Interdisciplinary Environmental Education on the Nation's Campuses:

Elements of Field Identity and Curriculum Design

A research study conducted by
The Council of Environmental Deans and Directors
of the National Council for Science and the Environment



Shirley Vincent, Ph.D.

June 2010

National Council for Science and the Environment
Improving the scientific basis for environmental decisionmaking

National Council for Science and the Environment

The National Council for Science and the Environment (NCSE) is a not-for-profit organization that improves the scientific basis for environmental decision-making.

NCSE specializes in bringing together diverse institutions and individuals to advance environmental science, education, and their applications in five strategic areas:

- Strengthening Education and Careers;
- Communicating Science to the Public through the online *Encyclopedia of Earth*;
- Organizing the National Conference on Science, Policy and the Environment;
- Developing Science Solutions to Specific Environmental Challenges; and
- Promoting Science-Driven Policy for the Environment.

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NCSE's University Affiliate Program works in collaboration with over 150 member institutions to strengthen academic environmental programs across the United States. Membership benefits and services include:

- Participation on the Council of Environmental Deans and Directors;
- Participation in multi-institutional collaborations to secure federal funding;
- Exclusive access to information on funding for environmental research and education;
- Complimentary participation in the National Conference on Science, Policy and the Environment;
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- Sabbatical opportunities; and
- Special reports and studies.

Council of Environmental Deans and Directors

The Council of Environmental Deans and Directors (CEDD) brings together environmental leaders at NCSE member institutions to improve the quality, stature and effectiveness of interdisciplinary environmental programs. CEDD supports curriculum advancement, interdisciplinary scholarship, leadership development, and improved program management through projects including:

- Agriculture & Environment
- Campus to Careers Study
- Climate Solutions Curricula
- Curriculum Study
- Energy Education
- Environment & Human Health
- Interdisciplinary Tenure
- Public Policy

This report is a product of CEDD's Curriculum Study initiative and is distributed as a service to members of the NCSE University Affiliate Program.

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Executive summary

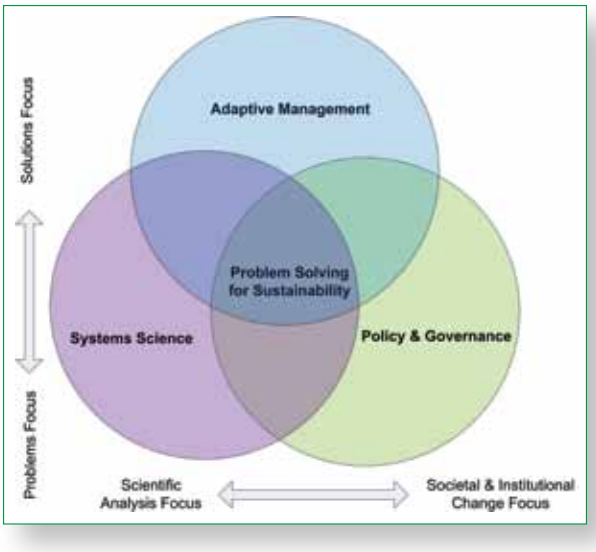
This report summarizes the results of an extensive research study of interdisciplinary environmental (IE) programs conducted by the Council of Environmental Deans and Directors of the National Council for Science and the Environment.

The report outlines the types of IE programs that exist, how many, where they are located in the country and where on campuses—and elucidates elements common to the wide diversity of IE programs, including what IE programs study, how, and why they study what they do:

- What—the interfaces of coupled human-nature systems.
- How—via interdisciplinary systems approaches and different epistemological viewpoints.
- Why—to prepare graduates to be sustainability-oriented problem solvers through scholarship, research, practice and informed citizenship.

Common IE program elements include five interdisciplinary knowledge areas and five integrated skills areas that together form a framework of ten core components of IE curriculum design centered on:

- The sustainable stewardship of natural resources through foundational natural science knowledge, understanding of coupled human-nature systems, and the role of economic development—business practices, technologies and the built environment.
- The development of skills for addressing environmental problems through systems-oriented technical analysis, societal systems understanding, and interdisciplinary, collaborative decision-making processes.



Finally, the study discovered that the expansive range of IE programs fall within three broad educational approaches. Each approach emphasizes different interdisciplinary knowledge and integrated skills sets to prepare different types of graduates.

- The *Systems Science* approach prepares environmental scientists to utilize interdisciplinary, natural sciences-oriented approaches for understanding environmental problems.
- The *Policy and Governance* approach prepares policy and governance specialists and environmentally literate citizens that focus on societal responses to environmental problems.
- The *Adaptive Management* approach prepares IE professionals that use interdisciplinary, collaborative, decision-making processes to devise practical solutions for managing environmental problems.

This report also introduces a new analytical service offered by the NCSE that enables IE program leaders to compare their programs to the study findings and to peer programs and institutions to assist in strategic planning, updating existing IE programs or designing new programs.

Introduction

Student demand for interdisciplinary environmental (IE) education has been growing rapidly since the 1990s and reached new heights last year. The escalating interest in environmental degree programs was widely reported in many publications including the Newsweek-Kaplan College Guide, the Princeton Review, the New York Times, and USA Today.

The number of IE degree-granting programs has more than doubled over the last two decades from 500 in 1990 to over 1,200 today and enrollments are soaring.

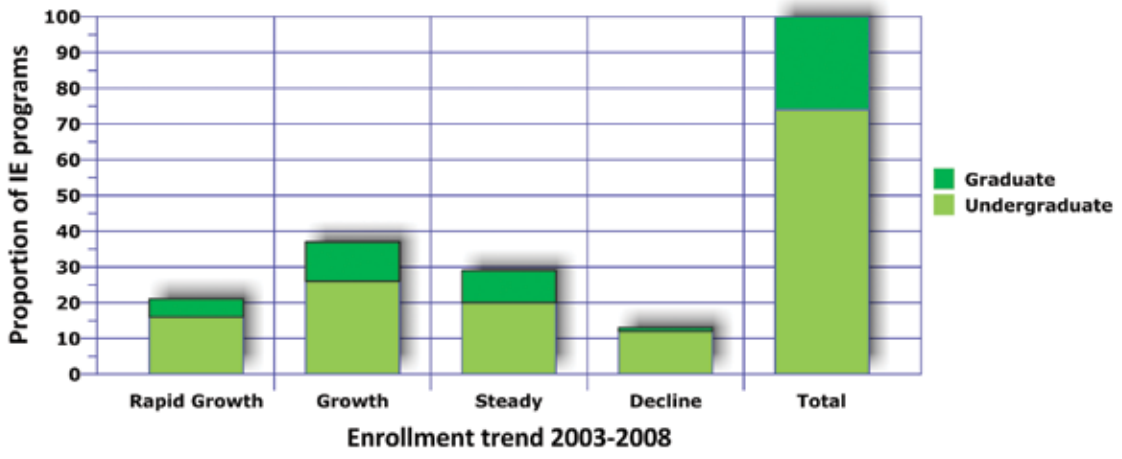
The growth in enrollment has been dramatic. The University of Michigan's Program in the Environment was initiated in 2003 with 35 students and today has 500. Likewise, the University of California at Los Angeles launched its Environmental Science major in 2006 with 10 students and three years later has 221. This level of growth is not unique to these two programs; the majority of IE programs are experiencing expanding enrollments.

The CEDD/NCSE survey of 260 IE programs in 2008 found that two-thirds reported a growth trend from Fall 2003 - Spring 2008 (Figure 1). In addition, a number of the programs that classified their growth as steady now report surging student interest in the semesters following the survey (Fall 2008-Spring 2010). For example, Antioch University New England reports that applications for their master's programs in Environmental Studies and Resource Management and Conservation are up 42% from the same time last year.

The University of Vermont reports that between 2008 and 2010 the number of environmental science and environmental studies majors at the school grew 37% from 495 to 679, and the number of degrees awarded rose 48% from 98 to an estimated 145.

Responding to this burgeoning student demand, universities and colleges have been initiating new IE degree programs. The CEDD/NCSE study reveals that two-thirds of the existing IE programs were created after 1991, and almost a quarter since 2001 (Figure 2).

