Environmental Science and Studies Programs Comparative and Strategic Analysis

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Executive Summary

Colleges and universities across the nation are facing challenges in three key areas: demands, deficits, and demographics. Higher education institutions in Delaware and other states in the South Atlantic census region are facing major budget challenges exacerbated by high levels of fiscal uncertainty. Demand for higher education in the region is growing; the number of students enrolled increased nearly 7% from 2009 to 2010.[1]

Universities across the nation are also facing expectations to improve their state's economies by strengthening partnerships with businesses, serving increasing numbers of adult learners, and working to retain young residents. A new report by the National Governors Association Center for Best Practices asserts that higher education must do a better job of aligning their programs with the economic needs of their states and highlights steps that state legislatures can take to encourage higher education institutions to embrace a more active role in economic development.[2]

Environmental education and research programs play an important role in economic development. A 2008 study, the *Jobs and Environment Initiative,* was designed to quantify the relationship between the economy, jobs and environmental protection. The study analyzed the environmental job market nationally and in nine states (Arizona, California, Connecticut, Florida, Michigan, Minnesota, North Carolina, Ohio and Wisconsin).[3] It identified the size of the environmental protection industry as $341 billion/year and growing (projected to reach $496 billion in 2020; larger than most industrial sectors and the top Fortune 500) and estimated the industry was responsible for the creation of 5.3 million jobs in 2005 distributed across all employment sectors. 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. The study, supported by the Rockefeller Foundation, the Merck Fund, and the Beldon Fund, also concluded there is a positive relationship between state environmental policies and economic/jobs growth and that the environmental industry, in contrast to other sectors, has been relatively "recession proof."

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 interdisciplinary environmental (IE) and sustainability education. New majors, minors, certificates, and executive education programs in environmental areas and sustainability are being established at an extraordinary pace and existing programs are striving to keep up with student demand. It has also catalyzed the creation of a steady stream of new IE research and education centers and institutes, colleges, schools and campuses dedicated to the study of the environment and sustainability. This situation creates tremendous opportunities but also strategic challenges for the Environmental Science and Studies (UD-ESS) programs at the University of Delaware.

[1] The Chronicle of Higher Education Almanac Issue 2010-11, August 27, 2010, Volume LVII, Number 1.
[2] National Governors Association Center for Best Practices. 2011 *Degrees for What Jobs? Raising Expectations for Universities and Colleges in a Global Economy*.
[3] 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.

The UD-ESS programs are strong programs with growing enrollments. They have a number of positive attributes and enjoy high levels of commitment from the students, the program director, the College of Earth, Ocean and Environment (CEOE) leadership and the participating faculty across the university. However, a notable challenge for the UD-ESS programs is the lack of clear alignment with the consensus national findings on ideal IE curricula and with emerging IE career paths for graduates. Both the Environmental Science (ENSC) program and the Environmental Studies (ENVR) programs are not well aligned with the consensus on the key characteristics of the field of IE education, do not clearly include the ideal interdisciplinary knowledge and integrated skills that should be part of the curricula of every IE program, and neither provides a curriculum that aligns with the most desirable (among IE program leaders, students and employers) ideal approach to IE education that prepare students to be environmental management and decision making professionals.

A number of changes are recommended that will strengthen the programs in relation to their national peers and current trends.

- Align the ENSC program toward an *Adaptive Management* approach or offer two tracks within the ENSC—a research track and a professional track.
- Offer fewer concentrations that are aligned with USEPA priority areas and applied/professional practice themes.
- Make the CEOE the home college for all UD-ESS majors.
- Restructure the core requirements to align better align the curricula with the key elements of IE field identity and the consensus on ideal curricula by developing a set of core courses specifically for ED-ESS majors.
- Offer honors degree options for both the ENSC and ENVR.
- Develop and utilize additional assessment and professional development processes such as student portfolios, advisory groups (may include students, alumni, employers, representatives from units across campus, etc.), and internship matching and career exploration programs.
- Create a home within CEOE to house the UD-ESS programs that will better support the interdisciplinary nature of these academic programs similar to the School of Marine Science and Policy.
- Establish structured partnerships with campus entities and external partners that provide students with enhanced opportunities.
- Develop new graduate degree programs and five-year accelerated baccalaureate/masters programs for UD-ESS students.

To achieve their leadership potential and continue to compete effectively with IE programs at top research universities the UD-ESS programs require structural changes and increased resources; ideally including resources for appropriate staffing and key core interdisciplinary tenure-track faculty lines and/or joint appointments.

Realizing the UD-ESS programs' full potential will benefit the university and help it achieve the environmental and sustainability leadership goals of the Path to Prominence strategic plan, enhance its status as an important driver of economic development in Delaware and the region, and increase

recognition of its importance as an education and research center preparing a 21st century workforce, conducting world-class research, and providing service to society.

The report is comprised of seven sections: (1) a short overview of the UD- ESS programs, (2) an overview of IE programs in the United States, (3) key findings from the NCSE national study, (4) comparison of the UD-ESS administrative programs' attributes to IE programs nationwide, (5) a comparison of the ENSC and ENVR degree programs' attributes to IE undergraduate degree programs at peer institutions and nationwide, (6) an overview of the evolving IE workforce, and (7) conclusions and recommendations.

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Section I – Overview of the Environmental Science and Studies (ESS) Programs

Institution Carnegie Classification Information

- *Basic Carnegie Class:* RU/VH Research University (very high research activity), public control (actually a hybrid public/private)
- *Student Enrollment:* Large, primarily residential (> 9,999 degree-seeking students; 25-49% degree-seeking undergraduates live on campus and at least 50% attend full time)
- *Enrollment Profile:* High undergraduate (professional/graduate students 10-24% FTE enrollment)

The Carnegie Classification has been the leading framework for recognizing and describing institutional diversity in U.S. higher education for the past four decades. Starting in 1970, the Carnegie Commission on Higher Education developed a classification of colleges and universities to support its program of research and policy analysis. Derived from empirical data on colleges and universities, the Carnegie Classification was originally published in 1973 and subsequently updated periodically to reflect changes among colleges and universities. This 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 University of Delaware (2010 profile) are used to tailor this report.

Degrees Awarded

- Bachelor of Science in Environmental Science
    - Atmospheric Science (Earth, Ocean and Environment)
    - Ecology and Organismal Biology (Agriculture and Natural Resources)
    - Environmental Chemistry (Arts and Sciences)
    - Environmental Soil Science (Agriculture and Natural Resources)
    - GeoScience (Earth, Ocean and Environment)
    - Hydrology (Earth, Ocean and Environment)
    - Marine Science (Earth, Ocean and Environment)
    - Pollution Control (Engineering)
    - Sustainable Energy Technologies (Engineering)
    - Water Quality and Resources (Engineering)
- Bachelor Arts in Environmental Studies
    - International Environmental Politics and Policy (Arts and Sciences)
    - Environmental Law, Policy and Politics (Arts and Sciences)
    - Environmental Economics and Resource Policy (Agriculture and Natural Resources)
    - Environment, Society and Sustainability (Earth, Ocean and Environment)

Statement of Purpose

How the overall educational and research purposes are defined for the Environmental Science and Studies (ESS) Programs are an important consideration for the report, therefore statements from the program brochure are included in this section.

The interdisciplinary Bachelor of Science in Environmental Science and the Bachelor of Arts in Environmental Studies are housed in the Department of Geography and are collaborative efforts involving several departments and colleges.

The Bachelor of Science in Environmental Science emphasizes a broad, scientific understanding of the character, function, and analysis of environmental systems. Environmental Science BS students will be able to contribute to societies understanding on and solutions to problems that arise from human occupancy and use of the planet and environment.

The goal is to given students in the program a broad-based, interdisciplinary introduction to the scientific concepts, policies and issues; the common analytical tools needed to explore environmental issues in depth through their specific concentration areas; and the ability to integrate and synthesize information from a multidisciplinary perspective in oral and written format through the capstone course.

The BS is Environmental Science program is rigorous in both math and science and includes courses in social science and policy that will help the environmental science major understand the societal context of his/her work. This foundation along with their specific concentration areas helps students appreciate the interconnectedness between understanding natural science processes and their applications and the social, political, and institutional frameworks in which environmental issues are considered.

The Bachelor of Arts in Environmental Studies assists students in gaining a deeper understanding of and appreciation for the environment and environmental systems, the impact of humans on the environment and environmental impacts on humans, the importance of environmental understanding when making economic, political and other policy choices.

The goal is to give students in the program a broad-based, interdisciplinary introduction to environmental policies and issues; the common analytical tools needed to explore them in depth through their specific concentration areas; and the ability to integrate and synthesize information from a multidisciplinary perspective in oral and written format through a capstone course.

The BA in Environmental Studies program's foundation courses are in the social sciences, humanities, and natural sciences with a focus in understanding the environmental field. This, along with their specific concentration area, allows students in connecting science and society and balancing the needs of humans and other inhabitants with the needs to conserve the earth's precious resources while developing strategies, policies and approaches to solve environmental issues and reduce environmental impact.

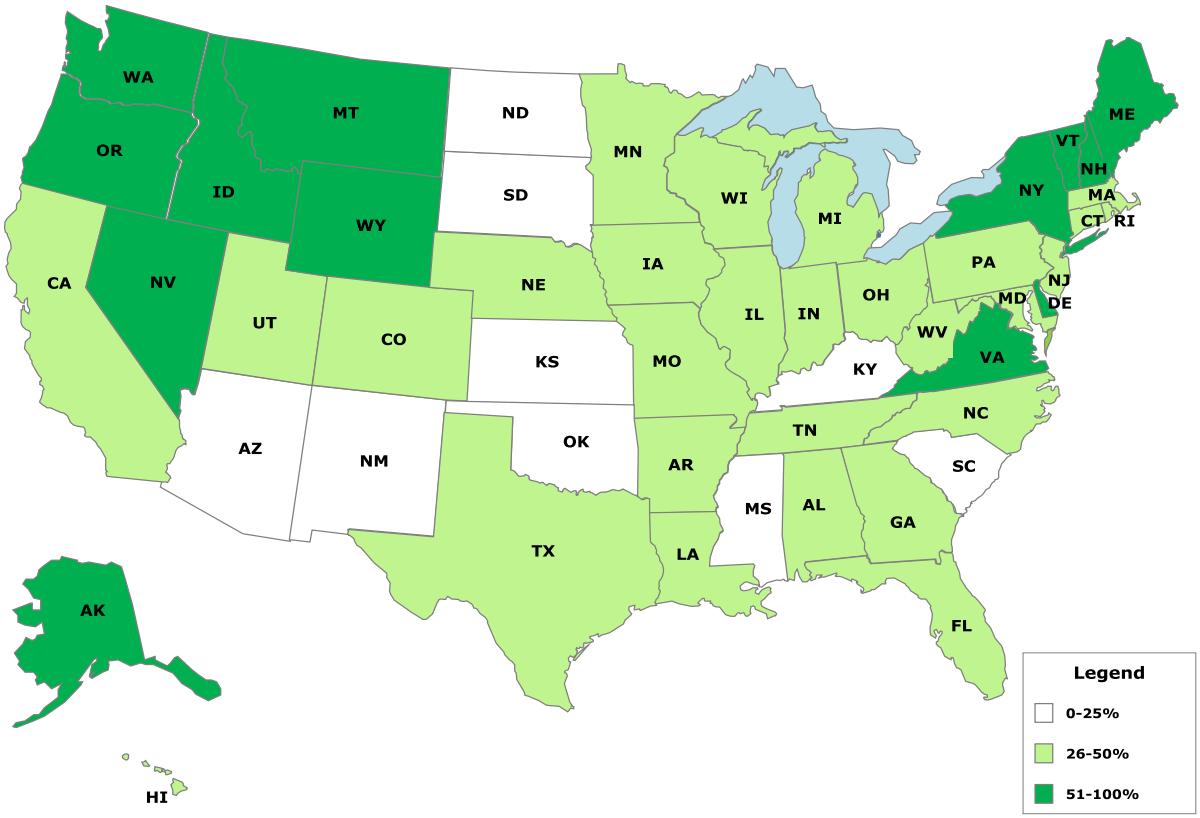
Section II – NCSE Study: IE Programs Overview

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.[4]

The National Council for Science and the Environment's study of interdisciplinary environmental (IE) programs conducted a census of IE programs in the United States in 2007 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 Delaware is higher at 60% (but only 3 institutions). States in the Northeast and in the Northwest have the highest proportions.

