

The Ecology and Environmental Sciences PhD Degree at Montana State University: Past, Present and Future

Introduction

Toward the end of the 20th century, scientific issues became more complex and most realized that the best approach to solving these issues was to develop multi-disciplinary proposals. Over time these approaches became more integrated multi-disciplinary and today studies addressing modern complex environmental issues are often referred to as integrated transdisciplinary studies. Aligned with the recognition that environmental issues were becoming more complex was establishment of cross disciplinary programs in many of the research funding agencies. For example, the National Science Foundation established a program titled *Biocomplexity Program: Coupling Human and Natural Systems*. This program was designed to address social-environmental issues that integrated human and natural systems, requiring the bringing together of researchers from the natural and social sciences. Emphasis was also placed on integrating teams of researchers from multiple departments and multiple universities. NSF and other federal agencies continue to develop research needs that cut across disciplines. With a need for trained researchers with an integrated foundation in natural and social sciences, many universities have developed integrated “environmental” degree programs (see Appendix A. Examples of Environmental Degree Programs at Other Universities). These programs often are managed by cross-departmental committees, but in other cases, they may fall under a transdisciplinary organization within the university structure (see, for example, Appendix D, university entities that supervise integrated environmental degree or research programs).

History of the Ecology and Environmental Sciences PhD Degree Program at Montana State University

With much of environmental science tending toward integrated multidisciplinary studies, faculty at Montana State University recognized the need for development of such a degree program at the University. In 2006 the departments of Ecology in the College of Letters and Science and Land Resources and Environmental Studies in the College of Agriculture proposed a PhD degree program in Ecology and Environmental Sciences (EES) that would function as an interdisciplinary “training ground” for MSU graduate students (see Appendix B. Proposal for a PhD Degree Program in Ecology and Environmental Sciences at Montana State University). Objectives of the program were “to meet the emerging requirements for an advanced degree in ecology and environmental sciences that is broadly interdisciplinary, and that provides advanced training in areas of critical interest to management of the State’s land and resources.” The proposal suggested that by “offering a joint Doctor of Philosophy degree in Ecology and

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Environmental Sciences it (*the University*) would seek to synthesize and leverage the broad offerings currently available at Montana State University into a unified degree program.” The faculty that might participate in this program were originally considered to be from the Department of Ecology in the College of Letters and Science, and the Department of Land Resources and Environmental Sciences (LRES) in the College of Agriculture. In addition, faculty in Earth Science (ESCI), Plant Science and Plant Pathology (PSPP), and Animal and Range Science (A&RS) were also expected to participate. The original list of anticipated participating faculty was not considered exclusive leaving open opportunity for faculty from other departments to participate when appropriate.

Utilization of the EES PhD Degree Program

When the EES PhD degree was established, the proposal to the Board of Regents stated that “this degree will replace the Doctor of Philosophy in Biological Sciences currently offered by the Department of Ecology, and the Doctor of Philosophy in Land Resources and Environmental Sciences currently offered in the Department of Land Resources and Environmental Sciences.” Consequently, this left one PhD degree program in Ecology unchanged (i.e., Fish and Wildlife Biology). However, the PhD program in Biological Sciences in Ecology was never terminated and continues to be a viable degree program. Land Resources and Environmental Sciences did not retain its PhD degree program and uses the EES PhD degree exclusively as its PhD offering.

Graduation Numbers. Since 2006, thirteen students have graduated with the EES PhD degree (9 in LRES and 4 in Ecology) (See Table 1). Additionally, during that period sixteen students have graduated with the Biological Sciences PhD degree in the Ecology Department.

Enrollment Numbers: In Fall 2010, enrollment in the EES PhD degree program included 27 in LRES, 3 in Ecology, 2 in Earth Sciences and one in Microbiology. In Ecology there were also 7 PhD students enrolled in Biological Sciences and 11 in Fish and Wildlife Biology. Earth Sciences had 17 students in the Earth Sciences PhD degree program, and in other departments that were considered to be users of the EES PhD degree, 6 were enrolled in the PhD in Plant Sciences within the Plant Sciences and Plant Pathology Department.