Figure 1. IE program enrollment trends 2003-2008



The number of IE programs has more than doubled from 500 in 1990 to over 1200 today. In just the last two years alone, the number of colleges and universities offering IE degree programs has increased by 4%.

Colorado State University, Yale University, Skidmore College, Lewis and Clark College—from large research intensive universities to small liberal arts colleges—higher education institutions of all types and sizes are developing new IE degrees programs in Environmental Studies, Environmental Science, Environmental Systems, Environmental Management, Environmental Policy and many other IE focus areas.

The CEDD/NCSE study is the first comprehensive survey of interdisciplinary environmental programs in the United States.

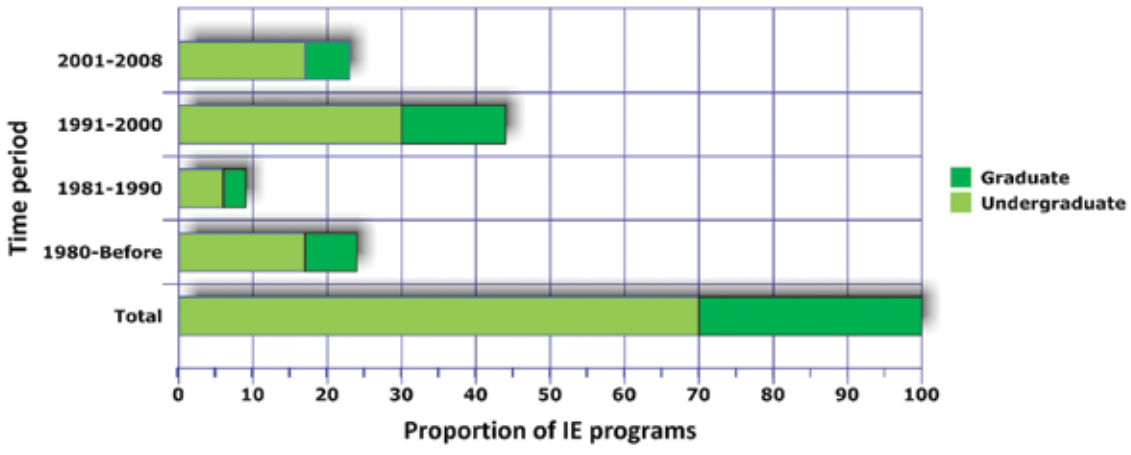
These institutions are doing their utmost to offer IE programs that both capture the interests of students and provide them with the knowledge and skills they need to establish successful careers.

Job opportunities for the graduates of IE programs are rising rapidly. The United States Department of Labor Occupational Outlook Handbook 2010-11 Edition predicts a 28% increase in the number of environmental scientist and specialist positions between 2008 and 2018, a growth rate much faster than the average for all occupations.

Simply Hired, a tool that tracks online job postings, reports an 18% increase in the number of environmental job postings from August 2008 to February 2010; solid growth in spite of the economic downturn.

Sustainability in a central focus for IE education and the graduates of IE programs are uniquely qualified to fill many emerging roles in the new green economy.

Figure 2. Time period IE programs established



The demand for sustainability professionals is exploding; Simply Hired reports a phenomenal increase of 115% in sustainability job postings from August 2008 to February 2010.

Faculty leaders and administrators of IE programs are learning and seeking insights from others on how to best adapt and align their educational offerings to attract students and prepare them for profes-

sional opportunities and environmentally literate citizenship. One important resource for these leaders is the Council of Environmental Deans and Directors (CEDD), a professional association of IE leaders, supported by the National Council for Science and the Environment (NCSE) as part of its affiliate program for colleges and universities.

This report summarizes the key findings of an extensive research project conducted for the CEDD/NCSE and introduces a new professional service that allows IE program administrators to benefit from comparing their IE degree programs against the study findings and other IE programs nationwide.

CEDD/NCSE offers a new comparative analysis service that provides valuable information and insights on IE administrative and degree program parameters.

The study explored IE field identity ("How are IE programs defined and what purpose do they serve?") and how essential knowledge and skills are structured in IE curricula.

It represents the first national empirical study of IE programs and involved the participation of IE program leaders at 264 colleges and universities in the United States representing 286 baccalaureate and graduate IE degree granting programs. The survey phase of the study obtained a nationally representative data set with comprehensive information collected for 260 IE degree granting programs and 343 IE degrees.

The "let many flowers bloom" approach in higher education in the United States gives rise to IE programs that reflect both the range of environmental problems faced by society and the array of career opportunities available for today's environmental graduates. This diversity represents both a challenge and an opportunity.

- A challenge because employers and students may not understand the competencies gained by the graduates of IE programs.
- An opportunity because program leaders can draw upon core strengths at each institution and build programs around a profoundly important question: "What types of environmental problem solvers do we want to graduate?"

The study also provides a framework for understanding the curriculum design of the wide range of IE educational programs. The study discovered that despite the diversity of IE degrees only three broad approaches to IE education were identified. Each approach emphasizes different interdisciplinary knowledge and integrated skills sets to prepare different types of graduates.

- The *Systems Science* approach prepares environmental scientists to utilize interdisciplinary natural sciences-oriented approaches for understanding environmental problems.
- The *Policy and Governance* approach prepares policy and governance specialists and environmentally literate citizens that focus on societal responses to environmental problems.
- The *Adaptive Management* approach prepares IE professionals that use interdisciplinary, collaborative decision-making processes to devise practical solutions for managing environmental problems.

This report will help you—the leaders of IE programs—understand your program and your field better. This report may also help you advance your programs and serve your students and society better.

Finally, this report illustrates how the study findings and representative national data set can provide a powerful tool to assist IE program leaders in strategic planning, updating existing IE programs or designing new IE programs based upon existing institutional strengths.

How many IE programs are there and where are they located?

A 2007 census of IE programs in the United States identified 840 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 3).

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.

States in the Northwest and the Northeast have higher proportions, some reaching 100% of their four-year colleges and universities.

