were used to insure the validity and practical significance of the results. First, the sample was randomly split into two groups and the results compared. Second, two different clustering algorithms (SPSS two-step method and Ward's method) were used and the results compared. Third, descriptive discriminant analysis was used to test the fidelity of cluster membership using the original importance rating variables. The discriminant analysis revealed 94% of the cases were correctly classified and that two dimensions that separate the clusters; both are highly significant predictors at $p<0.001$. Fourth, analysis of variance tests were conducted using program attribute variables to demonstrate significant differences between clusters. A number of significant differences in degree program attributes between the clusters were evident.

Appendix B – Participating Institutions and Programs

n=264 institutions, 286 programs
*Institutions/programs participating in both phases, ** institutions/programs participating in phase I only

Institution	State	Program name
Abilene Christian University	TX	Environmental Science Program
*Adelphi University	NY	Environmental Studies Program
*Alabama A&M University	AL	Environmental Science Program
Albright College	PA	Environmental Science and Studies Program
Alderson-Broaddus College	WV	Environmental Science Program
Alfred University	NY	Environmental Studies Program
*Allegheny College	PA	Department of Environmental Science
Anna Maria College	MA	Environmental Science Program
*Antioch University-New England	NH	Department of Environmental Studies
Aquinas College	MI	Environmental Science Program
Arkansas State University	AR	Environmental Science Graduate Program
Austin College	TX	Center for Environmental Studies
**Ball State University	IN	Department of Natural Resources & Environmental Management
**Bard College	NY	Environmental Policy Program
Barnard College	NY	Environmental Science Program
Bates College	ME	Environmental Studies Program
*Baylor University	TX	Department of Environmental Studies
Beloit College	WA	Environmental Studies Program
**Benedict College	SC	Environmental Health Science Program
Benedictine University	IL	Environmental Science Program
Bethany College	WV	Environmental Science Program
Boise State University	ID	Master of Public Administration-Natural Resources and Environmental Policy and Administration Program
**Bowdoin College	ME	Environmental Studies Program
Bowling Green State University	OH	Department of the Environment and Sustainability
Briar Cliff University	IA	Environmental Science Program
Brigham Young University	UT	Environmental Science Program
Bucknell University	PA	Environmental Studies Program
California Polytechnic State University-San Luis Obispo	CA	Forestry and Natural Resources and Environmental Management and Protection Programs
California State University-Channel Islands	CA	Environmental Science and Resource Management Program
California State University-East Bay	CA	Environmental Science Program
California State University-Long Beach	CA	Environmental Science and Policy Program
California State University- Monterey Bay	CA	Environmental Science, Technology and Policy Program

California State University- Sacramento	CA	Environmental Studies Program
California State University-San Bernardino	CA	Environmental Science Program
Canisius College	NY	Environmental Science Program
Carroll College	WI	Environmental Science Program
Castleton State College	VT	Environmental Science Program
**Catholic University of America	DC	Environmental Studies Program
Clark University	MA	Environmental Science and Policy Graduate Program, Department of International Development, Community and Environment
*Clemson University	SC	Environmental and Natural Resource Program
Cleveland State University	OH	Environmental Science Program
Cleveland State University	OH	Environmental Studies Program
Colby College	ME	Environmental Studies Program
Colby-Sawyer College	NH	Department of Environmental Studies
**Colgate University	NY	Environmental Studies Program
College of Charleston	SC	Environmental Studies Program
College of Saint Benedict/Saint John's University	MN	Environmental Studies Department
College of the Atlantic	ME	Graduate Program in Human Ecology
College of William and Mary	VA	Environmental Science and Policy Program
Colleges of the Fenway Consortium	MA	Joint Environmental Sciences Program
Colorado College	CO	Environmental Science Program
Columbia College	MO	Environmental Studies Program
Columbia University	NY	Master of Public Administration-Environmental Science and Policy Program
Concordia University at Austin	TX	Environmental Science Program
Cornell University	NY	Natural Resources Program
Cornell University	NY	Biology and Society Program
Cornell University	NY	Science of Natural and Environmental Systems Program
CUNY (City University of New York) Brooklyn College	NY	Environmental Studies Program
CUNY Hunter College	NY	Environmental Studies Program
Davis & Elkins College	WV	Environmental Science Program
Delaware State University	DE	Environmental Science Program
Doane College	NE	Environmental Science Program
Duke University	NC	Environmental Sciences and Policy Program
*Duquesne University	PA	Environmental Science, Management and Policy Programs
Eckerd College	FL	Environmental Studies Program
Elizabethtown College	PA	Environmental Science Program
Elmira College	NY	Environmental Studies Program
Evergreen State College	WA	Environmental Studies Program
Evergreen State College	WA	Graduate Program on the Environment
Ferrum College	VA	Environmental Science Program
*Florida Agricultural and Mechanical University	FL	Environmental Sciences Undergraduate Program