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



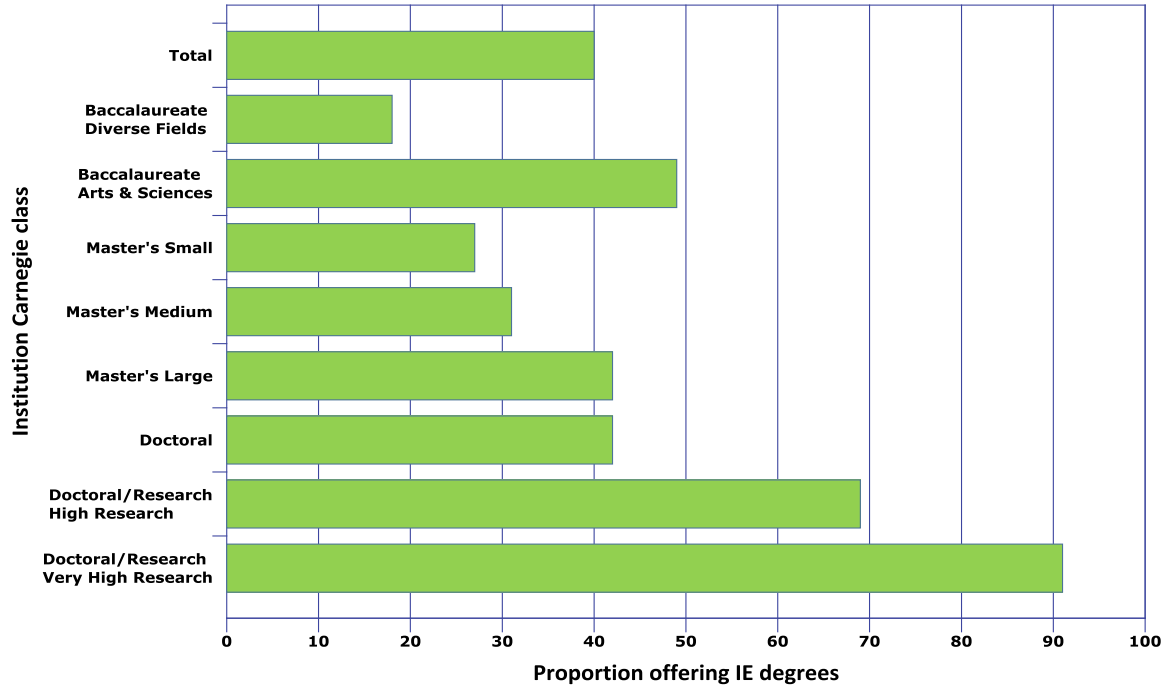
[4] The sample was representative based on four parameters (institution Carnegie class, control—public or private not-for-profit, census region, and degree name/level) and large enough to measure correlations between attributes with a power of 0.90 to detect a 0.20 (moderate) effect at α=0.05; statistical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

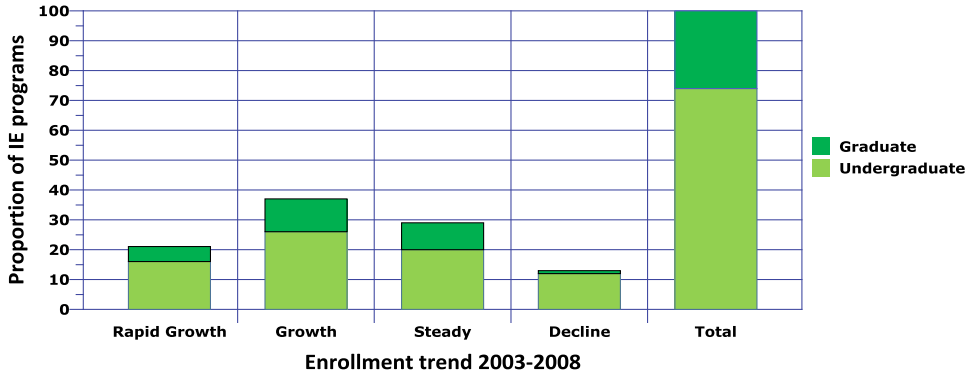
The growth in enrollment has been dramatic. The University of Michigan's Program in the Environment was initiated in 2003 with 35 students and today has 500 students. The University of California at Los Angeles launched its Environmental Science program in 2006 with 10 students and three years later 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

[5] "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.

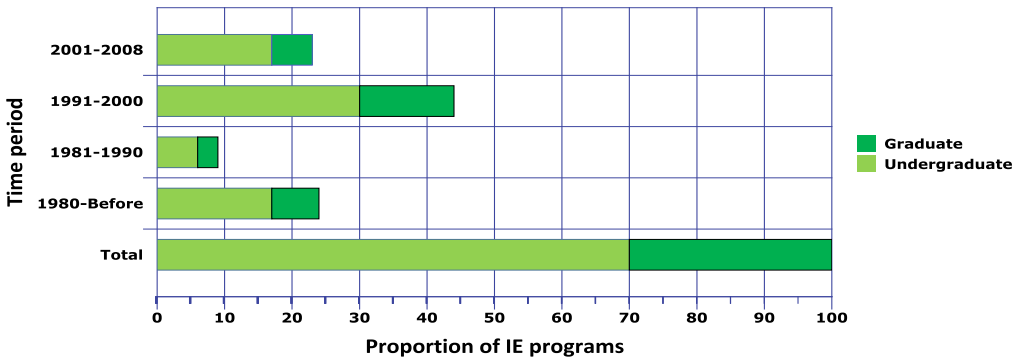
student interest in the semesters following the survey.[6] For example, Antioch University New England reports that applications for their Masters of Science programs in Environmental Studies and Resource Management and Conservation are up 42% from 2009. Similarly, the University of Vermont reports that 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. A 2009 study by the National Wildlife Federation found that the number of colleges and universities offering interdisciplinary environmental degrees jumped to 44% from the 40% identified in the 2008 NCSE survey.[7]

Figure 4. Time period IE programs established



[6]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.

[7] National Wildlife Federation's 2009 *State of the Campus Environment* report.

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).

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

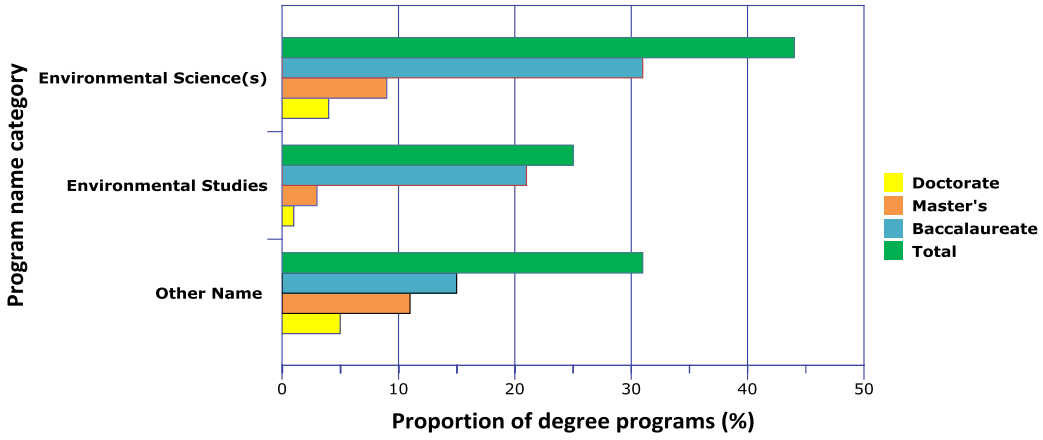
The census count of IE degree programs reveals they exhibit an amazing variety of degree program names and focus areas. Many institutions offer more than one type of IE degree; for example, 12% of institutions offer both undergraduate environmental science(s) and environmental studies degrees. Other 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[8]

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

[8] 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.[9]

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.[10] 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

Inclusion method	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."

[9] 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.

[10] 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.

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 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*.[11]

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.

[11] 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.

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 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.[12]

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[13]—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.

[12] 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.

[13] 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)

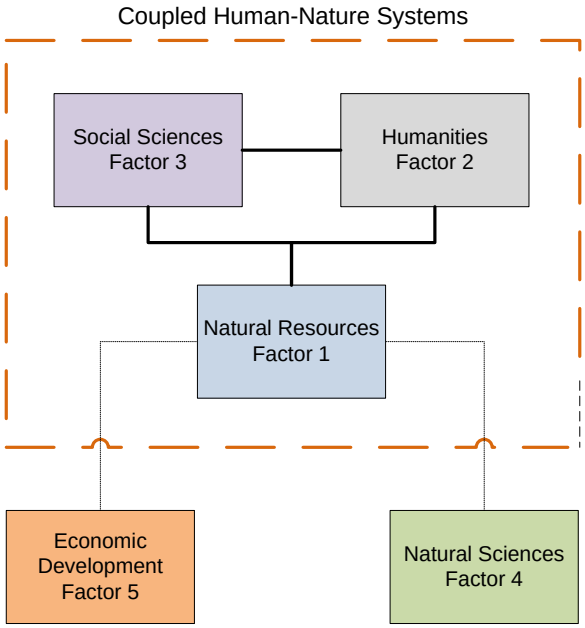
The *Natural Resources* component accounts for almost a third of the total variance explained by the model; this component best explains (predicts) how program administrators' importance ratings fall into the five components of interdisciplinary IE knowledge. In contrast, the other four components each 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)

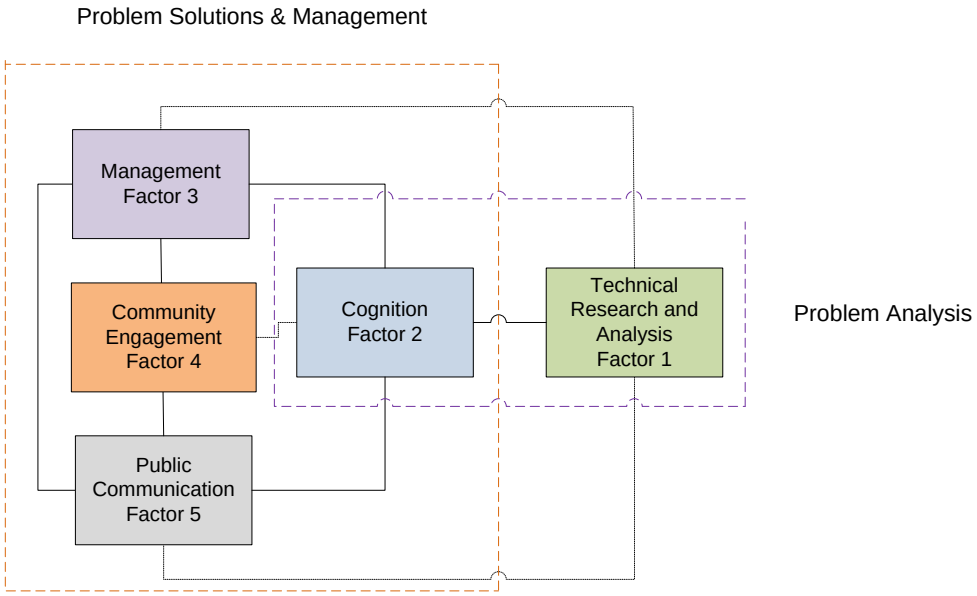
The *Technical Research and Analysis* component accounts for approximately a third of the total variance explained by the model; this component best explains (predicts) how program administrators' importance ratings fall into the five dimensions of integrated IE skills. In contrast, the other four components 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.[14] 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.

[14] 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

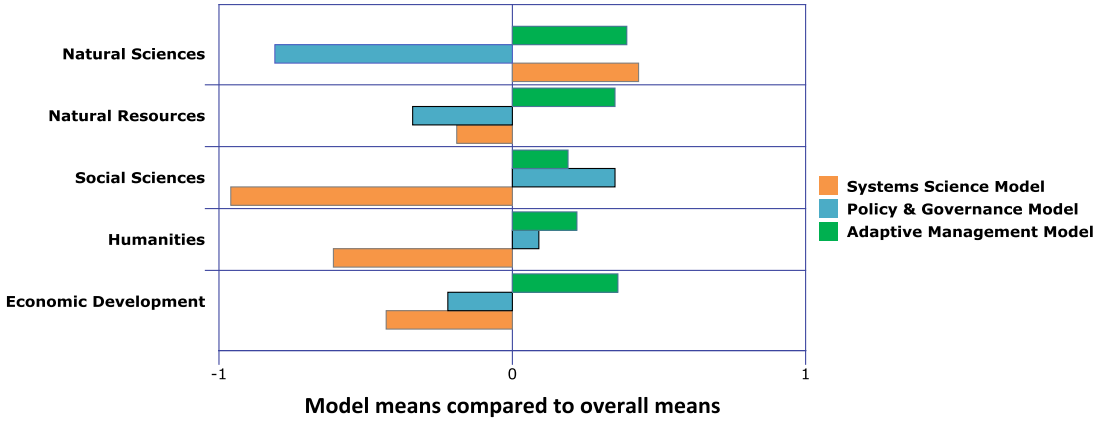


Figure 9. IE skills component means by educational approach/model

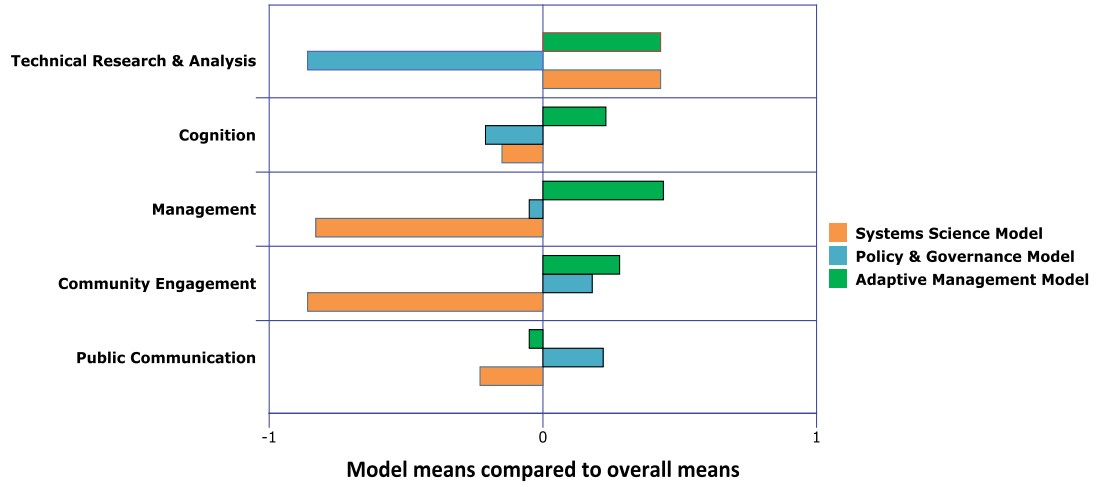


Figure 10 illustrates how the IE degree programs included in the survey aligned with the three models and the relationships between the models based on two dimensions that discriminate among the groups.