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Table 1. Graduation and enrollment numbers for departments considered to be users of the EES PhD degree program.

Department	EES PhD degree program mentioned in department web site	EES PhD Students Graduated (>2006)	Biol Sci PhD Students Graduated (>2000)	EES PhD Students Enrolled Fall 2010	Biol Sci PhD Students Enrolled Fall 2010	Fish and Wildlife Biol PhD Students Enrolled Fall 2010	Plant Sciences PhD Students Enrolled Fall 2010	Earth Sciences PhD Students Enrolled Fall 2010
LRES	Yes	9		27				
Ecology	Yes	4	16	3	7	11		
Earth Sciences	No			2				17
Microbiology	No			1				
Plant Sci/Plant Pathology	No						6	
Cell and Molecular Biol	NA		2					

Perceptions of the Ecology and Environmental Sciences PhD Degree Program

Faculty: Based On Response to Survey Originated by the Big Sky Institute

The Survey sent out to all faculty was based more upon finding out how the faculty perceived interdisciplinary graduate programs rather than how they perceived the EES PhD degree program. Since most of the faculty are not affiliated with programs that would use the EES PhD degree, obvious by the high number who were not familiar with the degree, this was a logical approach to the survey.

Over 70% of the 70 faculty who responded to the survey thought that MSU should encourage interdisciplinary programs. This was a response to a question on interdisciplinary programs in general and not specifically related to supporting or expanding the EES PhD degree program. On the other hand, the majority of faculty who responded to a question on expanding the EES interdisciplinary degree programs to include a Master's degree level responded positively. Of the 70 survey respondents, 20 indicated familiarity with the EES PhD degree program. Of these, four presently advise students in that program and nine serve on EES PhD graduate committees.

The faculty were also asked what interdisciplinary programs on campus would benefit from a graduate or undergraduate interdisciplinary degree option. Many programs were suggested, including, for example, Women's Studies, Native American Studies, Molecular Biosciences, Family and Community Health, Computer Sciences, Energy, Film and Photography, etc. Faculty were also asked what benefits an interdisciplinary graduate degree program might offer. Over half of the respondents thought it would attract new students while nearly 3/4th thought such degrees enhanced ways of approaching new developing strategic areas. Most of the 70 respondents saw this type of degree and the associated research as a possible avenue for finding new funding sources for graduate student and faculty research. About half of the faculty believed a student with an interdisciplinary degree potentially had many new job opportunities opened to them.

Some faculty were not supportive of interdisciplinary programs in general (a small minority). Of the survey respondents about 50% thought that interdisciplinary degree programs were "unclear" and generally lacked funding. About 20% thought that an interdisciplinary degree program was a drain on other degree programs. These respondents would rather see more support for more specific discipline-oriented degree programs.

Faculty Input Based on Interviews with Faculty from Several Departments

Two or more faculty in departments that presently use the EES PhD degree and one or two in other departments were interviewed about their thoughts on the usefulness of or attitudes toward the degree program. The following is a summary of the responses. It should be emphasized that the following thoughts do not represent all faculty within a particular department.