*Florida Agricultural and Mechanical University	FL	Environmental Sciences Graduate Program
**Florida Atlantic University	FL	Environmental Sciences Program
Florida Gulf Coast University	FL	Environmental Sciences Graduate Program
Florida Southern College	FL	Biology-Environmental Studies Program
Franklin Pierce University	NH	Environmental Science and Studies Programs
Fresno Pacific University	CA	Environmental Science and Studies Program
**Frostburg State University	MD	Environmental Analysis and Planning Program
Green Mountain College	VT	Natural Resources Management Program
Green Mountain College	VT	Environmental Studies Masters Program (Online)
Guilford College	NC	Environmental Studies Program
Gustavus Adolphus College	MN	Environmental Studies Program
Hamilton College	NY	Environmental Studies Program
Hampton University	VA	Marine and Environmental Science Program
Hardin-Simmons University	TX	Environmental Science Program; Environmental Management Graduate Program
**Hendrix College	AR	Environmental Studies Program
**Howard University	DC	Environmental Studies Program
*Humboldt State University	CA	Environmental Science & Natural Resources Planning & Interpretation Programs
Illinois Institute of Technology	IL	Environmental Management Program
Indiana University-Bloomington	IN	Environmental Science Graduate Program
*Indiana University-Northwest	IN	School of Public and Environmental Affairs
**Inter-American University of Puerto Rico	PR	Environmental Science Program
*Iowa State University	IA	Biorenewable Resources and Technology Interdepartmental Graduate Program
Ithaca College	NY	Environmental Studies Program
**Kentucky State University	KY	Agricultural and Environmental Science Program
Kings College	PA	Environmental Program in Biology
Lambuth University	TN	Environmental Science and Environmental Studies Program
Lehigh University	PA	Environmental Initiative
*Lewis & Clark College	OR	Environmental Studies Program
Lewis University	IL	Environmental Science Program
**Linfield College	OR	Environmental Studies Program
Lipscomb University	TN	Sustainability and Environmental Studies Program
Louisiana State University- Shreveport	LA	Environmental Science Program
Loyola University Chicago	IL	Environmental Science/Studies Program
Lynchburg College	VA	Environmental Science Program
*Macalester College	MN	Environmental Studies Department
Manchester College	IN	Environmental Studies Program
Marist College	NY	Environmental Science and Policy Program
Maryville College	TN	Environmental Studies Program
Meredith College	NC	Environmental Studies Program

Mesa State College	CO	Environmental Science and Technology
Messiah College	PA	Environmental Science and Studies Program
**Michigan State University	MI	Environmental Science and Policy Program
Michigan Technological University	MI	Environmental Policy Program
Michigan Technological University	MI	Applied Ecology and Environmental Sciences Program
Midland Lutheran College	NE	Environmental Science Composite Program
Montana State University-Billings	MT	Environmental Studies Program
Moravian College	PA	Environmental Studies Program
**Morgan State University	MD	Bio-environmental Sciences Doctoral Program
New York University	NY	Environmental Studies Program
**North Carolina A&T State University	NC	Plant, Soil and Environmental Science Program
**North Carolina State University	NC	Environmental Technology, Natural Resources, and Environmental Science Programs
North Carolina Wesleyan College	NC	Environmental Science Program
Ohio State University	OH	Environmental Science Graduate Program
Ohio University	OH	Environmental Studies Program
*Oklahoma State University	OK	Environmental Science Graduate Program
Olivet College	MI	Environmental Science Program
Oregon Institute of Technology	OR	Environmental Sciences Program
*Oregon State University	OR	Water Resources Graduate Program
Otterbein College	OH	Environmental Science Program
Our Lady of the Lake University of San Antonio	TX	Environmental Science Program
Pace University-New York	NY	Environmental Science Program
Pace University-New York	NY	Environmental Studies Program
Pacific University	OR	Environmental Studies Program
Pennsylvania State University	PA	Environmental Resource Management Program
Piedmont College	GA	Environmental Science Program
Principia College	IL	Biology and Natural Resources
*Purdue University	IN	Natural Resources and Environmental Science Program
Ramapo College of New Jersey	NJ	Environmental Studies Program
Randolph College	VA	Environmental Science and Studies Programs
Rider University	NJ	Environmental Science Program
Roanoke College	VA	Environmental Science and Policy Programs
Rochester Institute of Technology	NY	Environmental Science Program
Roger Williams University	RI	Environmental Science Program
Rollins College	FL	Environmental Studies Program
Salisbury University	MD	Environmental Issues Program