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

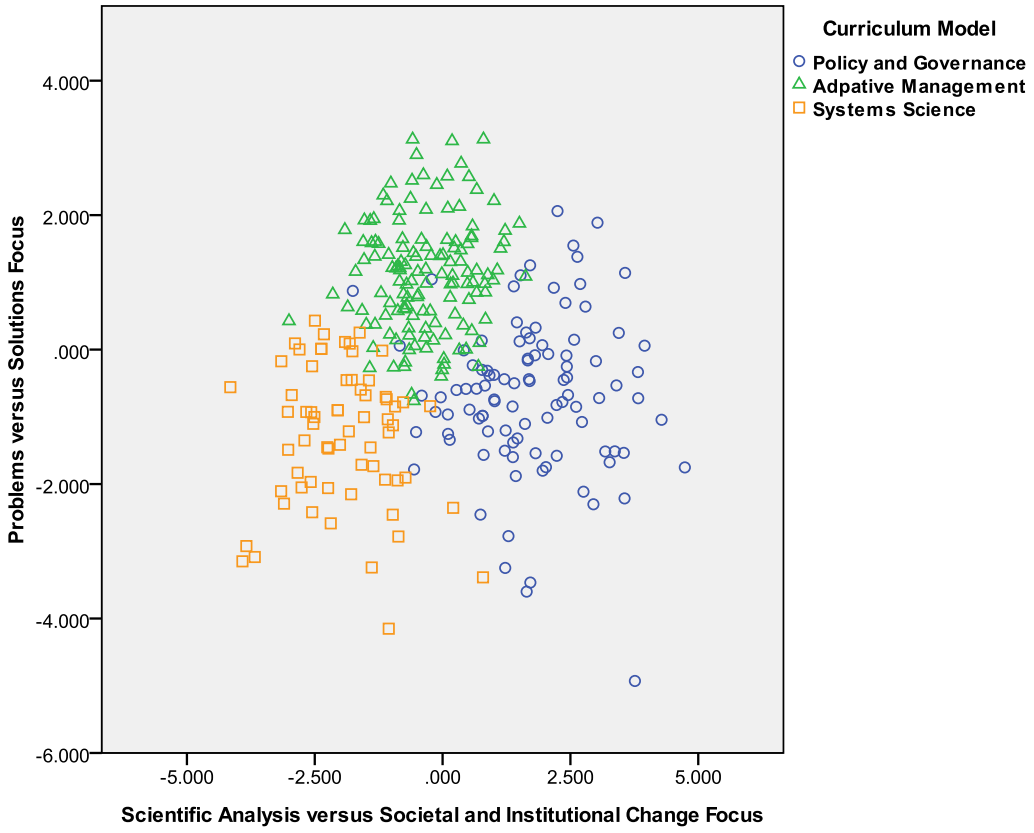
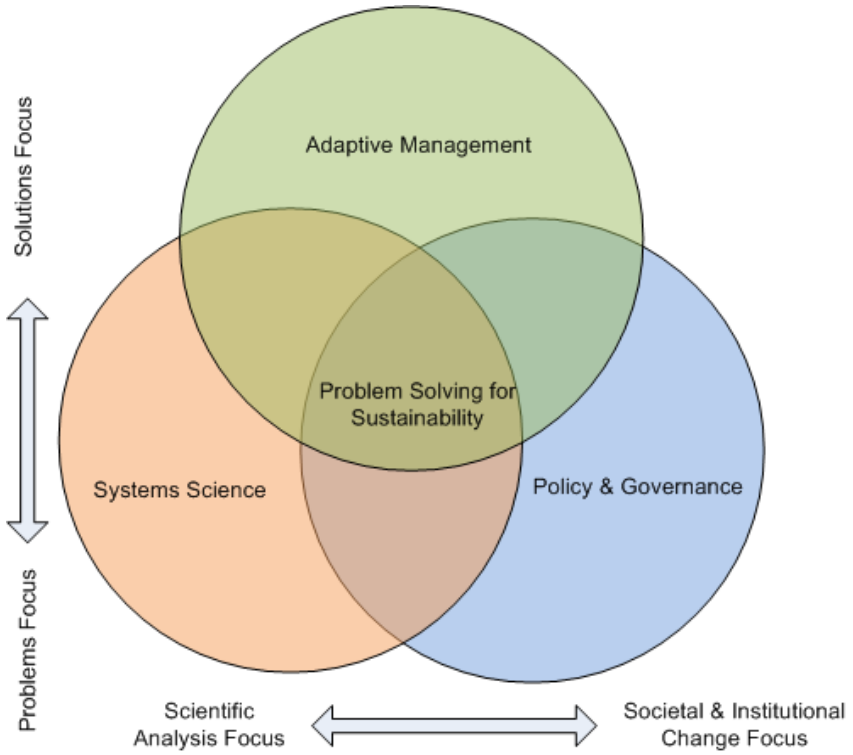


Figure 11 illustrates a unified framework for understanding IE programs in the United States based on the cluster and discriminate analyses. The three models are not opposed to each other; instead they overlap considerably so that some IE programs are situated on the boundaries of two or three models. 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

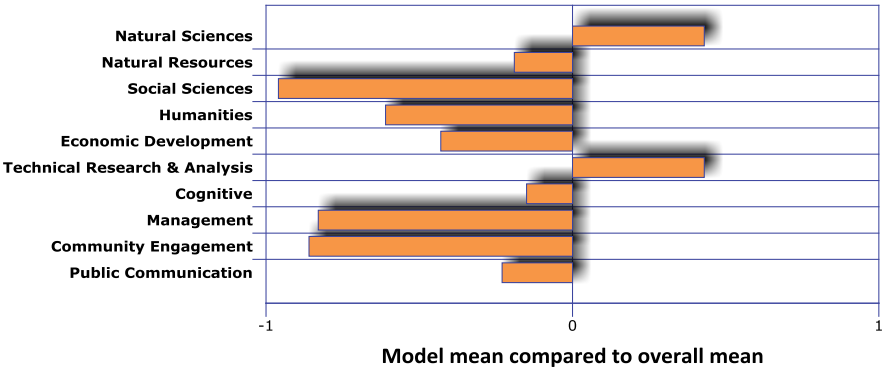
The *Systems Science* approach emphasizes in-depth knowledge of the natural sciences and technical research and analysis centered on laboratory and fieldwork skills. It has an analytic orientation that emphasizes traditional scientific skills and expertise in the natural sciences. *Systems Sciences* 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

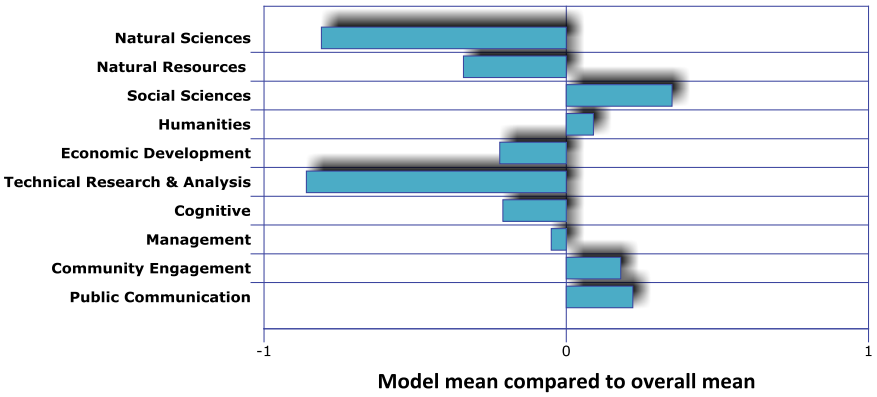
The *Policy and Governance* approach emphasizes the social sciences, humanities, and public engagement skills. The orientation for this model is societal and institutional change with a focus on public awareness and an emphasis on policy and governance processes. *Policy and Governance* programs prepare 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).

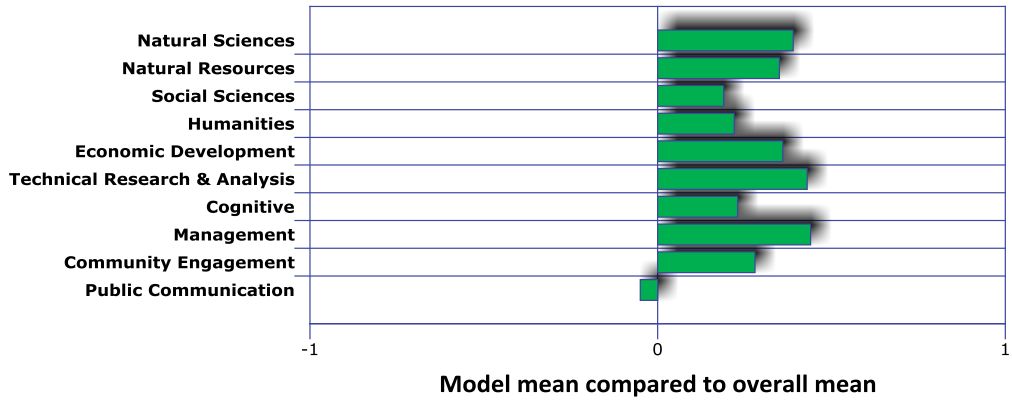
Compared with the other two models, it places:

- 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

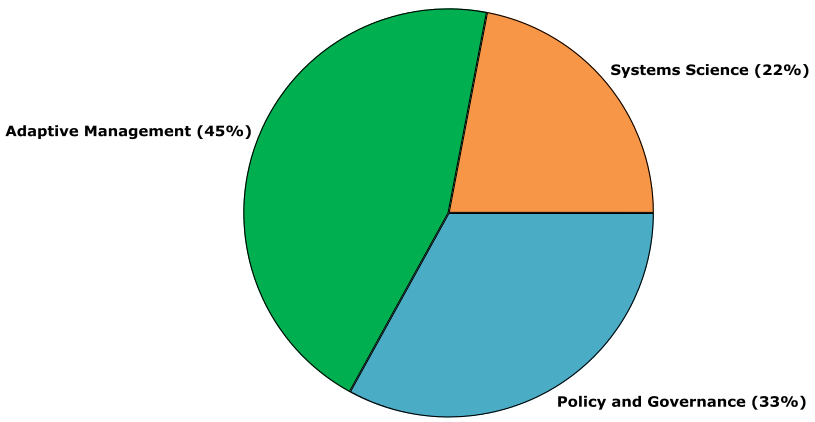


Table 9. Ideal curriculum models and enrollment trends

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 ESS Program Administrative Attributes with NCSE Study Findings

Competing Programs: Programs at Peer/Aspirational Institutions

The CEOE identifies twelve regional research universities as peer/aspirant institutions. 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. The undergraduate programs are highlighted in blue text; graduate programs are included to illustrate post-baccalaureate opportunities in environmental education at these institutions.

All twelve of the peer/aspirant institutions identified by the CEOE offer undergraduate environmental degree programs in the following areas: Environmental Science /and Earth/and Policy/and Technology, Environmental Studies, Environmental Policy, Environmental Resource Management/Natural Resources Management, Environmental Geosciences/Geology, Environmental Geography, Earth and Atmospheric Sciences with an Environmental Science concentration, Environmental Engineering/Environmental Systems Engineering, Agricultural and Extension Education with a concentration in Environmental Science, and Community, Environment and Development. Only seven offer degrees in Environmental Studies or Environmental Science.

Six of the undergraduate programs were included in the representative sample that participated in the 2008 NCSE survey and study—the Environmental Science BS and Environmental Studies BA programs at College of William and Mary, the Earth and Environmental Science BS and the Environmental Studies BS program at Lehigh University, the Environmental Resource Management BS program at Pennsylvania State University, and the Environmental Studies BA program at the University of Pittsburgh. Two of the six fell into the *Adaptive Management* model—the Environmental Science BS at William and Mary and the Environmental Resource Management BS at Penn State. Both of these program adopted sustainability as a core guiding principle and both reported rapid growth. Three were associated with the *Policy and Governance* model---the Environmental Policy BA at William and Mary, the Environmental Studies BS at Lehigh, and the Environmental Studies BA at Pittsburgh. The William and Mary degree includes sustainability as a core guiding principle and reported rapid grow; the Lehigh and Pittsburgh programs did not include sustainability as a core principle and reported steady enrollment. The sixth program—the Earth and Environmental Science BS program at Lehigh—fell within the *Systems Science* model, did not include sustainability as a core principle and reported steady enrollment. Consistent with the NCSE study findings, adoption of sustainability as a core guiding principle was associated with program growth and the *Systems Science* model was the least popular model.

Of the seven institutions offering environmental science and studies degree programs, one offers these degree programs through a degree-granting center—the Center for Environmental Studies at Brown University—and three have IE departments—the Department of Earth and Environmental Sciences (Lehigh University), the Department of Environmental Science and Technology (University of Maryland-College Park), and the Department of Environmental Sciences (University of Virginia). Four have IE

programs administratively housed in a traditional college—the Environmental Science and Policy Program in the College of Arts and Sciences (College of William and Mary), the Environmental Initiative in the College or Arts and Sciences (Lehigh University), the Environmental Science and Policy Program that spans three colleges (University of Maryland-College Park), and the Curriculum for the Environment and Ecology in the College of Arts and Sciences (University of North Carolina-Chapel Hill). The Environmental Studies BA program at the University of Pittsburgh is administratively located in the Department of Geology and Planetary Sciences.