Figure 3. Proportion of U. S. four-year institutions hosting IE programs

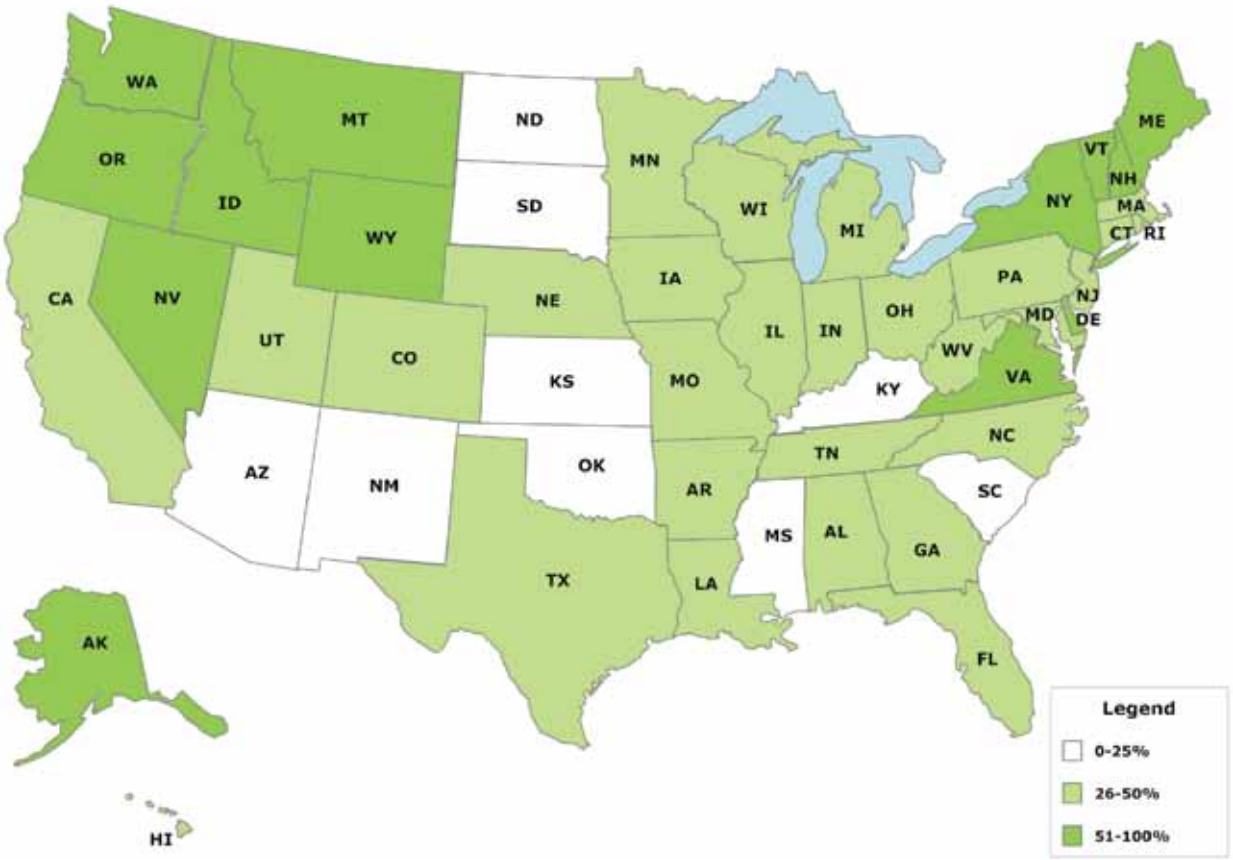
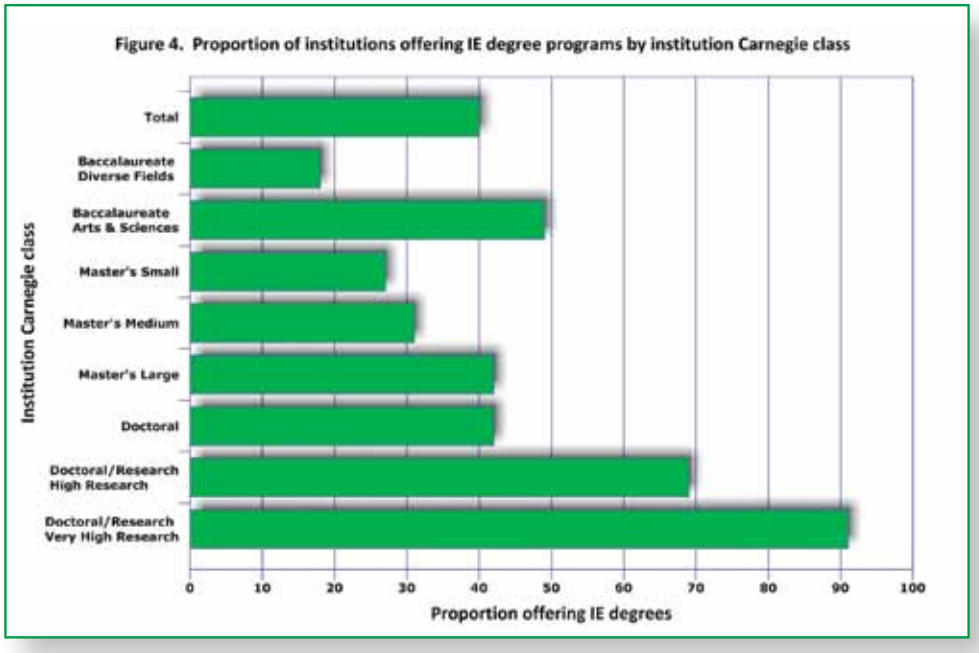


Table 1. U.S. institutions with IE degree-granting programs by state

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 also differs by institutional type. Doctoral institutions are twice as likely to offer IE degrees as master's or baccalaureate colleges and universities (Figure 4).



What types of IE programs exist?

IE degree programs exhibit an amazing variety in degree program names and focus areas. Many institutions offer more than one type of IE degree. For example:

- Barnard College offers undergraduate degrees in both 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 graduate degrees in Environment and Resources, Conservation Biology and Sustainable Development, Energy and Environmental Policy, and Water Resources Management.

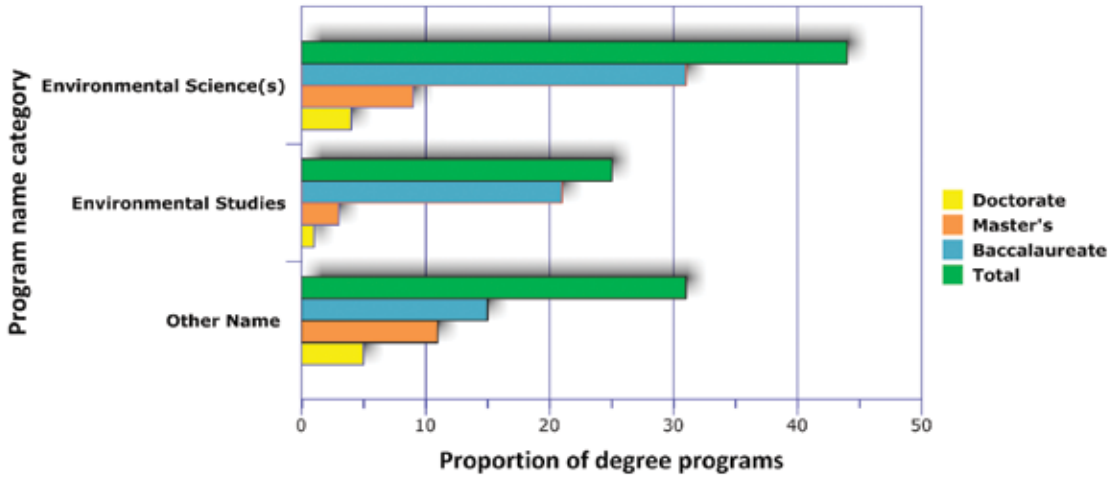
A large proportion of IE programs, 44%, are named environmental science or sciences (Figure 5).

Another 25% are named environmental studies. Degrees in environmental studies are awarded primarily at the baccalaureate level; only 11% of master's degrees and 5% of doctoral degrees are named environmental studies.

The remaining 31% of IE program names and focus areas vary widely, and include:

- Urban and Environmental Policy (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.

Most IE programs offer an array of specialization options that reflect the expertise of their faculty and the mission and geographical location of their institution. Three 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 and 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.
- Oklahoma State University's Environmental Science Graduate Program offers MS and PhD degrees in Environmental Science with six specializations: Water and Watershed Management; Environmental Policy and Conflict Management; Environmental Management; Environmental Chemistry, Toxicology and Risk Assessment; Environmental Education; and Sustainability.

Many programs allow students to design their own concentrations to match their specific goals and interests. The Environmental Study programs at the Evergreen State College and the Program in the Environment at the University of Michigan are two examples.

Where are IE programs located within colleges and universities?

IE degree programs are found in a variety of institutional locations ranging from an IE degree program within a traditional disciplinary department to IE degree programs offered through a consortium of colleges.

Altogether, only about a third of IE degree programs are located within their own IE administrative units—an environmental department, school or college, or cross-institutional entity.

The largest proportion of these, representing 23% of all programs, are located within their own department such as the Department of Environmental Science at Allegheny College, the Department of Environmental Studies at Antioch University New England, or the Department of Earth and Environmental Sciences at the University of Pennsylvania.