San Francisco University	CA	Geography-Resource Management and Environmental Planning Program
Santa Clara University	CA	Environmental Science and Studies Programs
Shenandoah University	VA	Environmental Studies Program
Sierra Nevada College	NV	Environmental Science and Policy Programs
Simmons College	MA	Environmental Science Program
Simons Rock College of Bard	MA	Environmental Studies Program
Skidmore College	NY	Environmental Studies Program
**Smith College	MA	Environmental Science and Policy Program
Southern Illinois University- Edwardsville	IL	Environmental Science Graduate Program
Southern New Hampshire University	NH	Environment, Ethics and Public Policy Program
**Spelman College	GA	Environmental Science and Studies Program
St. Anselm College	NH	Environmental Science Program
St. Edwards University	TX	Environmental Science and Policy Program
St. Lawrence University	NY	Environmental Studies Program
St. Louis University	MO	Environmental Science Program
St. Mary-of-the-Woods College	IN	Earth Literacy Graduate Program
St. Olaf College	MN	Environmental Studies Program
St. Vincent College	PA	Environmental Science Program
*SUNY at Binghamton	NY	Environmental Studies Program
SUNY at Buffalo	NY	Environmental Studies Program
SUNY College at Fredonia	NY	Environmental Science Program
*SUNY College at New Paltz	NY	Environmental Geochemical Science Program
SUNY College at Oneonta	NY	Environmental Sciences Program
SUNY College at Plattsburgh	NY	Environmental Science and Studies Program
SUNY College at Purchase	NY	Environmental Studies Program
SUNY College of Environmental Science and Forestry	NY	Department of Environmental Studies
SUNY Potsdam	NY	Environmental Studies Program
Tarleton State University	TX	Environmental Science Program
Taylor University	IN	Environmental Science Program
Tennessee Technological University	TN	Environmental Sciences Doctoral Program
*Texas A&M University	TX	Environmental Programs in the College of Geosciences
Texas A&M University-Corpus Christi	TX	Master of Public Administration-Environmental Science Program
The Richard Stockton College of New Jersey	NJ	Environmental Studies Program
Thiel College	PA	Environmental Sciences Program
*Towson University	MD	Environmental Science Graduate Program
Towson University	MD	Environmental Science and Studies Program
Trinity College	CT	Environmental Science Program
*Tufts University	MA	Urban and Environmental Policy and Planning Program
United States Military Academy	NY	Environmental Science Program
Unity College	ME	Environmental Analysis Program
Universidad Del Turabo	PR	Environmental Sciences Graduate Programs

University of Arkansas	AR	Environmental, Soil and Water Science Program
University of Arkansas	AR	Environmental Dynamics Doctoral Program
*University of California-Davis	CA	Environmental Science and Policy Department
University of California-Davis	CA	Environmental and Resource Sciences Program
University of California-Irvine	CA	Earth and Environmental Science Program
University of California-Riverside	CA	Environmental Sciences Graduate Program
University of California-San Diego	CA	Environmental Systems Program
University of California-Santa Cruz	CA	Environmental Studies Program
**University of Connecticut	CT	Environmental Science Program
University of Colorado-Boulder	CO	Environmental Studies Program
University of Colorado-Colorado Springs	CO	Geography and Environmental Studies Program
University of Evansville	IN	Environmental Studies Program
*University of Florida	FL	Natural Resource Conservation Program
*University of Florida	FL	Environmental Management in Agriculture and Natural Resources Program
**University of Georgia	GA	Agricultural and Environmental Sciences Program
University of Idaho	ID	Environmental Science Program
*University of Illinoi-Champaign Urbana	IL	Natural Resources and Environmental Sciences Program
University of Illinois-Springfield	IL	Environmental Science and Studies Graduate Program
University of Indianapolis	IN	Environmental Sciences Program
University of Kentucky	KY	Natural Resource Management and Conservation Program
University of Maine	ME	Aquaculture, Marine Science, Oceanography, Marine Biology, Marine Policy, Dual M.Sc. in Marine Policy and Marine Sciences
University of Maine	ME	Ecology and Environmental Sciences Program
University of Maine	ME	Quaternary & Climate Studies Programs
University of Maine-Farmington	ME	Environmental Planning and Policy Program
University of Maine-Presque Isle	ME	Environmental Studies Program
*University of Maryland-College Park	MD	Environmental Policy Program
*University of Massachusetts-Amherst	MA	Environmental Sciences Program
University of Massachusetts- Amherst	MA	Natural Resources Studies Program, Forest Resources Graduate Program
University of Massachusetts-Boston	MA	Earth and Geographic Science and Environmental Sciences Graduate Programs
University of Massachusetts-School of Marine Sciences	MA	Marine Sciences and Technology Program
University of Miami	FL	Marine and Atmospheric Science Program
University of Michigan-Ann Arbor	MI	Program in the Environment
University of Michigan-Dearborn	MI	Environmental Studies
University of Minnesota-Twin Cities	MN	Science, Technology and Policy Masters Program
University of Minnesota-Twin Cities	MN	Environmental Science, Policy and Management Program
University of Minnesota - Twin Cities	MN	Water Resources Science Graduate Program
University of Montana-Missoula	MT	Environmental Studies Program
University of Montana-Western	MT	Environmental Sciences and Environmental Interpretation Programs
University of Nebraska-Lincoln	NE	Environmental Studies Program
University of Nebraska-Lincoln	NE	Water Science Program