Table 11. Peer/aspirational institutions' environmental degree programs
*** degrees included in 2008 survey**

Institution	Carnegie Class; Control	Administrative Location	IE Degrees Offered
Boston College Chestnut Hill, MA	RU/VH; Private NFP	Department of Earth and Environmental Sciences; College of Arts and Sciences	• Environmental Geosciences BS
Brown University Providence, RI	RU/H; Private NFP	Center for Environmental Studies	• Environmental Science BS • Environmental Studies BA/MA
Carnegie Mellon University Pittsburgh, PA	RU/H; Private NFP	Environmental Policy Program; College of Humanities and Social Sciences	• Environmental Policy BA (secondary major only)
College of William and Mary Williamsburg, VA	RU/H; Public	Environmental Science and Policy Program; College of Arts and Sciences	• Environmental Science BS* • Environmental Policy BA*
		School of Marine Science and Virginia Institute of Marine Science	• Marine Science MS/PhD
		Department of Geology; College of Arts and Sciences	• Geology: Environmental BS
		Program in Public Policy; College of Arts and Sciences	• Master of Public Policy: Environmental Policy
		College of Law	• Law: Environmental and Natural Resource Law JD
Georgia Institute of Technology Atlanta, GA	RU/VH; Public	School of Earth and Atmospheric Sciences	• Earth and Atmospheric Sciences: Environmental Science BS

Institution	Carnegie Class; Control	Administrative Location	IE Degrees Offered
Lehigh University Bethlehem, PA	RU/H; Private NFP	Department of Earth and Environmental Sciences; College of Arts and Science	• Earth and Environmental Science BA/BS*/MS/PhD (5-yr dual degree BS and Environmental Engineering)
		Environmental Initiative; College of Arts and Sciences	• Environmental Studies BS* • Environmental Policy Design MA*
		Department of Civil and Environmental Engineering; College of Engineering and Applied Science	• Environmental Engineering BS/MS/PhD
Pennsylvania State University University Park, PA	RU/VH; Public	Department of Agricultural Economic and Rural Sociology; College of Agricultural Sciences	• Community, Environment and Development BS
		Department of Agricultural Economic and Rural Sociology; College of Agricultural Sciences	• Agricultural, Environmental and Regional Economics: Watershed Stewardship MS/PhD
		Department of Agricultural and Extension Education; College of Agricultural Sciences	• Agricultural and Extension Education: Environmental Science BS
		Environment and Natural Resources Institute; College of Agricultural Sciences	• Environmental Resource Management BS*
		Human Dimensions of Natural Resources and the Environment Program; Department of Agricultural Economics and Rural Sociology and Department of Geography	• Human Dimensions of Natural Resources and the Environment MA/MS/PhD (dual degree only)
		Department of Energy and Mineral Engineering; College of Earth and Mineral Sciences	• Environmental Systems Engineering BS
		Department of Geography; College of Earth and Mineral Sciences	• Geography: Physical/Environmental BA
		Department of Civil and Environmental Engineering; College of Engineering	• Civil and Environmental Engineering: Environmental and Water Resources BS • Master of Engineering: Environmental Engineering • Environmental Engineering MS/PhD

Institution	Carnegie Class; Control	Administrative Location	IE Degrees Offered
University of Maryland College Park, MD	RU/VH; Public	University of Maryland System Center for Environmental Science	• Marine-Estuarine-Environmental Science MS/PhD
		Department of Environmental Science and Technology; College of Agriculture and Natural Resources	• Environmental Science and Technology BS/MS/PhD
		Natural Resource Management Program; Department of Environmental Science and Technology; College of Agriculture and Natural Resources	• Natural Resources Management BS
		Environmental Science and Policy Program; College of Agriculture and Natural Resources , College of Behavioral and Social Sciences, College of Computer, Mathematical and Natural Sciences	• Environmental Science and Policy BS
		Institute for Applied Environmental Health; School of Public Health	• Master of Public Health: Environmental Health Sciences
		School of Public Policy	• Master of Public Policy: Environmental Policy* • Master of Public Management: Environmental Policy* • Policy Studies: Environmental Policy PhD*
		Department of Civil and Environmental Engineering; School of Engineering	• Civil and Environmental Engineering BS/MS/PhD
		Department of Atmospheric and Oceanic Science; College of Computer, Mathematics and Natural Sciences	• Atmospheric and Oceanic Science MS/PhD

Institution	Carnegie Class; Control	Administrative Location	IE Degrees Offered
University of North Carolina Chapel Hill, NC	RU/VH; Public	Curriculum for the Environment and Ecology; College of Arts and Sciences	• Environmental Science BS • Environmental Studies BA
		Department of Marine Sciences; College of Arts and Sciences	• Marine Sciences MS/PhD
		Department of City and Regional Planning; College of Arts and Sciences	• Master of Regional Planning: Land Use and Environmental Planning • Planning: Environmental Planning PhD
		Department of Geography; College of Art and Sciences	• Geography: Earth Environmental Systems BA • Geography: Environmental BA • Geography and Earth Systems Science MA/PhD
		Department of Environmental Sciences and Engineering; School of Global Public Health	• Environmental Engineering MS • Environmental Sciences and Engineering MS/PhD • Public Health: Environmental Sciences and Engineering BS • Master of Public Health: Environmental Sciences and Engineering • Public Health: Environmental Sciences and Engineering MS
		Department of Public Policy; College of Arts and Sciences	• Public Policy: Environment and Sustainability MS
University of Notre Dame South Bend, IN	RU/VH; Private NFP	Department of Civil Engineering and Geological Sciences; College of Engineering	• Environmental Geosciences BS • Environmental Engineering MS

Institution	Carnegie Class; Control	Administrative Location	IE Degrees Offered
University of Pittsburgh Pittsburgh, PA	RU/VH; Public	Environmental Studies Program; Department of Geology and Planetary Sciences; College of Arts and Sciences	• Environmental Studies BA*
		Department of Geology and Planetary Sciences; College of Arts and Sciences	• Environmental Geology BS
		Department of Environmental and Occupational Health; Graduate School of Public Health	• Master of Public Health in Environmental and Occupational Health • Environmental Health Sciences MS • Environmental and Occupational Health PhD
		Department of Civil and Environmental Engineering; College of Engineering	• Professional Master of Science in Environmental Engineering • Professional Master of Science in Sustainability and Green Design
		Graduate School of Public and International Affairs	• Master of International Development: Development Planning & Environmental Sustainability
University of Virginia Charlottesville, VA	RU/VH; Public	Environmental Thought and Practice Program; College of Arts and Sciences	• Environmental Thought and Practice BA
		Department of Environmental Sciences; College of Arts and Sciences	• Environmental Sciences BA/BS/MA/MS/PhD
		Department of Urban and Environmental Planning; School of Architecture	• Bachelor of Urban and Environmental Planning • Urban and Environmental Planning BS/MS • Master of Urban and Environmental Planning*
		Department of Civil and Environmental Engineering; College of Engineering	• Civil Engineering: Environmental Engineering BS • Master of Engineering in Civil Engineering: Environmental and Water Resources Engineering • Civil Engineering: Environmental and Water Resources Engineering MS/PhD
		Environmental and Land Use Law Program; School of Law	• Environmental and Land Use Law JD

Administrative Location

The UD-ESS programs have an unusual administrative structure—the programs are administratively housed within the Department of Geography in the College of Earth, Ocean and Environment (CEOE) but the programs themselves spans four colleges—the College of Earth, Ocean and Environment, the College of Arts and Sciences, the College of Agriculture and Natural Sciences, and the College of Engineering. The degree is a distributed degree such that students have two academic homes—the program and a "home" college based upon where their selected concentration originates. Four of the ten BS concentrations and one of the four BA concentrations are affiliated with the CEOE.

Undergraduate IE programs at research institutions are about evenly divided between academic units or programs that offer only undergraduate IE degrees (45%) and those that offer both undergraduate and graduate IE degrees (55%). Of these, undergraduate-only programs are most often administratively housed within a traditional department (40%) or within a program in a traditional college (40%), while combined undergraduate and graduate programs are most often located within their own IE department (43%; Table 12). Most programs administratively located within traditional departments draw upon faculty and courses outside the hosting department but the extent of cross-departmental and cross-college involvement varies considerably.

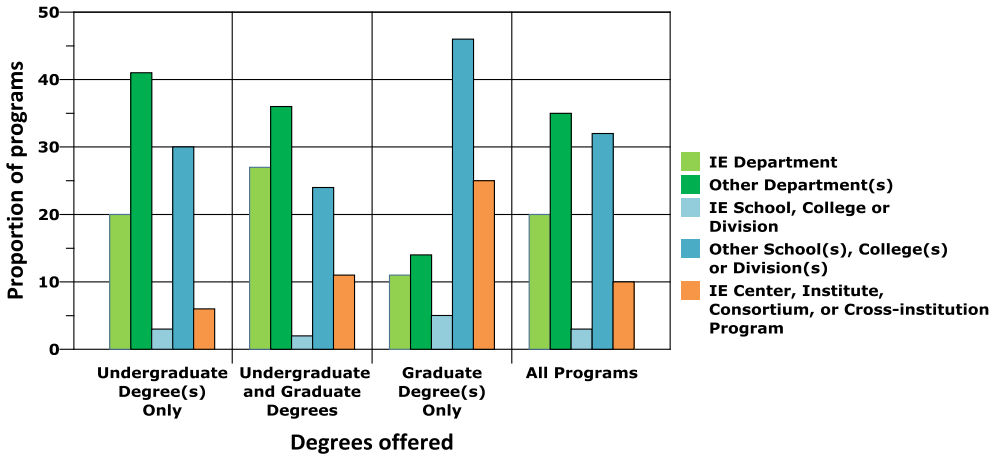
Table 12. Administrative location for undergraduate IE degree programs*

Program Type	IE Department	Other Department	IE College or School	Other College or School	IE Center or Institute
Undergraduate Only (*n*=45)	11%	40%	7%	40%	2%
Undergraduate and Graduate (*n*=54)	43%	19%	0%	24%	15%

*Programs at RU/VH and RU/H 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). The NCSE 2010 census of IE programs reveals that many institutions are creating new autonomous IE academic units: departments, schools, colleges, centers and institutes.

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%

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			
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.[15] 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.

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

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

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 UD-ESS programs are led by a Director with an appointment equivalent to a full-time program administrator. Administrative tasks are also performed by the Assistant Dean for Student Services of the CEOE who serves as an unofficial co-administrator. Two-thirds (67%) of the IE programs at research universities have program directors as the primary administrator. Of these, most characterize their appointments as part time; a small percentage lacks an official administrator (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 UD-ESS may have strategic advantages compared with programs lacking equivalent leadership capacity.

Table 16. IE program administrator appointments at research universities

Appointment Type	Administrator Title					
	Department Chair or Head *n*=19	Program Director, Chair or Coordinator *n*=56	School or Division Chair or Head *n*=2	College Dean, Associate Dean, or Assistant Dean *n*=3	Other* *n*=4	Total *n*=84
Full-time sole Administrator	42%	25%	0%	33%	0%	27%
Part-time Sole Administrator	21%	47%	0%	33%	50%	39%
Full-time Co-Administrator	11%	2%	100%	0%	0%	6%
Part-time Co-Administrator	10%	14%	0%	0%	25%	13%
Other	16%	7%	0%	0%	0%	8%
No Official Administrator	0%	5%	0%	33%	25%	6%
Total	23%	67%	2%	3%	5%	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.

The UD-ESS 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 UD-ESS programs are currently funded by an internal university grant and do not have an operating budget. Undergraduate IE programs at research universities are split between programs that report their operating budgets are equivalent or greater than programs with similar numbers of students (47%) and those who report their budgets are less than other programs of similar size (43%). The remaining programs were unsure how their budget compared with other programs (5%) or had no dedicated budget (5%).

On average, undergraduate programs receive approximately 82% of their funding from non-directed funds (institutional appropriations, tuition and fees), 9% from long-term directed funds (endowments, facilities, contracts) and 9% from short-term directed funds (grants, contracts, earmarks, donations; Table 18). About half of all IE undergraduate programs (49%; most at smaller institutions) are solely funded through non-directed institutional funding.

Table 18. IE Program funding sources

Source	Undergraduate programs (*n*=215) Mean proportion of funding from source*
Non-directed (i.e. tuition, institutional funding)	82%
Long-term directed (i.e. endowment, contracts)	9%
Short-term directed (i.e. grants, contracts)	9%

Program Specific Funding and Resources for Curricular Use

The UD-ESS does not have specialized computer centers, research or teaching laboratories, however, these facilities are available to UD-ESS students through their affiliate colleges. In addition, the curricula include the use of field sites at parks, reserves and field stations.

A number of IE programs do not have utilize specialized environmental facilities that support student education and professional skills development in their curricula; most use specialized computer facilities and laboratories, but only a little over half use institutional or other field sites or outside facilities (Table 19).

Table 19. Environmental facilities used in IE program curricula

Type of facility	Undergraduate programs (*n*=214)	Graduate programs (*n*=91)
IE computer centers	71%	79%
Specialized IE laboratories	53%	62%
Nature center or protected area	53%	51%
Field station or campus	45%	53%
Other facilities*	22%	23%

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

About half of IE undergraduate programs provide students assistance in participating in external learning opportunities (internships, field experiences, etc.), scholarships/fellowships, and travel support for conferences and scholarly activities and internal research grant opportunities. About half also provide faculty members travel support, but fewer provide access to internal research grants and program-specific resources for teaching and course development. About a quarter of programs provide service awards for students and faculty and only about a fifth support outreach activities (Table 20).

Table 20. IE programs' student and faculty resources

Program-specific resource	Undergraduate programs (*n*=214)
Student external learning opportunities	59%
Student scholarships or fellowships	47%
Student travel support	47%
Student research grants	41%
Student service awards	24%
Faculty travel	53%
Faculty research grants	40%
Faculty teaching or course development support	37%
Faculty service awards	25%
Outreach activities	19%
Other resources*	6%

*Institutional funds for projects and speakers, extramural funding sources, alumni and employer support.

Engagement with Campus Institutes/Centers and External Partners

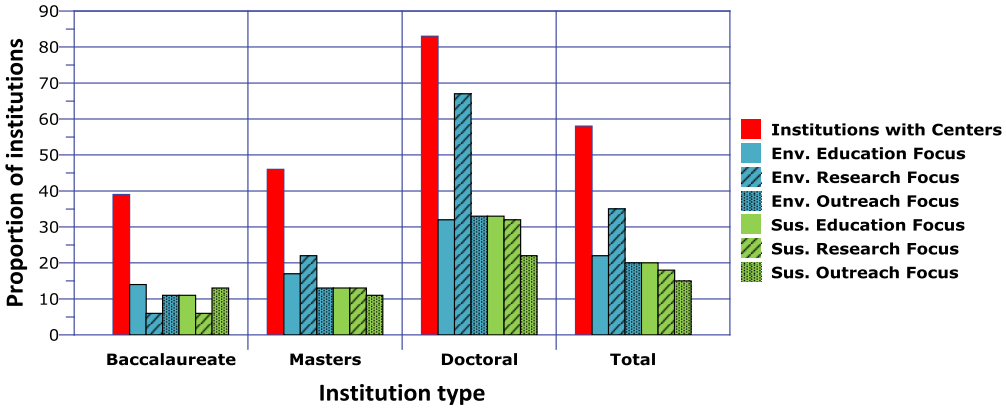
Campus Environmental/Sustainability Institutes/Centers

The University of Delaware hosts several centers with a primary focus on research and education related to the environment and sustainability, including the Delaware Environmental Institute, the Center for Marine Policy, the Center for Applied Coastal Research, the Center for Climatic Research, the Center for Managed Ecosystems, the Center for Energy and Environmental Policy, the Delaware Water Resources Center, and the Institute of Soil and Environmental Quality. Other centers that may include activities

relevant to the UD-ESS programs are the Institute for Public Administration and the Delaware Biotechnology Institute. Currently, the UD-ESS programs do not have defined ways in which these centers are utilized in the curricula, however students do benefit from educational opportunities provided by faculty participation in the centers.