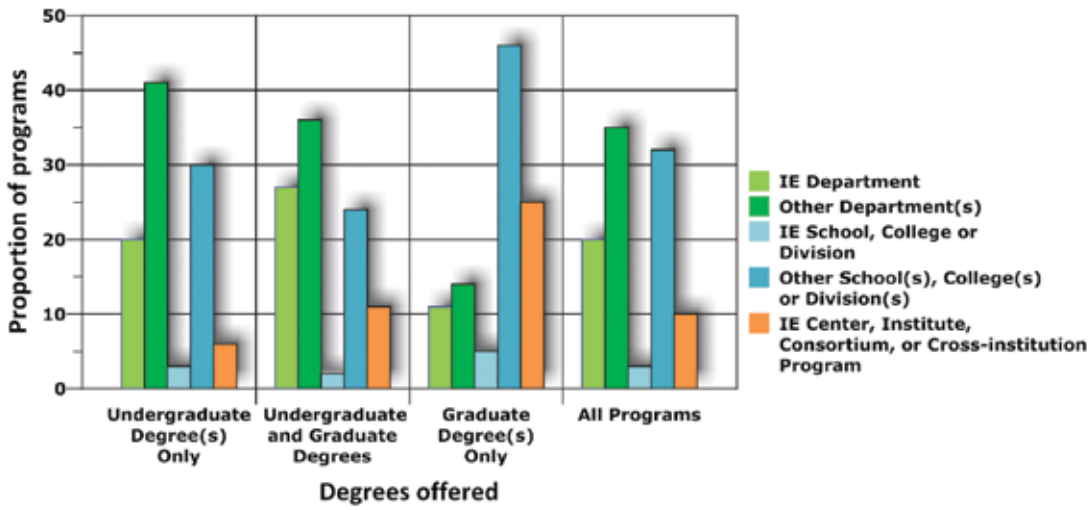
A few, about 4% of all programs, are situated within their own IE school or college such as the Huxley College of the Environment at Western Washington University or the Nicholas School of the Environment and Earth Sciences at Duke University.

Another group, representing 11% of all programs, are positioned within their own cross-institutional programs, institutes, or centers, such as the Center for Environmental Policy at Bard College or the Gaylord Nelson Institute for Environmental Studies at the University of Wisconsin at Madison.

The remaining two-thirds of IE degree programs are split between locations within a non-IE department (31%) or in programs that cross one or more traditional colleges (31%). Examples of these include:

- The Environmental Studies degree program located in the Department of Geology and Planetary Science at the University of Pittsburg.
- The Environmental Studies Program at the University of Nebraska at Lincoln that spans the College of Agricultural Sciences and Natural Resources and the College of Arts and Sciences.

Figure 6. IE degree program administrative locations



An interesting example of a multi-institutional approach occurs in southern California where degrees are offered in Environmental Science and Environment, Economic, and Politics by the Claremont Colleges Consortium comprised of Claremont Graduate University, Claremont McKenna College, Harvey Mudd College, Keck Graduate Institute of Applied Life Sciences, Pitzer College, Pomona College, and Scripps College.

Notably, IE programs frequently experience changes in their locations within administrative hierarchies relative to other degree-granting programs. In some cases these moves enhance the interdisciplinary mission of these programs and in other cases they create additional challenges. For example, Colorado State University recently formed a new School for Global Environmental Sustainability while the Environmental Science Graduate Program at Oklahoma State University was recently relocated from its own university-spanning program into a program within the College of Arts and Sciences.

The CEDD/NCSE survey reveals significant differences in program administrators' levels of satisfaction with a number of factors that influence program success, and differences in the ability of programs to offer an ideal interdisciplinary curriculum depending upon their programs' administrative locations.

Specifically, programs located within their own IE administrative units have program administrators who express that they feel:

- More likely to be able offer an ideal curriculum (based on comparison of ideal emphases on knowledge and skills versus actual emphases in program curricula)
- Significantly more satisfied with their ability to:
  - offer relevant degrees and specializations,
  - provide effective program leadership,
  - better prepare students for employment,
  - compete for funding and public support, and
  - participate in partnerships with other educational institutions and organizations.

What constitutes the IE field of study?

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

- IE programs should focus on the interfaces between human and natural systems (coupled human and natural systems).
- IE programs should adopt a holistic, interdisciplinary educational approach that fosters synthesis and systems-thinking skills.
- IE program curricula should include key concepts from the natural sciences, social sciences, applied sciences and humanities.
- 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.

The field identity for IE programs is sustainability-oriented scholarship, research and practice with an emphasis on interdisciplinary problem solving.

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 approaches 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 consensus view on 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:

- Sustainability Research Strategy, U.S. Environmental Protection Agency (2007)
- Transitions and Tipping Points in Complex Environmental Systems, National Science Foundation Advisory Committee on Environmental Research and Education (2009)

Discussions at several 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.

The concept of sustainability is open to many forms of interpretation and application. In the context of IE programs sustainability is interpreted as achieving resilient, sustainable relationships between actions taken to improve the human condition and the natural environment.

The centrality of the concepts of sustainability in IE programs is evidenced by the level of importance placed on sustainability knowledge in IE degree curricula, and by the inclusion of sustainability in the majority of IE degree programs.

The importance of sustainability knowledge in program curricula is affirmed by its mean rating of "moderate to high importance" across all IE degree program types, and by the large majority of programs that 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 include sustainability in their curricula through required or optional coursework and/or through research or applied learning experiences.

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

This trend is increasing. Since the completion of the survey, 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 states: "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."

What knowledge and skills are included in IE program curricula?

Competence in higher education is often defined as achieving specified learning outcomes that include theoretical and practical understanding, cognitive abilities, and mastering techniques relevant to a specific field of study.

Essential knowledge and skills in the curricula of IE programs consist of five interdisciplinary knowledge components and five integrated skills components.

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 field and the expertise and qualifications of IE graduates;
- facilitate cooperation and communication among faculty from a wide range of disciplines; and
- form a potential basis for IE program assessment, professional licensure, and perhaps degree program certification/accreditation.

The CEDD/NCSE study discovered how IE program leaders group disciplinary knowledge areas and related skills into five interdisciplinary IE knowledge components and five integrated IE skills components. These components and their interrelationships provide a broad learning outcomes framework that serve as a guide for structuring IE programs courses and curricula. They may also 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 by each IE program.

IE Interdisciplinary Knowledge Components

The five interdisciplinary IE knowledge components are:

- *Natural Sciences*
- *Natural Resources*
- *Social Sciences*
- *Humanities*
- *Economic Development*

Each IE knowledge component is an amalgam of various disciplinary areas that contribute to the component to various extents. For example, *Natural Sciences* includes concepts from three disciplinary knowledge areas—life sciences, physical sciences and ecology—with life sciences most prominent (Table 2).

IE programs combine and incorporate these knowledge components into their courses and curriculum designs in myriad ways, however, broad similarities in how these components contribute to IE degree curricula can be discerned.

The study suggests that the *Natural Resources* knowledge component occupies a central position in IE programs: all four of the other knowledge components are significantly correlated with it and it best explains how program leaders combine disciplinary knowledge concepts into interdisciplinary IE program components.

Social Sciences and *Humanities* are highly correlated with *Natural Resources* and with each other, forming an integrated knowledge area labeled *Coupled Human-Nature Systems.*

Natural Sciences and *Economic Development* are moderately correlated with *Natural Resources,* but not with each other or with *Social Sciences* or *Humanities.*

Analysis of the knowledge factor structure combined with program leader's 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 business practices and technologies that together comprise the built environment and economic development provide context for understanding coupled human-nature systems.

Table 2 shows the relationships between disciplinary knowledge areas and the five interdisciplinary IE knowledge components. The center column lists the five interdisciplinary knowledge components. The right column lists the disciplinary areas that comprise the content of each knowledge component and the proportion each contributes to the component. The left column illustrates that *Natural Resources, Social Sciences* and *Humanities* are highly correlated with each other to create a knowledge area labeled *Coupled Human-Nature Systems.*

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) language arts (31) philosophy & ethics (21)
Economic development	Economic development	engineering & built environment (73) business (27)

IE Integrated Skills Components

The five integrated IE skills components are:

- *Cognition*
- *Technical Research and Analysis*
- *Management*
- *Community Engagement*
- *Public Communications*

Each IE skills component is 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 3).

Just as with the IE knowledge components, IE programs incorporate a diversity of skills into their program curricula in a multitude of ways, but they do share broad similarities in how they are structured within IE degree curricula.

The study reveals that IE skills fall into two integrated sets—a *Problem Analysis* set and a *Problem Solutions and Management* set.