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Land Resources and Environmental Studies Department. Faculty within the LRES Department have no choice but to use the EES PhD degree for their PhD students although presently there are still a few graduate students “grandfathered” into the LRES PhD degree which was removed as an offering in 2007. Apparently, the LRES PhD degree still is on Banner as a degree offering. Several faculty in a meeting discussing the EES PhD degree commented that the EES PhD degree was more appropriate for most of them because their specialties aligned more with ecological or environmental sciences than with the LRES PhD degree, in part, because the term “Land Resources” was never clearly defined. Of the four faculty formally interviewed (some brief discussions with others as well), most were happy with the EES PhD offering, although some do not necessarily think the degree (EES) is descriptive in detail of what their students are researching and thus may recommend that their PhD students use better descriptors of their expertise when seeking positions following graduation. On the other hand, faculty whose research has ecological or environmental science orientation which includes many in the department (e.g., microbial ecology and soil ecology) find the concepts of “ecology” and “environmental science” within the EES PhD degree appropriate for their students. Some faculty in LRES do not have a problem with the EES PhD degree being used by other departments but recognize that the other departments would have to “accept” the degree as one of its offerings to allow faculty members within the department to “use” the EES PhD degree for their students. During interviews with LRES faculty content of the EES PhD degree program was discussed. Some like the openness of the degree (i.e., few if any course requirements) and some would like to see more possibilities for transdisciplinary activities available for graduate students within the degree structure with these offerings available to other students as well.

Ecology Department. Faculty within the Ecology Department have three choices of PhD degrees for their students. Obviously, those students pursuing studies in fish and wildlife ecology will “automatically” apply to the PhD degree program in fish and wildlife studies. Faculty with students doing research along more singular lines of research usually will recommend the PhD degree in Biological Sciences. This may include PhD students undertaking ecological research. Faculty directing students in interdisciplinary-oriented studies will most likely recommend the EES PhD degree program. A couple of the faculty interviewed in Ecology do not think MSU has sufficient expertise to offer a truly interdisciplinary degree, that is, across many disciplines. For example, a degree program that would address the multi-faceted aspects of climate change. Also, based on comments from the department head who shared thoughts from faculty meeting discussions and interviews with two other faculty who represented different subdisciplines within ecology, Ecology faculty believe the EES PhD degree is too broad when applied to many departments and had few if any requirements or expectations. They thought the Ecology faculty prefer to have some say in degree structure and requirements and thus have maintained the Biological Sciences PhD degree program. Ecology faculty (e.g., wildlife faculty) also liked the idea of possible interdisciplinary activities (e.g., seminars) that might be related to the EES PhD degree but would be available to all graduated students. In all cases, the degree program within

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which a student is located is decided by which program the student applies to based upon interest and potential faculty advisor.

Earth Sciences Department. Faculty within the Earth Sciences Department presently use the EES PhD degree program for their students when it is applicable to the research of the faculty and student. Based on comments from three faculty and the Department Head, faculty in Earth Sciences generally identify with that title and thus prefer the PhD degree in Earth Sciences for their students. In most cases students applying to Earth Sciences have initially applied to this degree program. However, if graduate students wish to work with Earth Science faculty on broader issues, for example, hydrology of wetlands, or paleoecology, the EES PhD degree is considered quite appropriate for those students in the Earth Science Department; however, faculty would expect students using the EES PhD degree in Earth Sciences to have a foundation in appropriate Earth Science disciplines depending on the research sub-discipline of the student. One geography faculty member within the Earth Sciences Department considered his discipline broader than even the concepts aligned with the EES PhD degree and thus “accepts” the PhD degree in Earth Sciences for their students whereas another geography faculty uses the degree for her students. The concept that the EES PhD degree is not “broad enough” appears to conflict with the idea voiced by several faculty both within Earth Sciences and elsewhere that the EES PhD degree should be considered a transdisciplinary, cross-departmental degree program, used in part, to train students to think and be able to converse “outside the box”.

Engineering College. Based on an interview with a faculty member in the Civil Engineering Department (the department has an environmental engineering program), some Civil Engineering faculty might consider the EES PhD degree appropriate for potential graduate students who wished to do research in related fields to Civil Engineering but did not want to pursue an engineering degree (i.e., PhD in Engineering which is offered across the College of Engineering). Civil Engineering would have to accept the use of the EES PhD degree program for their faculty to use the degree for one of their students. That faculty member was concerned that if they used the EES PhD degree, departments that have that degree as their only degree, or one of several degrees, might “require” the Engineering faculty member to be affiliated in some way with that department. Discussions with the Vice-Provost for Graduate Education indicate that acceptance of the EES PhD degree program by a college or department would allow it to use the degree for its students.