Most doctoral degree granting institutions have one or more centers dedicated to environmental and/or sustainability issues with the majority focused exclusively on facilitating faculty collaboration on environmental research (Figure 17).

Figure 17. Institutions hosting environmental and/or sustainability centers



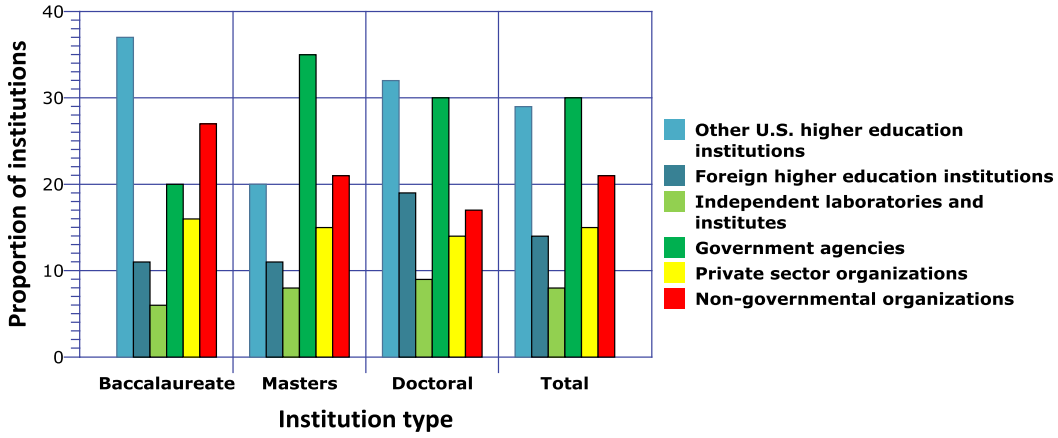
External Partnerships

The UD-ESS program currently does not have formal relationships with any external partners although collaborative agreements are being pursued with other foreign higher education institutions, including Beijing Normal University in China. 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).[16] 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.

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

Figure 18. External affiliates and partners



Participation in research projects, internships and other applied learning opportunities are the most common form of cooperative opportunities provided for students (ranging from 41% to 70% of IE programs with affiliate/partner relationships); participation in joint research is the most common form of collaboration for IE program faculty (36%-57%; Table 21). About a third of IE programs offer shared educational programs (36%-48%) and collaborative service learning or outreach experiences (26%-37%) for students.

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

Opportunities	UG/GR (*n*=45)	GR only (*n*=47)
Students participate in field/internship/applied learning experiences	52% - 49%	50%
Students participate in research programs	52% - 70%	44%
Students participate in education programs	48% - 48%	27%
Students participate in service learning/outreach	37% - 26%	31%
Faculty participate in research programs	46% - 57%	47%
Faculty participate in education programs	28% - 33%	29%
Faculty participate in service learning/outreach	28% - 26%	22%
Faculty participate in field/internship/applied learning experiences	22% - 30%	29%
Other *	0% - 0%	7%

*Students and faculty participate in demonstration projects.

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 gauging student, alumni and faculty satisfaction (Table 22).

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 UD-ESS programs currently have developed and implemented three assessment protocols that measure students' performance in achieving specified learning outcomes. These include assessment of three key learning goals for students enrolled in the Environmental Science BS program, student learning in an UD-ESS capstone environmental impact analysis course, and the efficacy of Discovery Learning Experience courses taken by many UD-ESS students. All of these assessment protocols adhere to best practices in assessment and provide evidence of the successful achievement of learning goals for the Environmental Science program and for students taking the capstone and Discovery Learning Courses. The Environmental Studies BA program was established in 2009 and has not yet undergone assessment.

Other recommended assessment tools for IE programs include student 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.[17] Internal (representatives from relevant units across the campus, UD-ESS 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.

Table 22. IE program assessment criteria

Criteria	Overall (*n*=260)	IE department (*n*=50)	Other department(s) (*n*=89)	IE school, college, division (*n*=8)	Other school(s), college(s), division(s) (*n*=80)	IE center, institute, cross-institutional program (*n*=25)
Student satisfaction	82%	94%	82%	88%	75%	96%
Internal review	61%	76%	54%	50%	61%	76%
Graduation rates	57%	74%	48%	63%	60%	60%
External review	52%	76%	39%	25%	54%	60%
Alumni satisfaction	51%	64%	53%	50%	41%	64%
Job placement	56%	58%	57%	75%	51%	72%
Faculty satisfaction	42%	50%	38%	50%	43%	48%
Student scholarship	39%	44%	32%	38%	43%	56%
Student portfolios	15%	18%	12%	13%	18%	20%
Other*	8%	12%	9%	0%	5%	12%

[17] 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 V – Comparison of ENVS and ENSC Degree Program Attributes with NCSE Study Findings

Enrollment, Objectives and Requirements

Program Enrollment Compared with Peer Programs

Table 23 illustrates enrollment data for the representative sample of undergraduate environmental science and studies programs that participated in the NCSE study for the 5-year period 2003-2008 (academic years). The census of programs conducted prior to the survey found a total of 373 undergraduate Environmental Science(s) programs (46% of all undergraduate IE programs) and 255 undergraduate Environmental Studies programs (32% of all undergraduate IE programs).

Both programs—the Environmental Science program (ENSC) and the Environmental Studies program (ENVR)—have high enrollments in comparison to peer programs at other research universities. Both are also growing rapidly—the ENSC program has grown 60% over the last year and the ENVR program 62%.

Anecdotal evidence suggests the programs could continue to grow; in 2010 the University of Vermont reports over 400 students enrolled in its Environmental Studies program and over 300 in its Environmental Science program, and the University of Michigan's Program in the Environment (which has science and studies tracks) reported over 350 majors.

Table 23. Comparison of ENVR and ENSC program enrollment to peer programs*

Degree Program	Peer Programs 2003-2008		Enrollment		
	Mean	Min/Max	2005-2008 Mean	2008-2010 Mean	Current
Environmental Studies BA/BS	*n*=13		-	20	63
	35	2/100			
Environmental Science(s) BS	*n*=26		-	90	142
	26	15/201			

*Comparable degree programs at doctoral RU/VH and RU/H universities.

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.[18] 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.

[18] Analysis of variances tests, p≥.05.

For undergraduate programs located at research universities the differences in average enrollment based on degree program names are similar (Table 24). The mean number of students enrolled in undergraduate programs named environmental science(s) is slightly lower than the mean for programs named environmental studies or those classified as policy, planning and management. Programs with other names have the highest average enrollments.[19]

Table 24. Undergraduate Program Enrollment by Name Type*

Degree Program Name Type	Average Enrollment 2003-2008	
	Mean	Min/Max
Environmental Science(s) (n=23)	57	15/201
Environmental Studies (n=26)	66	2/350
Policy, Planning and Management (n=13)	66	7/245
Other Science (such as Marine Sciences) (n=3)	84	3/220
Other (such as Environmental Systems) (n=8)	82	25/200

*Degree programs at doctoral RU/VH and RUH universities.

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.[20] The *Adaptive Management* approach has a significantly higher proportion of programs experiencing growing enrollments compared to the *Systems 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 findings for undergraduate programs located at research universities differ from programs overall in that the average number of students enrolled in degree programs associated with the *Adaptive Management* model is higher for programs named environmental science(s), but not for programs named environmental studies (Table 25). Consistent with the findings for all programs, a higher proportion of undergraduate programs named environmental science(s) fall within the *Systems Sciences* model (many of these are located within traditional departments) and a higher proportion of programs named environmental studies fall within the *Adaptive Management* model.

[19] Other sciences include Marine Sciences, Soil and Water Sciences, Environmental Geosciences. Other includes The Environment (BS and BA), Environmental Systems (BS and BA), Natural Resources, Natural Resource Conservation, Environmental and Natural Resources, and Environmental Geography.

[20] The names of degree programs were associated with the three ideal approaches, although not significantly so—a degree program named environmental studies, for example, may be associated with any of the three models (see the discussion on the prevalence of degree names types in the section of the report that discusses the models).

Table 25. Program enrollment by model

Degree Program Type*	Enrollment by Program Model 2003-2008					
	Policy & Governance		Adaptive Management		Systems Science	
	Mean	Min/Max	Mean	Min/Max	Mean	Min/Max
Environmental Studies BA/BS	*n*=3		*n*=5		*n*=3	
	35	2/90	28	11/50	27	5/40
Environmental Science BS	*n*=2		*n*=7		*n*=11	
	25	25/25	82	17/201	48	15/105

*Degree programs at doctoral RU/VH and RUH universities.

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[21] (undergraduate degree programs);
- Advancing environmental research[22] (undergraduate degree programs); and
- Improving environmental policy decisions[23] (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).

The ENSC program shares only one of the three objectives correlated with undergraduate program growth: advancing environmental research. The ENVR program shares two of the three: providing community service and preparing students to be environmental leaders. Both programs include sustainability in required coursework, and opportunities to participate in sustainability oriented research and applied/service learning projects; the ENVR program also includes sustainability as a core educational principle.

[21] Student participation in community-based applied or service learning experiences or internships.
[22] Student participation in environmental or sustainability research.
[23] Student participation in policy-oriented research or applied learning experiences.

Degree Requirements

Bachelor of Science in Environmental Science

- Minimum of 124 credit hours required for the BA degree; 58 hours in core courses required for the major
- An approved 3-6 credit field experience is required that integrates the components of the student's selected concentration in an experiential learning environment (i.e. internship, study abroad or research). For ES students this experience must include data collection, manipulation of data sets and weekly reports/field notes.
- A 3-credit capstone course is required to be completed the last semester of the senior year
- Students select a concentration consisting of 5-6 courses; options include atmospheric science, ecology and organismal biology, environmental soil science, geoscience, hydrology, marine science, pollution control, sustainability energy technology, and water quality and resources
- Students must also complete breadth requirements (Creative Arts and Humanities, History and Cultural Change, Social and Behavioral Sciences, and Mathematics, Natural Sciences and Technology), and general and university credit requirements for the university and their concentration college

Bachelor of Arts in Environmental Studies

- Minimum of 124 credit hours required for the BA degree; 44 hours in core courses required for the major
- An approved 3-6 credit field experience is required that integrates the components of the student's selected concentration in an experiential learning environment (i.e. internship, study abroad or research)
- A 3-credit capstone course is required to be completed the last semester of the senior year
- Students select a concentration consisting of 5-6 courses; options include international environmental politics and policy; environmental law, policy and politics; environmental economics and resource policy; and environment, society and sustainability
- Students must also complete breadth requirements (Creative Arts and Humanities, History and Cultural Change, Social and Behavioral Sciences, and Mathematics, Natural Sciences and Technology), and general and university credit requirements for the university and their concentration college

The requirements for undergraduate ENSC and ENVR degree programs are fairly typical of those required for the majority of undergraduate IE programs (Table 26). Both the ENVS and the ENSC require a minimum of 124 credit hours; typical credit hour requirements for baccalaureate degree programs nationwide are between 120 and 128. Both require completion of a capstone synthesis course; capstone courses are required by most undergraduate IE programs. Both require a field/experiential experience, a requirement for 14-32% of programs.

The survey did not include a question on how many hours are required for core courses or for specializations within a degree (areas, tracks, concentrations, majors) but almost all programs require a sequence of core courses and most offer several specialization options. The number of concentrations

offered is unusual; the maximum noted in the 2008 census was eleven and the mean was four to five. Together, the UD-ESS programs offer fourteen—ten for the ENSC degree and four for the ENVR degree.

Table 26. 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).

Alignment with IE Field Identity

In this section the ENSC and ENVR degree 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 UD-ESS 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. Curricula should include 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.

The program brochure describes the goal of the ENSC major as:

- to give students in the program a broad-based, interdisciplinary introduction to the scientific concepts, policies and issues;
- the common analytical tools needed to explore environmental issues in depth through their concentration areas; and,
- the ability to integrate and synthesize information from a multidisciplinary perspective in oral and written format through a capstone course.

The primary focus is on the rigor in math and science and appreciation of the "interconnectedness between understanding natural science processes and their applications and the social, political and institutional frameworks in which environmental issues are considered."

The program brochure describes the goal of the ENVR major as:

- to give students in the program a broad-based, interdisciplinary introduction to environmental policies and issues;
- the common analytical tools needed to explore environmental issues in depth through their concentration areas; and,
- the ability to integrate and synthesize information from a multidisciplinary perspective in oral and written format through a capstone course.

The primary focus is on understanding the environmental field and on "connecting science and society and balancing the needs of humans and other inhabitants with the needs to conserve the earth's precious resources."

The ENVS program and the ENSC program are fairly well-aligned with the national consensus on IE program field identity. However neither program has the stated goal of preparing students to be sustainability-oriented problem solvers. The focus on the interfaces of human societies and natural systems is implied but it's unclear whether the goal is to focus on the interfaces using an emphasis on one lens or perspective (natural science or social science) rather than primarily studying either natural systems or social systems.

Both degree programs do explicitly embrace an interdisciplinary educational approach that requires students to complete courses in the natural sciences, social sciences, and humanities and applied sciences. However, key concepts are not clearly integrated into a coherent systems-based approach to problem understanding and solutions development. With the exception of the Introduction to the Environment course the courses are developed and offered by traditional departments; very few are specifically designed as interdisciplinary environmental courses; the resulting curriculum is primarily multi-disciplinary with interdisciplinary integration left up to the students. Coursework in applied

sciences and professional fields are not included in required coursework but they are required for some concentrations.

Specific elements missing from the learning goals for both degrees that will ensure alignment with the key elements of IE program field identity are:

1. A more explicit focus on sustainability, including key concepts and context specific indicators and the role of governance and public stakeholders in progress toward a more sustainable future;
2. A more explicit focus on coupled human-nature systems approaches and methodologies for interdisciplinary integration in knowledge production and collaborative decision making processes;
3. An understanding of different epistemological perspectives (philosophy of science) in addressing environmental problems coupled with an understanding of the roles of technology, history, politics, cultural worldviews, values and science in environmental decision making.