The *Cognition* and *Technical Research and Analysis* skills components are highly correlated, forming a integrated skills area named *Problem Analysis.*

The *Cognition, Management, Community Engagement* and *Public Communication* skills components are highly correlated with other, forming another integrated skills area named *Problem Solutions and Management*.

Analysis of the skills factor structure combined with program leader's comments from the study indicates that:

- Cognitive skills, with their emphasis on systems thinking and problem solving, are a key element for both the analysis of environmental problems and formulation of solutions.
- Devising solutions and implementing adaptive management plans for addressing environmental problems requires management skills and societal engagement.

Table 3 shows the relationships between skills areas and the five integrated IE skills components. The center column lists the five integrated skills components. The right column lists the skills that comprise the content of each skills component and the proportion each contributes to the component. The left column illustrates the two subsets of skills components that are highly correlated with each other to create the two integrated skills areas: *Problem Analysis* and *Problem Solutions and Management*.

Table 3. Integrated IE skills components

Integrated area	IE skills	Skills sets (proportion of skills 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)

How do programs approach curriculum design in IE education?

IE programs in the United States exhibit tremendous diversity in terms of curricula, knowledge components, skill components, and in the types of IE problem solvers they graduate.

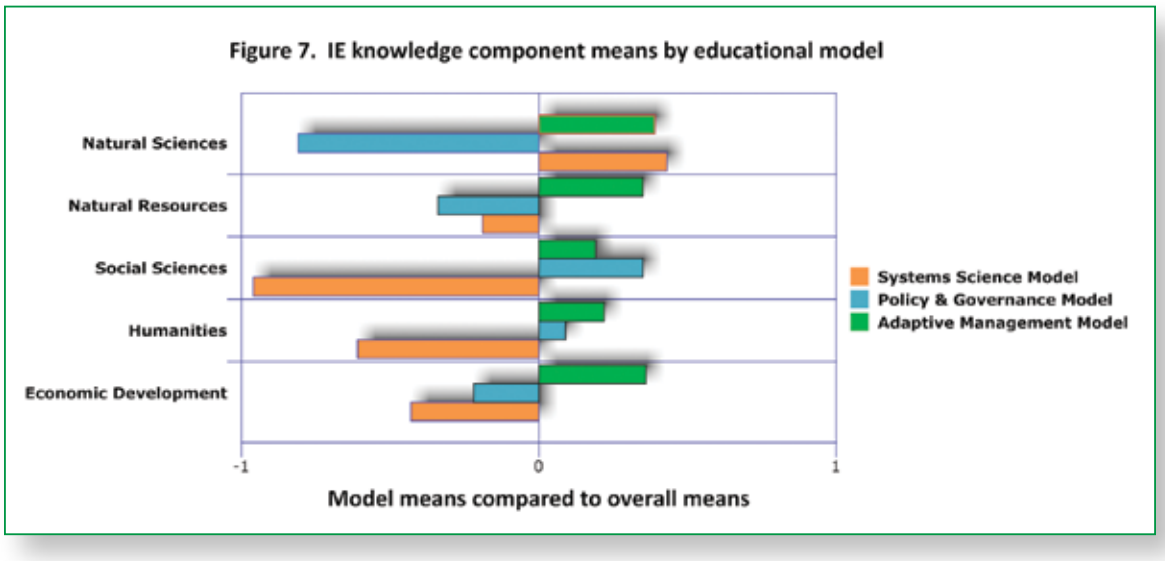
However, the CEDD/NCSE study has discovered that this diversity of programs fit within a broad framework of three "model" or "prototype" approaches to IE education:

- *Systems Science*
- *Policy and Governance*
- *Adaptive Management*

IE programs study coupled human-nature system interfaces through the application of interdisciplinary knowledge and integrated skills using three approaches: Systems Science, Policy and Governance and Adaptive Management.

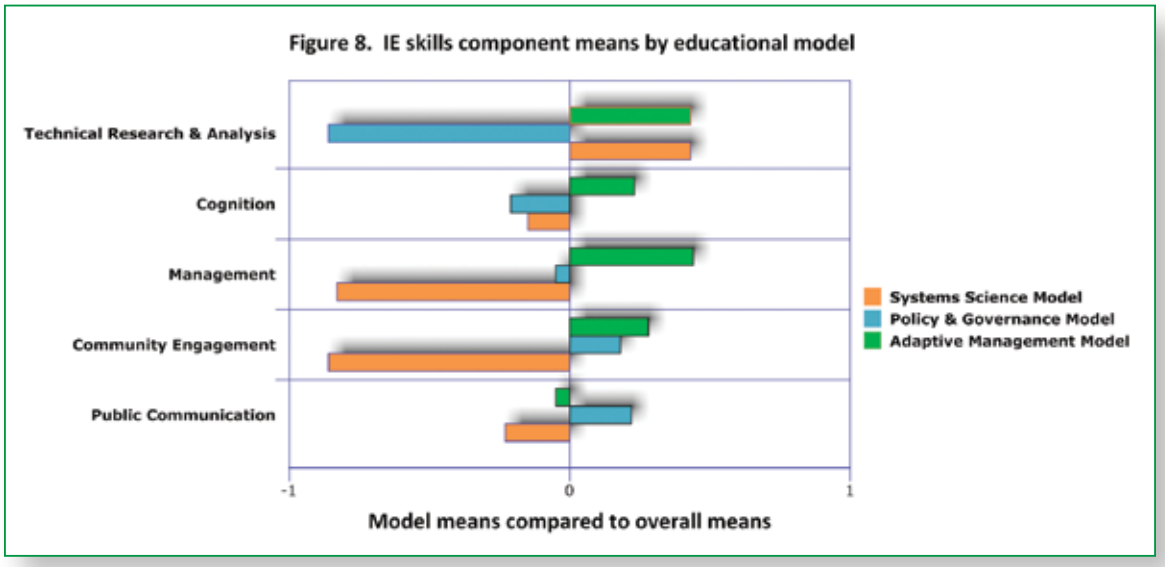
The labels for the model approaches are based upon their characteristics. The most important characteristics are the levels of importance placed on the five IE interdisciplinary knowledge and five IE integrated skills components. Each of the approaches emphasizes the components differently from the other two approaches and from the mean emphases for IE programs overall.

The three approaches represent the views of groups of program administrators that rate the ideal curricular emphases of the ten IE knowledge and skills areas in similar ways. Figures 7 and 8 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 the other two approaches.



The three model approaches are also characterized by features of the degree programs associated with each of the models. These include:

- the proportions of degree types (name and level),
- certain degree program requirements,
- specific degree program objectives, and
- inclusion of sustainability.



The models are not opposed to each other; instead they overlap considerably so that some IE programs are situated on the boundaries of two or even all three models (Figure 10).

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 all three models: Biology and Society BA/BS (*Policy & Governance*), Natural Resources BS/MS/PhD (*Adaptive Management*) and Science of Natural and Environmental Systems Science BS (*Systems Science*).

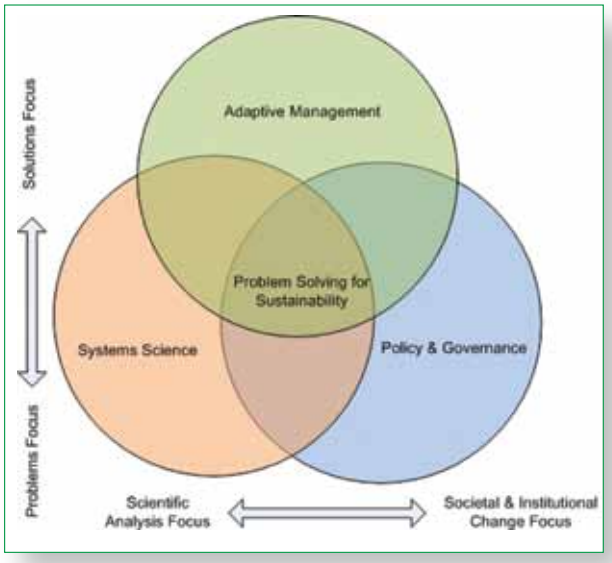
The remainder of this report will be primarily devoted to describing and illustrating these three approaches and showing how the framework that they provide allows colleges and universities to see their particular IE program(s) in the context of the field. Figures 9 illustrates the unified framework for considering interdisciplinary environmental programs in the United States.