University of Nevada-Las Vegas	NV	Department of Environmental Studies
University of New England	ME	Environmental Science and Studies Programs
University of New Hampshire	NH	Environmental Science Program
University of New Hampshire	NH	Natural Resources and Earth Systems Science Doctoral Program
University of New Mexico	NM	Environmental Science Program
University of New Mexico	NM	Water Resources Program
University of North Carolina-Pembroke	NC	Environmental Science Program
University of North Carolina-Wilmington	NC	Environmental Studies Programs
University of North Dakota	ND	Environmental Geography Program
**University of North Texas	TX	Environmental Science Program
University of Northern Iowa	IA	Environmental Geography Program
University of Pennsylvania	PA	Environmental Studies Program
University of Pittsburgh-Johnstown	PA	Environmental Studies Program
University of Pittsburgh	PA	Environmental Studies Program
University of Portland	OR	Environmental Studies Program
**University of Redlands	CA	Environmental Science, Environmental Studies and Environmental Management Programs
University of Rhode Island	RI	Environmental Economics and Management Program
University of Rhode Island	RI	Environmental Science and Management, Wildlife and Conservation Biology
University of Rio Grande	OH	Environmental Science Program
University of Rochester	NY	Environmental Science and Studies Programs
**University of Scranton	PA	Environmental Science Program
**University of South Carolina-Columbia	SC	School of the Environment
*University of Southern California	CA	Environmental Studies Program
*University of St. Francis-Joliet	IL	Environmental Science Program
University of St. Thomas	TX	Environmental Science and Studies Program
University of St. Thomas	MN	Environmental Studies Program
University of Tennessee	TN	Environmental and Soil Sciences Program
University of Texas-Arlington	TX	Environmental and Earth Sciences Program
*University of Texas-Austin	TX	Sustainable Design Program
University of Texas-El Paso	TX	Environmental Science and Engineering Doctoral Program
University of Texas-El Paso	TX	Environmental Science Program
University of the Pacific	CA	Environmental Studies Program
*University of Tulsa	OK	Environmental Policy Program
University of Vermont	VT	Environmental Sciences Undergraduate Program
University of Virginia	VA	Urban and Environmental Planning Program
University of Washington-Seattle	WA	Program on the Environment
University of Washington-Tacoma	WA	Environmental Science Program
University of West Georgia	GA	Environmental Science and Studies Program
University of Wisconsin-Madison	WI	Public Affairs-Energy and Environmental Policy Graduate Program
University of Wisconsin-Madison	WI	Environment and Resources Program

University of Wisconsin-Madison	WI	Conservation Biology and Sustainable Development Program
University of Wisconsin-Madison	WI	Water Resources Management
University of Wisconsin-Milwaukee	WI	Conservation and Environmental Science Program
University of Wisconsin-Stevens Point	WI	Natural Resources Graduate Program
*University of Wyoming	WY	Rangeland Ecology and Watershed Management Program
*University of Wyoming	WY	Earth System Science Program
Upper Iowa University	IA	Environmental Science Program
*Vassar College	NY	Environmental Studies Program
Villanova University	PA	Environmental Science and Studies Program
Warren Wilson College	NC	Environmental Studies Program
Washington and Jefferson College	PA	Environmental Studies Program
Wellesley College	MA	Environmental Studies Program
Western Carolina University	NC	Environmental Science Program
Westfield State College	MA	Environmental Science Program
William Paterson University of New Jersey	NJ	Department of Environmental Science
**Williams College	MA	Environmental Studies Program
Wilson College	PA	Environmental Studies Program
Winthrop University	SC	Environmental Sciences/Studies Program
Worchester Polytechnic University	MA	Environmental Studies Program
**Yale University	CT	School of Forestry and Environmental Studies