Emphases on Ideal Knowledge and Skills Components

In this section, the current curricula and ideal curricula (as reported by the program director) of the ENSC and the ENVR are compared to the ideal curricula of IE programs nationwide. Please note that the data for ideal IE program curricula were analyzed in the first two sections of this report; the NCSE study queried program administrators on their current curricula as well as ideal curricula for each degree their program offers. The findings, including the factor score results and factor solution structures for current curricula are very similar to the results for ideal curricula and are therefore not included in this report.

Recall that the study revealed five interdisciplinary knowledge components and five integrated skills components for ideal IE curricula which are emphasized differently in three ideal educational approaches (the findings for undergraduate and graduate programs were essentially identical and so were combined for better statistical robustness). Figure 19 illustrates the component scores (emphasis on the ten knowledge and skills components) for the ENSC and ENVR degree programs compared to the means for all programs. The patterns are not consistent with any of the three ideal curricula models—*Systems Science*, *Policy and Governance* or *Adaptive Management*; instead they have unique patterns that reveal their unique structures.

The factors scores are based on the importance in ideal curricula/emphasis in current curricula on knowledge and skills areas ratings provided for the current ENSC and ENVR programs and on ideal ENSC and ENVR programs (on a four point scale of minimal/none=0, low=1, moderate=3, high=3). The factor scores are derived primarily from the ratings of the knowledge and skills areas that were significantly correlated with the factor. The knowledge and skills areas' degree of correlation with each factor influences the factor scores.

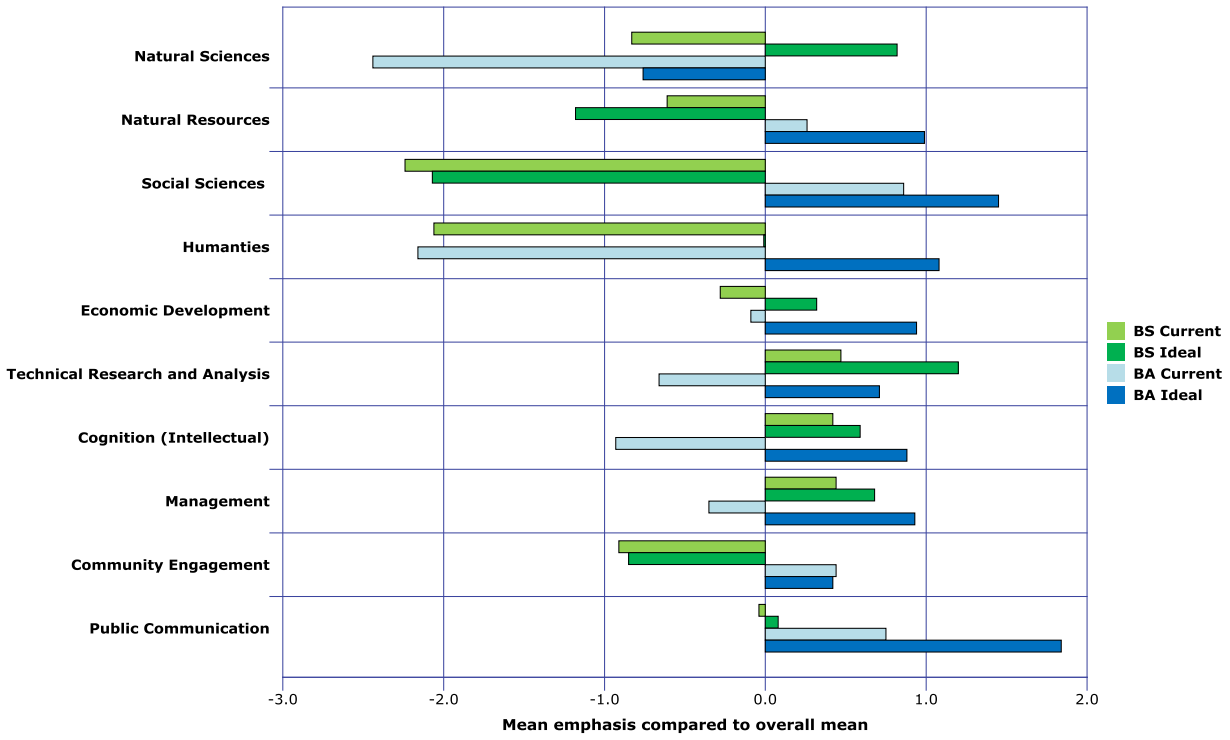
The ENSC current curriculum has component scores well below the mean for two knowledge components—*Social Sciences* and *Humanities* and around the mean for the other three components. The current ENSC program is natural sciences intensive with high emphasis on the physical sciences.

Because the life sciences and ecology are not emphasized as much in the current curricula the score on *Natural Sciences* for the current ENSC program was below the overall average.

The ideal ENSC curriculum exhibits higher scores for the *Natural Sciences* component due to a higher emphasis on life sciences and ecology, and on the *Economic Development* component due to a higher emphasis on business concepts. Both the current and ideal curricula are above the mean for three skills components—*Technical Research and Analysis*, *Intellectual*, and *Management.* Both are at the mean for the *Public Communication* and below for the *Community Engagement* skills components.

The ENVR current curriculum has component scores above the mean for the *Social Sciences*, at the mean for *Natural Resources* and *Economic Development* and substantially below the mean for *Natural Sciences* and *Humanities* knowledge components. The ideal curricula has scores above the mean for all but the *Natural Sciences* which is also closer to the mean that for the current curricula. The current ENVR curriculum exhibits scores about the mean for two skills components---*Public Communication* and *Community Engagement*—and below the mean for the other three. In contrast, the ideal curriculum exhibits scores above the mean for all five components. The differences between the current and ideal curricula are greater for the ENVR degree but there are also substantial differences in the ENSC degree as well.

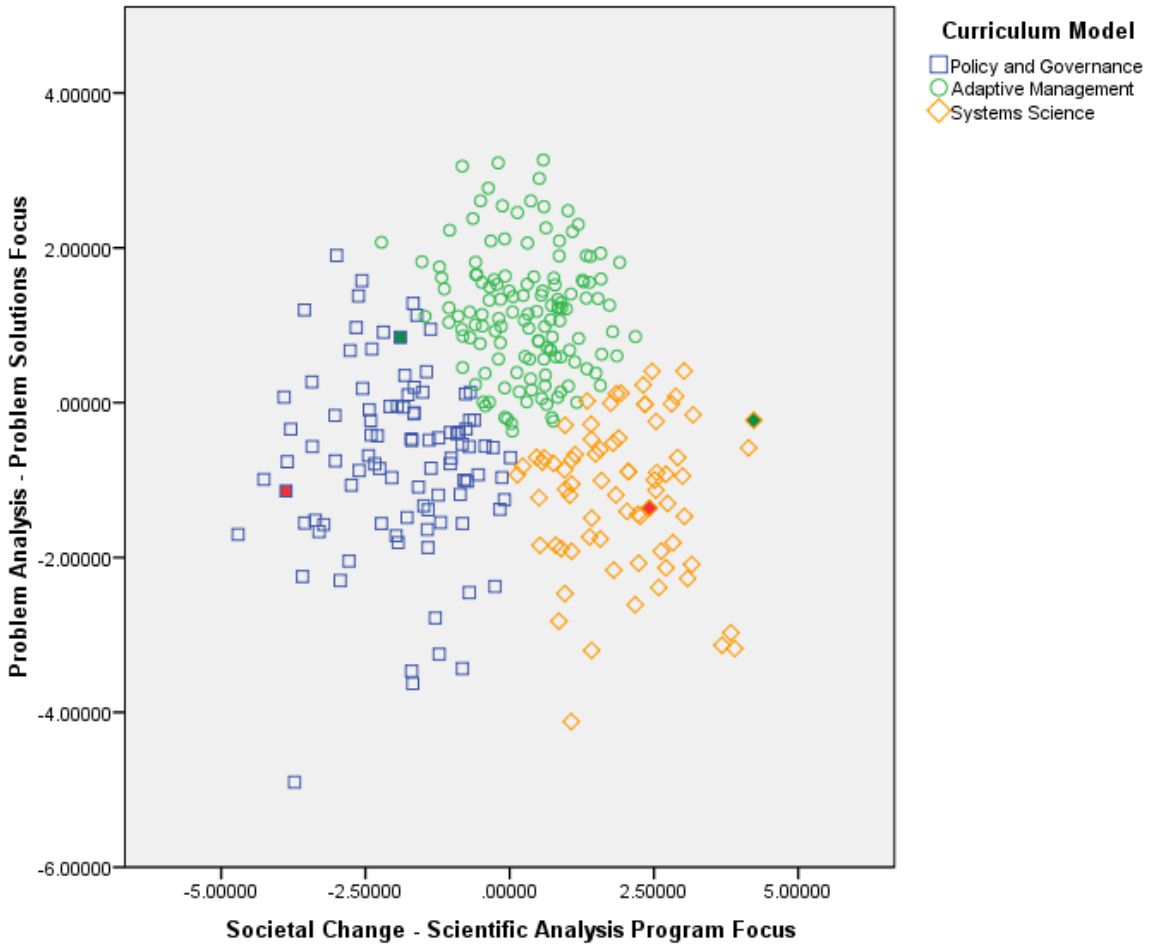
Figure 19. Comparison of Knowledge & Skills Components



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 20. Programs plotted on two dimensions that distinguish approaches (ideal curricula)
(Red square = ENVR current, green square ENVR ideal; Red diamond = ENSC current, green diamond ENSC ideal)



When plotted together with the 304 programs from the original NCSE study, the current ENSC curriculum falls right in the center of the *Systems Science* group indicating emphasis on the natural

sciences and technical analysis of environmental problems. The ideal ENSC curriculum moves up on the second dimension indicating more emphasis on managerial skills and natural resources management knowledge and further to the right on the first indicating an even stronger emphasis on natural sciences and technical research and analysis skills. Both are situated within the *Systems Science* approach.

The current ENVR curriculum falls on the leftmost edge of the *Policy and Governance* group indicating a high emphasis on social analysis of environmental programs. In contrast, the ideal ENVR curriculum moves up on the second dimension indicating a higher emphasis on solutions development and also more to the right indicating a more balanced emphasis on a combined social and natural systems analysis of environmental problems. Both are situated in the *Policy and Governance* approach with the ideal lying on the border with the *Adaptive Management* approach.

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).[24] It identified the size of the environmental protection industry as $341 billion/year and growing (projected to reach $496 billion in 2020; larger than most industrial sectors and the top Fortune 500) and estimated the industry was responsible for the creation of 5.3 million jobs in 2005 distributed across all employment sectors. 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, Delaware and other states in the region 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. In 2008, environmental scientists and specialists held 85,900 jobs; an additional 6,200 jobs were held by environmental faculty. 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 (EPA) 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.

[24] 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.

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 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 (USEPA) 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."[25]

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.[26] 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.[27] The report emphasizes the need for environmental education and research to

[25] 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.
[26] http://www.epa.gov/ocfo/plan/plan.htm.
[27] National Science Foundation AC-ERE. 2009. *Transitions and Tipping Points in Complex Environmental Systems*. Washington, DC: National Science Foundation.

"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 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.[28] Transdisciplinary processes include other types of actors in addition to scientific and technological experts, including environmental practitioners, policymakers, economic sector representatives, and public stakeholders.[29] 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 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". [30] These forms of expertise align well with the

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

[29] *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.

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

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).

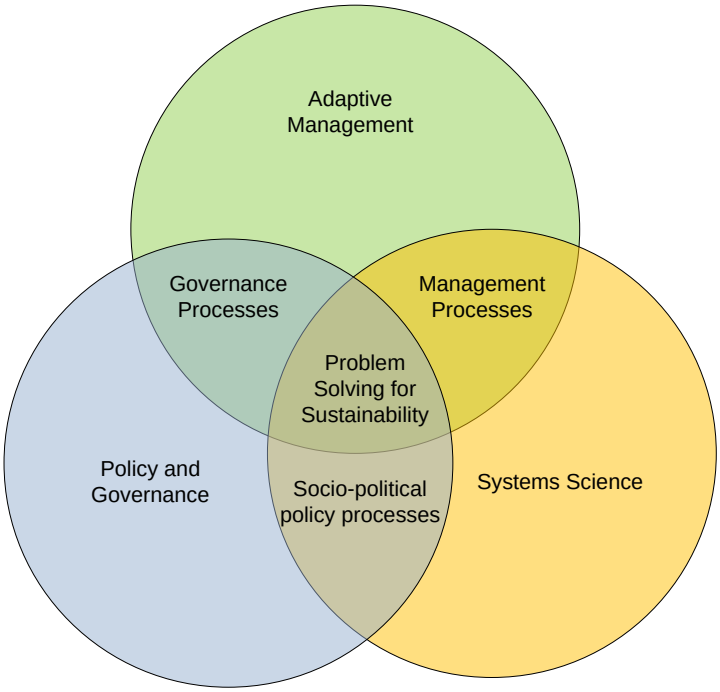
The *Systems Science* model can prepare scientists who, through their combination of breadth of understanding of sustainability and interdisciplinary processes and disciplinary depth in an area of the natural sciences or in a thematic area such as biodiversity can effectively participate in interdisciplinary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

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 21 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 21. 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 hundreds. 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.[31]

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."[32] 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.[33] 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.[34]

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.[35] Higher education is another sector where demand for sustainability professionals is high.[36]

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[31] Hossay, P. and T. Chirenje, 2011. *Proposal for a Sustainability Degree Program,* The Richard Stockton College of New Jersey.

[32] MIT Slocan Management Review and the Boston Consulting Group. 2011. Sustainability: The 'Embracers' Seize Advantage. *MIT Sloan Management Review.*

[33] United States Conference of Mayors. 2008. *Current and Potential Green Jobs in the U.S. Economy*. Global Insight, Lexington, MA.

[34] 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.*

[35] Willard, M., et al. 2010. *The Sustainability Professional: 2010 Competency Survey Report*. International Society of Sustainability Professionals.

[36] Association for the Advancement of Sustainability in Higher Education. 2010. *Higher Education Staffing Survey*. AASHE.

The SimplyHired.com trend tool tracks internet job postings; it illustrates there are currently many more job postings with environmental in the title/description (~2.25% of all postings) compared with sustainability (~.2%). However, there has been substantial growth in sustainability jobs over the past few months (an 83% increase since April 2010) in comparison to environmental jobs which have remained steady (Figure 22).