Figure 10 illustrates the spectrum of diversity of IE programs within the three IE educational approaches framework. The symbols represent 304 degree programs included in the CEDD/NCSE study. Their location is plotted on two dimensions that define the primary differences between the three

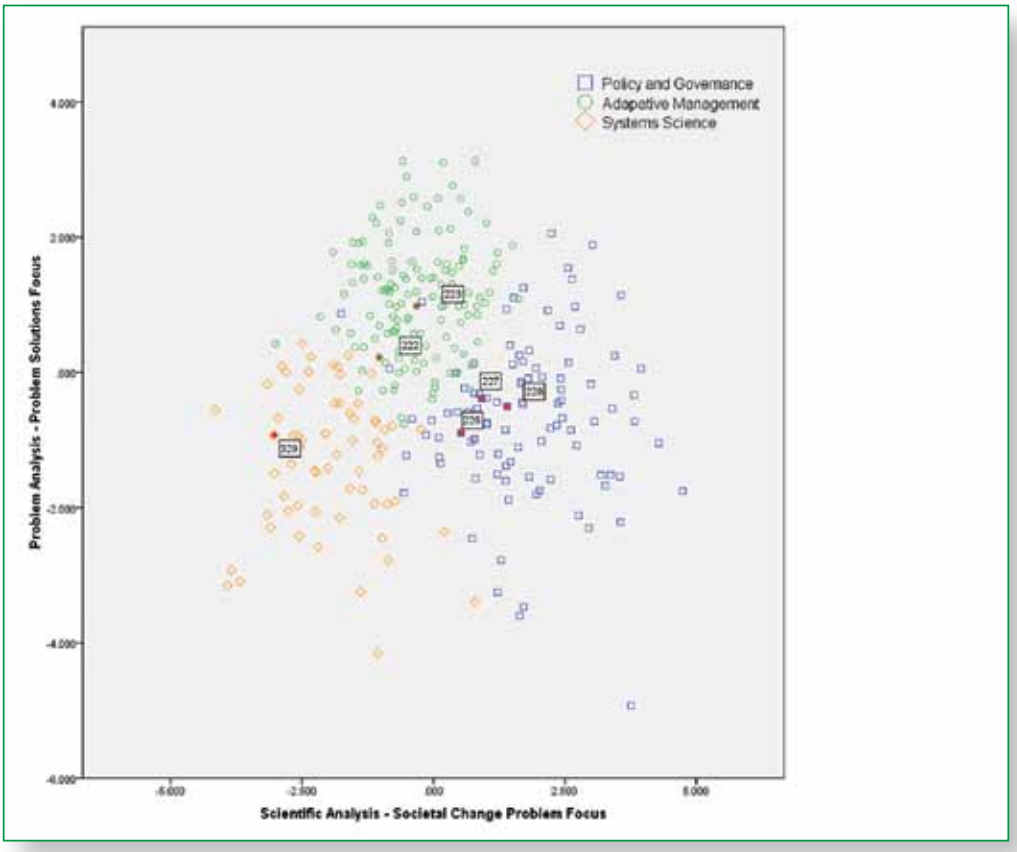
educational approaches: (1) a focus on natural-sciences oriented scientific analysis versus societal interactions analysis, and (2) a focus on understanding environmental problems versus devising practical solutions for managing environmental problems.

- The diamonds on the bottom left are programs whose characteristics broadly align with the *Systems Science* approach.
- The squares on the bottom right show programs whose characteristics broadly align with the *Policy and Governance approach.*
- The circles in the top middle show programs whose characteristics broadly align with the *Adaptive Management* approach.

Figure 9. A framework for considering interdisciplinary environmental programs in the U. S.



Fgure 10. IE degree programs plotted on two dimensions that distinguish educational models



The cases highlighted in boxes represent the example degree programs discussed below. Case 329 is the Environmental Systems Science BS degree program at the University of Wyoming. Cases 226 (BA), 227 (MS) and 228 (PhD) are the Environmental Studies degree programs at the University of Colorado at Boulder. Cases 222 (BS) and 223 (BA) are the Environmental Systems degree programs at the University of California at San Diego.

In the following pages, the characteristics or each approach is described in greater detail and one example program for each approach outlined. Caveat: Examples are not models of the "ideal" for each of the three approaches; nor are they presented as program models. They are presented only as illustrative examples to aid in understanding the framework.

The *Systems Science* approach

Systems Science programs prepare students to conduct interdisciplinary analyses to develop scientific understanding of the complexity of coupled human nature systems.

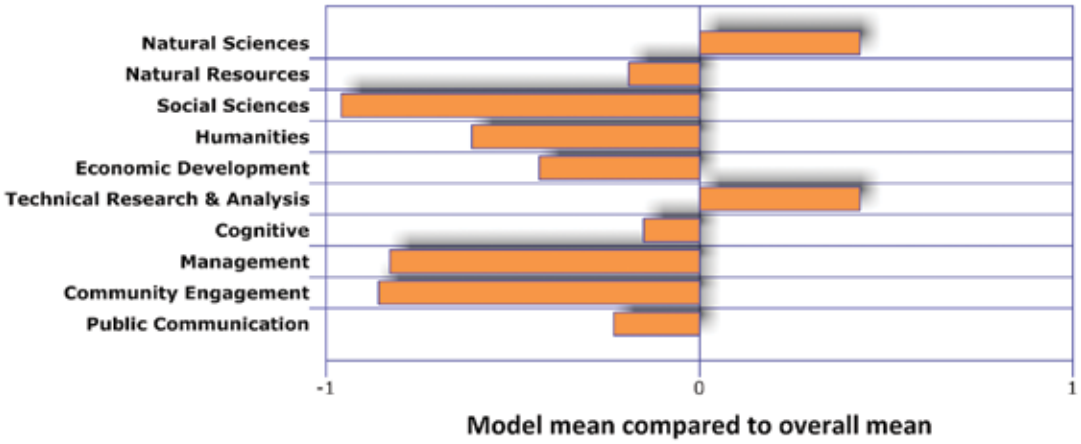
The *Systems Science* approach emphasizes in-depth knowledge of the natural sciences and technical research and analysis skills centered on laboratory analyzes and fieldwork. It has an analytic orientation that emphasizes problem understanding via traditional scientific skills and expertise in the natural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

This model places highest emphasis on the *Natural Sciences* knowledge component and the *Technical Research and Analysis* skills component (Figure 11).

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 11. IE knowledge and skills means for the Systems Science model



The *Systems Science* model is the least popular of the three approaches, representing the ideal for 22% of all IE degree programs, and is the most unique, exhibiting the most significant differences with the other two models.

Degree programs associated with the *Systems Science* approach:

- Are more likely to be named environmental science 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% versus 68-70% for the other two models).
- Are more likely to be located within a non-IE department (43% versus 27-28% for the other two models).
- Are significantly less likely to require participation in a service learning project (graduate degrees).
- Are more likely to include the objective of preparing students for graduate and professional school (undergraduate degrees) and preparing students to be environmental academics (graduate degrees).
- Are significantly less likely to include the objectives of (1) preparing students to be environmental leaders and change agents, and (2) improving environmental policy decisions (undergraduate degrees).
- Are significantly less likely to include sustainability in degree program curricula in any of the five ways measured—(1) core guiding principle, (2) required coursework, (2) optional coursework, (4) research experiences, or (5) applied/service learning experiences (all degrees).

Example: University of Wyoming Earth Systems Science Program

UNIVERSITY OF WYOMING

The interdisciplinary Bachelor of Science in Earth Systems Science program at the University of Wyoming is representative of a *Systems Science* IE program. The program is intended "to be rigorous enough to prepare individual students for graduate studies in their chosen Concentration."