Figure 22. Job posting trends for environmental and sustainability

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.[37] 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 auditors*
- *Sustainability consultant*
- *Energy consultant*
- *Environmentally friendly production experts*
- *Design and materials consultant*
- *Green construction management*
- *Organic and sustainable food production*
- *Nonprofit management*
- *Policy advocate*
- *Community organizer*
- *Sustainability educator*

[37] Hossay, P. and T. Chirenje, 2011. *Proposal for a Sustainability Degree Program,* The Richard Stockton College of New Jersey.

- *Planner or municipal sustainability official*
- *Regulatory agent*

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.[38] 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

[38] 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.

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 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 – Conclusions and Recommendations

The University of Delaware is a prominent leader and innovator in environmental education and sustainability in higher education. The university's strategic plan adopted in 2008, The Path to Prominence, identifies The Initiative for the Planet as one of six key initiatives—a commitment to leadership in environmental research and education and in campus sustainability. The Environmental Studies program was established in 2009 in response to this initiative.

The foundations of the current College of Earth, Ocean and Environment (CEOE) were established in 1970 making it one of the oldest university programs dedicated to the study of the environment. The CEOE has been undergoing a major transition that strengthens its preeminent role in interdisciplinary environmental education and research. The original Marine Studies graduate college was transformed into the new School of Marine Science and Policy, and the Department of Geological Sciences joined the CEOE in 2006 and the Department of Geography in 2009. The CEOE now offers undergraduate and graduate degrees in Geography (BA, MA, MS, PhD), Geology (BA, BS, MS, PhD), Geography Education (BA), Earth Science Education (BA), Environmental Science (BS), Environmental Studies (BA), Marine Science (BS), Marine Studies (MS, PhD), Ocean Engineering (MS, PhD), Oceanography (PhD) and professional Master of Marine Policy and Master of Marine Management degrees.

The CEOE is a longtime leader in Mid Atlantic marine and ocean research and management and is the administrative home of the Delaware Geological Survey, the Delaware Geographic Alliance, the University of Delaware Sea Grant Program, and the Scientific Committee on Oceanic Research. It is part of the Mid Atlantic Fisheries Management Council, the Mid Atlantic Governors' Coalition on Regional Ocean Governance and the lead institution for the NOAA Sea Grant Mid Atlantic Research Plan.

The University's reputation as an environmental educational leader is evidenced by its ability to attract students from across the United States—a majority of of its freshmen are from other states—and by its large and growing undergraduate programs in environmental science and studies.

The Environmental Science program was established in the early 1990s and has a successful history of multi-disciplinary education in the environment. The Environmental Science (ENSC) and Environmental Studies (ENVR) programs span several colleges, allowing students to specialize in a concentration in one of four: The College of Earth, Ocean and Environment (CEOE), The College of Arts and Sciences (CAS), The College of Agriculture and Natural Resources (CANR) or the College of Engineering (CE). The majority of students in both majors choose to matriculate in either the CEOE or CAS.

UD-ESS Administrative Program Attributes Summary

The administrative attributes section of the report compares the Environmental Science and Environmental Studies (UD-ESS) programs to IE programs nationally in six areas: (1) peer/aspirational institutions' IE programs, (2) administrative location/structure of the program, (3) program leadership and faculty, (4) program resources—availability of different types of program-specific funding and other resources, (5) engagement with campus institutes/centers and external partners, and (6) program assessment criteria and procedures.

All twelve of the peer/aspirant institutions identified by the CEOE offer undergraduate environmental degree programs in Environmental Science/and Earth/and Policy/and Technology, Environmental Studies, Environmental Policy, Environmental Resource Management/Natural Resources Management, Environmental Geosciences/Geology, Environmental Geography, Environmental/Environmental Systems Engineering, Agricultural and Extension Education with a concentration in Environmental Science, and Community, Environment and Development.

Six of these programs were included in the representative sample that participated in the 2008 NCSE survey and study: two are aligned with the *Adaptive Management* model, three with the *Policy and Governance* model and one with the *Systems Science* model. Consistent with the NCSE study findings, adoption of sustainability as a core guiding principle was associated with program growth and the *Adaptive Management* and *Policy and Governance* models were more prevalent than the *Systems Science* model.

Seven of the twelve institutions offer undergraduate programs in environmental science and studies. One offers these degree programs through a university-spanning center, three through departments of environmental science(s), four through autonomous programs that span a college or colleges, and one through the Department of Geology and Planetary Sciences.

The administrative location of the UD-ESS program (in a traditional department) was revealed by the National Council for Science and the Environment (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. 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. Most importantly, these programs were also the most successful at offering ideal IE curricula. The UD-ESS programs are unique since although they are administratively housed within a traditional department, they are located in an IE college and span four colleges similar to an institution spanning program.

Leadership capacity and core faculty resources are significant competitive factors for IE programs. Program leadership was one of four factors rated of high importance for program success in the NCSE survey. The UD-ESS programs have a full-time Director, an important advantage.

However, the program is at a disadvantage compared with many peer programs due to lack of an operating budget and very limited staffing and resources. Additional leadership, staffing and resource capacity is needed to be able to enhance the UD-ESS students' educational experiences (including development of UD-ESS honors programs), support faculty participation for program development (i.e. course development), and develop defined relationships with campus environmental research centers and/or formalized partnerships with other higher education institutions and external organizations. Most importantly, the program has no capacity for hiring core interdisciplinary tenure-track faculty through faculty lines or joint appointments.

Program assessment is an important area of strength; the program director has expertise in assessment and has established effective assessment protocols for the Environmental Science program, the required

UD-ESS senior capstone course, and Discovery Learning Courses taken by UD-ESS majors. However the programs do not utilize innovative new approaches such as the development and evaluation of student portfolios or processes that strive to align curriculum better with emerging workforce needs. The students expressed a desire for both of these types of assessment-related activities.

ENSC and ENVR Degree Programs Attributes Summary

The degree attributes section of this report compares the UD-ESS degree programs to IE degree programs nationally in six areas: (1) enrollment number and trend, (2) degree requirements, (3) curricular alignment with key elements of IE field identity, (4) curricular emphases on the ideal components of IE knowledge and skills, (5) curricular alignment with the IE ideal educational models framework, and (6) curricular alignment with evolving workforce preparation needs.

Both programs—the ENSC and the ENVR—are large in comparison to peer programs at other research universities. Both are also growing rapidly—the ENSC program has grown 60% and the ENVR program 62% in the last year.

The NCSE study found a number of factors that correlate positively and significantly with enrollment trend and number. 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 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 the *Adaptive Management* model were more likely to exhibit a growth trend than the other two models.

The ENSC degree program shares one of the three objectives correlated with undergraduate program growth—advancing environmental research—but not the objectives of preparing students to be leaders and change agents or providing community service. The ENVR degree program shares these two goals but not the objective of advancing environmental research (although it does of advancing sustainability research) shown to be correlated with undergraduate program enrollment growth. Both programs include sustainability in required and optional coursework, and in sustainability-oriented research experiences and applied/service learning opportunities. Sustainability is a core educational principle for the ENVR program but not the ENSC. The ENSC program curriculum aligns with the *Systems Science* model and the ENVR with the *Policy and Governance* model.

The degree requirements for both ESS programs are generally consistent with those of other undergraduate IE programs at research universities. The programs have a strategic advantage over the majority of programs by requiring an experiential component—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. Based on comparisons with the NCSE national findings on ideal IE curricula, both UD-ESS programs are not well aligned with the consensus on the key characteristics of the field of IE education and not ideally structured in terms of inclusion of the ten ideal interdisciplinary knowledge and integrated skills that should be part of the curricula of every IE program.

The mission and goals of the ENSC program and the ENVR programs are not clearly aligned with the national consensus on IE program field identity because neither program has the stated goal of preparing students to be sustainability-oriented problem solvers and the focus on the interfaces of human societies and natural systems is implied but the curricula appears to primarily focus on either natural systems or social systems. Both UD-ESS degree programs do explicitly embrace an interdisciplinary educational approach that requires students to complete courses in the natural sciences, social sciences, humanities and applied sciences. However, key concepts are not clearly integrated into a coherent systems-based approach to problem understanding and solutions development. As a result, the curricula are primarily multi-disciplinary with interdisciplinary integration left up to the students.

The UD-ESS programs are aligned with two of the three ideal approaches to IE education that prepare students for three broad categories of IE careers: the *Systems Science* model that prepares students as environmental research scientists and technicians (or entry into natural sciences-oriented graduate programs), and the *Policy and Governance* model that prepares specialists and citizens involved in environmental policy, planning, administration and governance. Neither program is aligned with the most desirable IE model (most popular among program administrators, students and employers), the *Adaptive Management* model, that prepares students to be environmental and sustainability management and decision making professionals.

Specific elements missing from the learning goals for both degrees that will ensure alignment with the key elements of IE program field identity are:

1. A more explicit focus on sustainability, including key concepts and context specific indicators and the role of governance and public stakeholders in progress toward a more sustainable future;
2. A more explicit focus on coupled human-nature systems approaches and methodologies for interdisciplinary integration in knowledge production and collaborative decision making processes;
3. An understanding of different epistemological perspectives (philosophy of science) in addressing environmental problems coupled with an understanding of the roles of technology, history, politics, cultural worldviews, values and science in environmental decision making.

The NCSE study identified ten core components that should be included in all IE program curricula—five interdisciplinary knowledge components and the five integrated skills components. The ideal IE knowledge components were rated of overall level of importance for ideal IE program curricula in the following order: *Natural Sciences, Natural Resources, Social Sciences*, *Humanities*, and *Economic*

Development. The ideal IE skills components were rated of overall level of importance in the following order: *Cognition (Intellectual), Technical Research and Analysis, Community Engagement, Public Communications,* and *Management*. The components are emphasized and structured into a coherent curriculum based on the ideal educational approach chosen for each degree program—*Systems Sciences*, *Policy and Governance* or *Adaptive Management*.

The UD-ESS programs do not clearly incorporate all ten in a cohesive, structured program that emphasizes systems-approaches to interdisciplinary problem-solving. The students expressed a desire for programs that better structured the curricula to address problem understanding from natural sciences and socio-political perspectives as well as solutions development that integrates scientific analysis, community engagement (stakeholder involvement, conflict resolution) and process management. The ENSC students wanted more understanding of policy and collaborative decision-making and the ENVR students wanted more qualitative skills (especially social science statistics) and science.

The ENSC is positioned within the *Systems Science* approach because of its higher emphasis on the natural sciences versus the social sciences.[39] The ENVR program is positioned within the *Policy and Governance* approach due to its higher emphasis on social sciences and lower emphasis on scientific technical analysis and research skills. The ideal ENVR program is located close to the border of the *Adaptive Management* approach due to higher emphases on management and community engagement skills.

The alignment of the ENVR BA is consistent with programs nationally—69% of IE BA programs at research universities are aligned with the *Policy and Governance* model. However the alignment of the ENSC degree with the *Systems Science* model is not consistent with the majority of IE BS programs at research universities. Most BS programs (48%) are aligned with the *Adaptive Management* model. Only 34% of BS programs are aligned with the *Systems Science* model and 18% with the *Policy and Governance* 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.

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. Employers are also seeking discipline-focused specialists with broad understanding of sustainability and collaborative decision making processes, however, increasingly the traditional science disciplines and many professional disciplines (such as public health, business management, agriculture, architecture, landscape design, and urban planning and community development) are focused on problem solving for sustainability and interdisciplinarity/transdisciplinarity collaborative processes in the context of their own disciplines/professions. IE programs must clearly differentiate the competencies of their graduates from the competencies of graduates of traditional programs focused on understanding natural processes and anthropogenic perturbations. IE degree programs that draw substantially upon traditional disciplinary traditions must be careful that they do

[39] The position on the horizontal axis is primarily due to the curricular emphases on natural sciences knowledge and technical research and analysis skills.

not end up preparing students to view environmental and sustainability issues only through traditional disciplinary lenses rather than through a true IE approach.

Key elements that distinguish IE programs from traditional programs include: (1) breadth of knowledge, (2) understanding of how different epistemologies, cultures and sociopolitical milieus both facilitate and impede effective environmental problem solving, and (3) skills in interdisciplinary and transdisciplinary methodologies to support systems thinking, systems-based interdisciplinary research, and transdisciplinary collaborative knowledge production and decision-making processes. It is the *process* of integrating and synthesizing knowledge for interdisciplinary and transdisciplinary real-world problem solving that distinguishes the IE field from other disciplines.

Recommendations

Consider realigning the ENSC toward an Adaptive Management approach. The UD-ESS should consider which ideal IE model approach is the best fit for the ENSC. An *Adaptive Management* approach prepares students to be "meta experts" who understand competing knowledge claims and the types of expertise required for environmental and sustainability problem-solving and therefore can serve as decision-process administrators and managers. This approach is consistent with a transdisciplinary approach to problem solving as well as evolving IE workforce needs as defined by the federal government, employers and IE professionals. It is also the preferred model for IE program leaders and students; ESS students enrolled in both programs expressed interest in curricula more aligned with this model. Alternatively, the ENSC program could have research and professional tracks aligned with the *Systems Science* and *Adaptive Management* approaches respectively.

Consider offering fewer concentrations aligned with environmental/sustainability themes. The three ENSC concentrations offered through the College of Engineering—Pollution Control, Sustainable Energy Technology, and Water Quality and Resources—each have fewer than 5 students. This is at least partially due to course prerequisites and College of Engineering requirements but may also be due to a lack of student interest. One ENSC concentration—Environmental Soil Science—has no students likely because it is offered as a minor by the Department of Plant and Soil Sciences. Three of the ENSC concentrations are essentially a minor in a disciplinary area—Ecology and Organismal Biology, Environmental Chemistry, and Geoscience. The remaining three—Atmospheric Science, Hydrology and Marine Science—are the most interdisciplinary and are the most popular with students. The Marine Science concentration fulfills the requirements for the Marine Studies minor offered by CEOE. Another similar minor—Coastal and Marine Geoscience—is also offered by the CEOE.

ENVR students feel that the four concentrations offered are all essentially the same and often choose the Environment, Society and Sustainability concentration because they prefer the CEOE as their home college. The ED-ESS students all expressed a desire for themed-based concentrations that prepared them for real world problem solving and development of professional skills.

Concentrations ideally should be designed to align with knowledge and especially professional skills related to problem-solving for sustainability in one of the four priority areas delineated by the USEPA—sustainable water resources, sustainable communities (including health and planning), energy and climate (including adaptation, mitigation and communication) and sustainable materials and processes

design. I recommend offering fewer, redesigned concentrations for both majors. For the ENSC majors hydrology could become sustainable water resources or watershed management, atmospheric science could become energy and climate or renewable energy (incorporate technology courses from engineering), marine sciences could become coastal and marine management to distinguish it from the marine studies minor. Additional minors may be developed based on the existing concentrations and institutional strengths---for example sustainable materials design (chemistry and chemical engineering) or sustainable ecosystems management (biodiversity, land use planning, and climate adaptation).

The ENVR concentrations should focus on emerging career growth areas such as sustainable enterprise management, environmental management systems, community planning and administration, policy development and analysis, and/or international sustainable development.

Consider making CEOE the home college for all ESS students. Currently the UD-ESS students have two academic homes, the CEOE and the college where their concentration resides. This arrangement was designed to facilitate cross-college participation in the program based on the responsibility based budget process (RBB) adopted by the university that allocates funds based on student enrollment in the courses taught by different units. While this structure worked well to engage the participation of the other colleges, it is viewed as highly detrimental by the students (the ones I spoke with at least). The students identify their home as the CEOE and prefer to have consistency in advising (rather than having dual advisors in the ESS programs and in their concentrations) and in the program requirements required to complete their degree. They feel unrecognized and left out in their concentrator colleges. Since the majority of students select concentrations within CEOE and the core course requirements compel the students to take courses in other colleges, the fiscal impact of consolidating all ESS students administratively in the CEOE is minimal. Conversations with college representatives indicate that the participating colleges would not be opposed to this change.

Consider restructuring the core to better align the curricula with the key elements of field identity and ideal curricula by developing a set of core courses specifically for UD-ESS majors. Neither degree program includes an explicit focus on the interfaces of human societies and natural systems, or on the goal of preparing students to be sustainability-oriented problem solvers, or explicitly includes systems thinking and synthesis as key learning outcomes. Both programs should share core curricular requirements that focus on sustainability as a core principle, preparing students to understand how sustainability is defined, operationalized and evaluated in different contexts and across geographic and temporal scales.

The ENSC and ENVR programs currently appear to only incorporate leadership, management skills, sustainability and systems-approaches in an ad hoc manner rather than as distinctive educational goals for program graduates. These are key characteristics, knowledge domains, and skills that employers emphasize. The workforce of the future requires an increase in complex communication and expert thinking skills. For IE professionals this translates to leadership; oral, written and digital communication skills for both expert and lay audiences; broad understanding of environmental and sustainability issues and concepts; and skills in system-thinking and collaborative decision-making and knowledge production processes.

All students should understand complexity and interdisciplinary/transdisciplinary systems approaches for addressing environmental problems and ideally participate in a real world problem-solving experience using systems methodologies (capstone experience, internship, research, etc.). Both programs should include an understanding of different epistemological perspectives (philosophy of science) in addressing environmental problems; and the roles of history, politics, cultural worldviews, values and science in environmental decision making. A global perspective coupled with leadership and management skills are optimal core competencies for all students; especially IE graduates.

A series of four core courses and a senior capstone course can be designed to introduce students to the ten interdisciplinary knowledge and integrated skills components found in ideal IE curricula. These five courses may include: (1) an overview of the fundamentals of environmental science and studies including current issues and an introduction to core concepts of sustainability (Introduction to the Environment); (2) a course that integrates core concepts in the natural sciences relevant to understanding natural systems and anthropogenic perturbations—this course should include understanding of the scientific method, the limitations of science, and uncertainty; (3) a course that integrates core concepts in the social sciences and humanities relevant to understanding the interrelationships between social and natural systems—this course should include economic systems, historical perspectives, ethics, and values; and (4) a course that introduces systems approaches for developing new understanding and knowledge or for facilitating policy development and management decisions—this course should include a discussion of differing epistemological and methodological perspectives on environmental issues as well as an introduction to stakeholder involvement and conflict resolution, and (5) a capstone course focus on a real-world problem using a simplified sustainability-oriented, systems-based problem solving process recommended by the National Research Council as a national model.

The current capstone required for UD-ESS majors is an excellent problem-based learning course; however it is based on a rubric explicitly based on geography proficiencies rather than IE proficiencies. Ideally the capstone course should include a real world problem solving exercise that includes perspectives from the natural sciences (i.e. ecology, hydrology), the social sciences (i.e. policy, law, economics, behavioral sciences), the humanities (i.e. history, ethics, aesthetics, values), the applied sciences (i.e. available technology, feasibility) and professional fields (i.e. management, success indicators, implementation, administration). See issue three of the *Journal of Environmental Studies and Sciences* for a series of IE capstone course case studies and *Sustainability and the U.S EPA* (National Research Council) for a the sustainability assessment and management framework that elucidates a national model for sustainability-oriented, systems-based problem solving.

The development of new courses will require resources; however, since all UD-ESS students will be required to take the core courses they should ultimately provide a positive return on investment for the UD-ESS programs based on the RBB model.

Consider offering honors degree programs for both majors. The UD-ESS students strongly desire honors options for both the ENSC and ENVR degree programs. Making CEOE the home college for all

UD-ESS majors and allocating resources for course development (courses within CEOE and courses offered through other academic units) will help to facilitate this important student goal.

Consider additional assessment and professional development processes. Recommended assessment tools for IE programs include student 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.[40] Internal (representatives from relevant units across the campus, UD-ESS 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.

The UD-ESS students requested more focus on professional development with more information provided on environmental and sustainability careers and more formalized internship matching. 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 for the UD-ESS programs.

Consider a new autonomous administrative unit for the UD-ESS programs. The UD-ESS has significant challenges based upon its location within the institutional hierarchy, burgeoning demand for environmental and sustainability education, and limited resources. In order to continue to grow, fulfill its potential to contribute to University of Delaware's strategic goals in environmental education and research, and to compete effectively with peer programs at other research universities, the UD-ESS programs require more administrative agency. 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 support optimal IE program curriculum development while ameliorating the tenure and promotion challenges often cited as problematic for interdisciplinary scholars.

The UD-ESS programs need more autonomy to enhance their visibility and enable them to develop interdisciplinary courses and to facilitate cross-campus partnerships with other departments, university research centers (such as the Environmental Institute) and external partners. Ideally the UD-ESS would be able to hire core interdisciplinary faculty (tenure-track lines and/or joint appointments).

[40] 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.

One way to advance the University of Delaware's and CEOE's strategic goals, leverage limited resources efficiently, and ensure that the IE majors receive an ideal IE education is to create a unified school located within the CEOE that merges the UD-ESS programs with the Departments of Geography and Geology. The creation of a new school of the environment/sustainability that complements the School of Marine Sciences and Policy can fulfill a number of important institutional goals by supporting an explicitly interdisciplinary environmental community while also drawing upon related strengths across CEOE and the university. It could 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.

One example of a program undergoing a similar transition is the Department of Environmental, Earth and Ocean Sciences at the University of Massachusetts-Boston which was formed in 2005 by the merger of the undergraduate only Earth and Geographic Sciences department from one college and the graduate only Environmental, Coastal, and Ocean Sciences department from another; it is now transitioning to a new school of the environment. Another example is the at University of Virginia where the departments of Geography and Geology where merged to create a department of Environmental Sciences that now offers undergraduate and graduate degrees in environmental sciences and has four areas of specialization: surface geology and geomorphology, atmospheric processes, hydrology, and ecology.

An IE school can provide a hub for CEOE collaboration with other environmental research centers across the university and with other institutions of higher education, governmental, and private and public sector for-profit and not-for-profit entities by connecting and integrating environmental expertise in environmental and sustainability areas other than marine science and policy. It can also nurture interdisciplinary research by providing a stable forum for developing and implementing joint projects and create a visible university organization dedicated to solving pressing environmental societal problems—becoming an additional CEOE focal point for external organizations seeking assistance and advice on environmental and sustainability issues, and supporting collaborative environmental science and sustainability teaching and research with partner institutions and organizations.

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 institutes, colleges, schools and campuses dedicated to the study of the environment and sustainability. Examples include the School of Sustainability at Arizona State University, the School for Global Environmental Sustainability at Colorado State University, the School of Global Sustainability at the University of South Florida, and the School for Sustainability and the Environment at Chatham University (housed on its own campus).

Representatives of newly instituted IE schools 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 schools 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 organizes 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. Some schools provide a hub for collaborative education programs and research initiatives for faculty tenured in other academic units. Two that share this model are the School for Global Environmental Sustainability at Colorado State University and the School of Global Sustainability at the University of South Florida.

Although each institution structures their unit differently, representatives of newly instituted IE schools agree that three key elements must be effectively addressed in implementing a successful new academic unit: (1) a shared vision for the unit with support from across the campus, especially from top administrators and faculty (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. Case studies and guidance on Interdisciplinary hiring, tenure and promotion is available on the NCSE website (Hiring, Tenure and Promotion: Guidance for Individuals and Institutions**;** http://ncseonline.org/CEDD/cms.cfm?id=1505).

Establish structured partnerships that provide students with enhanced opportunities. Most research institutions have one or more centers dedicated to environmental and/or sustainability issues with the majority focused exclusively on facilitating faculty collaboration on environmental research. However, a number of institutions are developing innovative partnerships with sustainability-oriented centers and institutes that go beyond facilitating faculty research and collaboration to provide invaluable educational resources and opportunities for IE students at all levels—undergraduate to doctoral. The UD-ESS program should consider ways to leverage its new, nascent and existing centers to enhance undergraduate interdisciplinary environmental and sustainability education and research.

Nationally, formal external partnerships are also 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 ESS

program should work with existing prospects and potential new partners that can enhance environmental and sustainability education, research and outreach that benefit society.

The University of Michigan is an example of a research institution that is developing innovation research and educational partnerships with two institutes affiliated with the university: The ERB Institute for Global Sustainability Enterprise and the Graham Sustainability Institute. Both provide a variety of learning and skills development opportunities for students enrolled in the undergraduate Program in the Environment and in graduate programs offered by the School of Natural Resources and the Environment.

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.

An example of an IE program that has developed a variety of formal partnerships—with a number of domestic higher education institutions, governmental entities, and non-governmental organizations—is the School of Environmental Sciences (SES) at Florida A & M University (FAMU) which offers undergraduate and graduate degrees in environmental sciences. FAMU is one of fifteen Florida higher education institutions that are members of the Florida Institute of Oceanography (FIO). The FIO is a state organization established in 1967 to maximize marine research and education by supporting faculty research via shared resources and vessels. Since 2008, the FIO has been designated as one of Florida's Academic Infrastructure Support Organizations. It operates the Keys Marine Laboratory, has a close working relationship with the Florida Department of Environmental Protection, and conducts education initiatives for K-12. Recently, the FIO has taken a leadership role in the national Oil Spill Academic Task Force assessing the impact of the Deepwater Horizon Oil Spill in the Gulf of Mexico. The FIO coordinates collaborative marine and coastal research, and provides member institutions with ship time and facilities at the Keys Marine Laboratory for teaching and research.

The FAMU SES has developed strong partnerships with the Harvard School of Public Health (MA) and with seven other higher education institutions through its leadership in a NOAA funded Environmental Cooperative Science Center. These include Creighton University (NE), Delaware State University (DE),

Jackson State University (MS), Morgan State University (MD), Texas A&M University at Corpus Christi (TX), the University of Miami (FL) and the University of Nebraska at Lincoln (NE).

The FAMU SES also has established partnerships with a number of federal and state governmental organizations and key non-governmental organizations focused on environmental education and sustainability issues in higher education. Governmental organizations include the U. S. Geological Survey; the U. S. Environmental Protection Agency, the Florida Department of Health, the Florida State legislature, and the National Estuarine Research Reserves (Apalachicola, FL; Mission-Aransas, TX; Chesapeake Bay, MD; Grand Bay, MS; Townsend, DE; Dover, DE; Florida Keys, FL).

FAMU SES students and faculty are engaged with these 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. The SES is also actively engaged with a number of local and regional non-governmental organizations through its involvement in numerous program development and educational research initiatives.

The CEOE has numerous relationships with external partners focused on marine science, policy and management that provide opportunities for students; these types of partnerships should be extended to provide similar opportunities for UD-ESS students focused on other environmental areas.

Consider developing new IE graduate degree and dual-degree options for UD-ESS majors. Neither the ENSC nor the ENVR provide an opportunity for seamlessly continuing education in environmental studies or sciences via five-year accelerated bachelor/masters programs. The majority of IE program undergraduates continue their education and many IE programs are developing five-year accelerated degree programs. University of Delaware students should have the opportunity to seamlessly continue their studies in appropriate masters-level graduate programs and/or five-year programs. The Marine Studies, Marine Policy, Marine Management, Energy and Environmental Policy, Water Science and Policy programs are ideal existing candidates for 5-year programs. New graduate programs in Environmental Science and Studies should be considered; Professional Science Masters which combine studies in science and business are increasingly in demand.[41]

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. A dual environmental master's degree combined with a policy focused master's degree offered would likely be very competitive (only three other universities offer this option). Other dual options, including a MSES-Master of Business Administration program and dual degree options in public health should also be considered. 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.

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

The UD-ESS programs are strong programs with growing enrollments. They have a number of positive attributes and enjoy high levels of commitment from the students, the program director, the CEOE leadership and the participating faculty. However, in order to achieve their leadership potential and continue to compete effectively with IE programs at top research universities the UD-ESS programs require structural changes and increased resources; ideally including resources for a full-time director and appropriate staffing resources and key core interdisciplinary tenure-track faculty lines.

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 α=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 α=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 α=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 α=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 $\geq$ 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 $\geq$ 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 Masters 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 Masters 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 Masters 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 Pittsburghh-Johnstown	PA	Environmental Studies Program
University of Pittsburghh	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