The program encompasses faculty from four colleges and eight departments, but retains a strong focus on depth in a traditional disciplinary area and a department-oriented curriculum structure.

- The curriculum design is described as "depth in a particular disciplinary area."
- The degree program includes the faculty of eight departments located in four colleges: The Department of Secondary Education in the College of Education, The Department of Atmospheric Science in the College of Engineering and Applied Sciences, the Renewable Resources Department in the College of Agriculture and Natural Resources, and the Anthropology, Botany, Geography, and Zoology and Physiology Departments in the College of Arts and Sciences.
- Students are required to declare a concentration in one of seven areas: Anthropology, Atmospheric Science, Biology, Botany, Geography, Geology and Geophysics or Soil Science.
- Sustainability is included only in required coursework.

- The curriculum includes an ESS core which includes a required internship, foundation courses in math, physics, chemistry, geographic information systems, remote sensing and biogeochemistry, and courses required for the chosen concentration.
- The ESS core consists of five courses: two introductory courses which cover the physical Earth system and human impacts (Geochemical Cycles and the Earth System, Environmental Change), a course in computer and conceptual modeling, a senior-level capstone course that focuses on problem solving, and a course that provides credit for an approved internship (required internship).
- Program objectives are to prepare students for graduate and professional schools and for environmental careers.

The *Policy and Governance* approach

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-natural system interfaces.

This model places highest emphasis on the *Social Sciences* knowledge component and the *Public Communication* skills component (Figure 12).

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.

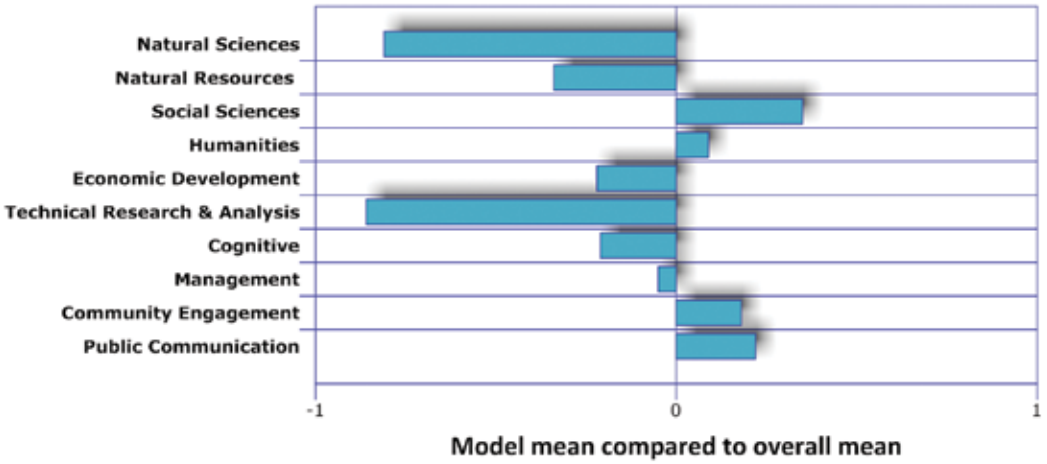
The *Policy and Governance* model represents the ideal for a third, 33%, of all IE degree programs.

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 (1) preparing students to be environmental leaders and change agents, and (2) improving environmental policy decisions (undergraduate degrees).

- Are most likely to include sustainability in degree program curricula in all five ways measured—(1) core guiding principle, (2) required coursework, (2) optional coursework, (4) research experiences, or (5) applied/service learning experiences (all degrees).

Figure 12. IE knowledge and skills means for the Policy and Governance model



Example: University of Colorado at Boulder Environmental Studies Program

The degree programs offered by the Environmental Studies Program at the University of Colorado at Boulder are representative of the *Policy & Governance* approach. The program offers BA, MS and PhD degrees emphasizing the "interconnections of environmental science and decision making." The program also offers dual graduate degrees in environmental studies/law (MS/JD or PhD/JD) and environmental studies/business (MS/MBA) and two certificates in Environment, Policy and Society and Hydrologic Sciences.

The program is administered through the Office of Environmental Studies in the College of Arts and Sciences. Both the undergraduate and graduate degrees draw on courses and expertise from more than thirty participating departments, centers, other units on campus, and nearby federal labs.

- The curriculum design for the BA, MS and PhD programs are described as "multiple options with universal core requirements."

- The undergraduate program offers two tracks: Society and Policy that focuses on the social sciences, and Environmental Science that focuses on the physical sciences; students chose a specialization with their chosen track. The Society and Policy track includes four specialization options: (1) Environment and Natural Resources, (2) International Environment and Development, (3) Decision making, Planning and Public Policy, or (4) Environmental Analysis. The Environmental Science Track includes three specialization options: (1) Water, (2) Biogeochemistry, or (3) Climate.

- The undergraduate curriculum includes a common core curriculum, track-specific required cours-

es, and specialization courses. The common core includes an introductory environmental studies course plus courses in biology, chemistry, geography or geology or atmospheric science, economics, statistics or calculus (depending on the track), environmental ethics and environmental policy. The Society and Policy track-required courses include ecology and conservation practice. The Environmental Science track-required courses include ecology, hydrology and a field course.

- Undergraduate students are encouraged to take advantage of the Undergraduate Internship and Undergraduate Research Opportunities Programs, but are not required to complete an internship or participate in undergraduate research.
- The graduate programs offer five secondary core curricular emphases: Water, Policy, Energy, Biogeoscience, and Environmental Social Science; students may also design their own.
- The graduate curriculum includes a common core curriculum and a secondary core. The common core includes three courses: Policy, Science and the Environment; Environmental Philosophy and Environmental Science.
- Sustainability is a core guiding principle for all degree programs and is included in required and optional coursework, and in research and applied/service learning experiences.
- Degree program objectives for all degree programs include preparing students to be environmental leaders and change agents and improving environmental policy decisions.

The *Adaptive Management* approach

Adaptive Management programs prepare students to solve complex environmental problems using integrated decision processes that directly inform adaptive policy and management decisions to effectively manage the natural-human system interfaces.

The *Adaptive Management* approach emphasizes coupled human-nature systems knowledge and both problem analysis and solutions and management skills. This approach has a professional orientation that emphasizes interdisciplinary knowledge production and decision making processes that include the input of societal stakeholders.

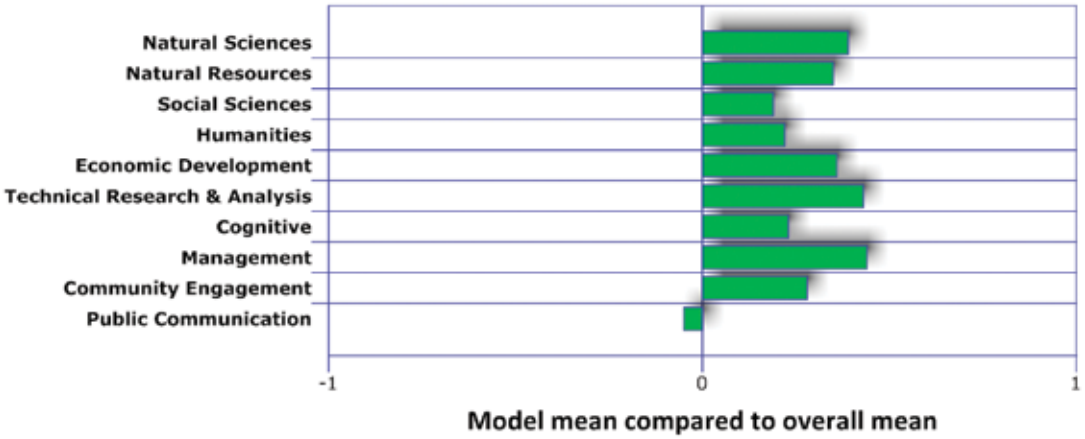
Compared to the overall mean for all IE programs this model places greater emphasis on all knowledge and skills components with the exception of *Public Communication* skills (Figure 13).

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).

The *Adaptive Management* model is the most popular of the three approaches, representing the ideal for 45% of all IE degree programs.

Figure 13. IE knowledge and skills means for the Adaptive Management model



Degree programs associated with the *Adaptive Management* approach:

- Are more likely to have a name other than environmental science 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).
- Include a higher proportion of master's of science and doctoral 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 (1) preparing students to be environmental leaders and change agents, and (2) improving environmental policy decisions (undergraduate degrees).
- Are more likely to include sustainability in degree program curricula in all five ways measured—(1) core guiding principle, (2) required coursework, (2) optional coursework, (4) research experiences, or (5) applied/service learning experiences (all degrees).

Example: University of California at San Diego Environmental Systems Program

The Environmental Systems Program at the University of California at San Diego offers undergraduate degrees that are representative of the *Adaptive Management* educational approach. The program is designed to prepare graduates for a wide spectrum of environmental careers and graduate programs and focuses on preparing students to "apply analytical tools that cross disciplinary boundaries" in order to "effectively manage complex environmental problems."

The Environmental Systems Program is located within the Division of Physical Sciences but is supported by a wide range of participating faculty from the natural sciences, social sciences, humanities, engineering, and medicine.

- The curriculum design is described as "multiple options with universal core requirements." There is a strong emphasis on a rigorous natural science foundation, as well as an introduction to the policy sciences for all students enrolled in the major.
- The program offers four tracks: three for BS students—(1) Earth Sciences, (2) Ecology, Behavior and Evolution, (3) Environmental Chemistry, and one for BA students—Environmental Policy.
- The curriculum includes a lower-division core curriculum (biology, chemistry, physics, mathematics and economics); an upper division integrated three-course sequence (Environmental Systems courses that focus on environmental biology, the solid and fluid Earth, and environmental science and solutions); two additional upper-division courses in environmental economics and policy analysis; an advanced track (minimum of 7 upper-division courses); and a senior integrative project and seminar.
- The Environmental Systems program "places a significant value on interdisciplinary problem solving" and requires all students to complete a three-quarter upper-division Senior Internship/Project sequence during their senior year. The Senior Project is designed by the student to focus on an interdisciplinary environmental problem or research topic such as biodiversity conservation, coastal zone management, environmental health, climate change, environmental justice, or urban air quality. The Senior Project includes an off-campus or laboratory internship component.
- Sustainability is a core guiding principle for both degree programs and is included in required and optional coursework, and in research experiences.
- Degree program objectives for both the BA and BS include preparing students to be environmental leaders and change agents and improving environmental policy decisions.

A new service for IE program leaders

The CEDD/NCSE study allows program leaders to learn from their peers across the nation. The study findings and the nationally representative data set of 260 programs and 343 degrees provides a wealth of information for comparison. A wide variety of program parameters can be assessed against the study findings and against the parameters of other programs that participated in the study.

A comparative analysis report provides valuable information and insights to assist in strategic planning, new program design or existing program revision processes.

Reports may be tailored to individual program needs and may include comparison of existing or planned programs against:

- The four key characteristics of IE program field identity
- The ten broad IE interdisciplinary knowledge components and integrated skills components
- The three educational approaches framework
- Administrative program characteristics including:
  - location within the university
  - faculty
  - resources
  - assessment criteria
  - partnerships
- Degree program characteristics including:
  - enrollment
  - objectives
  - requirements
  - curriculum design
- Indicators of success characteristics including:
  - enrollment trends
  - ability to provide ideal curricula
  - satisfaction with factors that influence success, such as the ability to attract external funding

If you would like to explore having such an analysis conducted, please contact:

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Acknowledgements

The CEDD/NCSE curriculum study would not have been possible without the time and efforts of the environmental program leaders who participated in the Q methodological study and the survey of IE programs. Their contributions are greatly appreciated. The author also wishes to acknowledge the contributions of Dr. Will Focht to the conception, design and conduct of this study.

Methodology

The 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 curriculum 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 social sciences 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). Kruskal-Wallis is a non-parametric test of the difference in the shape or location (central tendency) of the populations underlying two or more groups.

The study was conducted in two phases: (1) an initial online survey and Q methodology analysis with a sample comprised of 61 CEDD members, and (2) a nationwide online survey and data analysis with a sample of 260 respondents representing IE programs awarding 343 degrees.

Phase I. 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 and has been widely used as a research tool for empirically determining the perspectives of participants in a variety of 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 Council of Environmental Deans and Directors.

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

Q Study 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 (see Appendix A for the list of participating institutions). 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 compared using proportions for the Q survey sample data and the census IE program data collected in preparation for the national survey at α=.05 (two tailed test). Four parameters were tested: institution control (public or private-not-for-profit), institution basic Carnegie class, institution U. S. census division, and program degree type (name/level). The sample was found to be representative for all four parameters.

Phase II. 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 program curricula. Third, principal component analysis followed by SPSS two-step method clustering 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 ideal curriculum types, 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=.05 for all analyses.

National Survey 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.

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 degree programs with related names such as sustainability, environmental policy, environmental management and natural resources management. Programs that offer only associate degrees, minors/certificates, and professional degrees in allied fields such as environmental engineering, environmental law, environmental health and safety, environmental chemistry/toxicology, environmental geology/hydrology, conservation biology, sustainable agriculture, forestry/rangeland management, environmental economics, natural resource geography, and environmental statistics were not included. Altogether, a total of 840 interdisciplinary environmental programs at 652 institutions awarding 1,183 degrees were identified as meeting the selection criteria (the count was conducted in fall 2007).

Completed survey responses were received from administrators of 260 of the 840 programs (addressing 343 degrees)—a response rate of 31% (see Appendix A for a list of participating institutions). This sample was sufficient to measure correlations between attributes with a power of 0.90 to detect a 0.20 effect size at α=.05; statistical frequencies have a margin of error of ±5%.

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 basic Carnegie class, institution control (public or private-not-for-profit), institution census division, and degree types (name/degree level). The sample was found to be representative for all four parameters.

Exploratory Factor Analysis. Exploratory (maximum likelihood) 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 complete sets were obtained for analysis. Factor analysis reduced the 39 knowledge and skill ratings into a fewer number of 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 environmental program curricula.

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

$p<0.001$; all of the factors were shown to be reliable.

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

Factor rotation is used to simplify data structures by rotating factor axes so that the variables are loaded maximally on only one factor (minimizes unexplained variance). Orthogonal rotation maintains factor independence while oblique rotation allows factors to correlate. Oblique rotation should be used if factors are believed to be related. Since it was suspected that 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.

The meaning of each factor is interpreted using factor loadings. A factor loading is the Pearson correlation coefficient of 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 group 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 graphical outputs that aid interpretation.

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

Relationships. Finally, two types of analysis of variance tests ($\alpha=0.05$) were used to explore relationships among ideal curriculum types, knowledge and skill factors, and other program and degree attributes: one-way analysis of variance (ANOVA) for scale variables and Kruskal-Wallis one-way analysis of variance by ranks (KWANOVA) for ordinal and categorical variables.

Related publications:

Vincent, Shirley and Will Focht. 2010. A Search for Identity: Exploring Core Competencies for Interdisciplinary Environmental Programs. (submitted to the *Journal of Higher Education*).

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): 1-11.

Vincent, Shirley. 2010. *Interdisciplinary Environmental Education: An Exploration of Field Identity and Core Competencies:* The results of a national survey and study conducted by the Council of Environmental Deans and Directors of the National Council for Science and the Environment, Washington, DC.

Vincent, Shirley and Will Focht. 2009. 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.

Vincent, Shirley and Will Focht. 2009. *Perspectives on Environmental Program Curricula and Core Competencies.* A report of the Curriculum Committee of the Council of Environmental Deans and Directors, National Council for Science and the Environment, Washington, DC.

Appendix—list of participating institutions/programs

(*n*=264 institutions, 286 programs)

**Institutions/programs participating in both phases, ** institutions/programs participating in phase I only*

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
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College of the Atlantic (ME) Graduate Program in Human Ecology
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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
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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
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Messiah College (PA) Environmental Science and Studies Program
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