Social Sciences (e.g., Political Sciences). The thinking within Political Science, based on discussion with the department head is that the department has little capacity to support a student where their primary interest might not be social sciences. Given the opportunity, some faculty within the department would be willing to advise doctoral students using the EES degree as long as there was a complementary advisor from an ecology or environmental science department. The major contribution of the Political Science Department could be to lend support to, for example, an ecological or environmental science student who might want to move toward policy study/application. Exposing students at the beginning of their career to either the academic or

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administrative world would do great things and probably shorten the learning curve. One solution for facilitating these types of interactions might be a shared faculty position in human dimensions or similar area between Political Science and Ecology or LRES (under present university structure, that might be difficult to accomplish at multiple levels.)

Many other faculty still could be interviewed but general faculty thinking about the EES PhD degree and its potential usefulness has been captured by the survey and interviews described herein.

Students: Based on Response to Survey of EES PhD Degree Students

Present and recently graduated PhD students who had been or are enrolled in the EES PhD degree program were surveyed about their perceptions of the degree. Thirteen students responded to the survey. Most thought the degree was effective for their needs, but some did not know much about the degree they were listed under. This may be because the degree has little structure to it and the students continue their academic career working with a graduate adviser and graduate committee. The students responded to questions requesting ideas that might improve the degree program and perhaps give it greater visibility. One recommendation that also came from faculty was a need for a cohesive seminar program. It was not clear whether this was a seminar series with outside speakers, or a seminar “class” that would bring the students together to discuss some common interdisciplinary issue. Results of the student survey also raised the idea of a reading group related to the degree program. Also some students suggested that students might “be in charge” of the seminar or equivalent organized program. Students also recommended that there be some way for students to interact, not necessarily in a formal academic setting. Informal social gatherings or discussions might fulfill this need but it should be partially organized by the students to allow “buy in”.

Potential of the EES PhD Degree Program

The potential for the EES PhD degree program is broad, and this breadth is supported by many faculty based on the survey and interviews. On a university-wide perspective, the PhD degree program in Ecology and Environmental Sciences could be a flexible, interdisciplinary, problem-oriented program designed to increase students' understanding of multiple, intersecting science issues. Students in this program could learn to collaborate with transdisciplinary teams to conduct research and provide solutions to specific ecological or environmental problems. This degree program not only could build on the skills generated by discipline-based studies, but make it possible to address linkages across several disciplines.

Alternative “Homes” for the EES PhD Degree

Present Home(s)

The EES PhD program was initially proposed to be a doctoral degree program within the Ecology and Land Resources and Environmental Sciences departments. The use of the degree by several other departments and faculties was also suggested in the proposal to the Regents. Today, three departments are utilizing the degree for some or all of their doctoral students.

At present, management of student applications and maintenance of the degree website are housed in the Ecology Department. Initial applications to the EES PhD degree program are routed to the Ecology Department. Ecology then shares these applicants with the LRES Department. It is uncertain whether the Ecology Department shares the applications with other appropriate departments or faculty outside Ecology and LRES. In many cases, potential doctoral students have already contacted a faculty member about working with them, but in a few cases applicants are “applying blind” to the degree and often a department. Also, with Ecology the first word of the degree, potential students searching for universities to study at may miss the “Environmental Sciences” aspect of the EES PhD degree and thus apply only to the Ecology Department, missing the LRES Department.

Having the present “home” of the EES PhD degree program exclusively in Ecology appears to be functional but perhaps not the best location for the degree’s long-term “home” because both time and interest are limited, sharing of applicants with appropriate departments or faculty is limited, and the degree website and national promotion of the degree tend to falter leaving the degree without any “leadership” (e.g., faculty or administrative guidance) on campus. Consequently the degree has become an enabling degree to the departments that utilize it but not an important component of a possible interdisciplinary educational and research emphasis on the MSU campus.

Potential Alternatives for a Home for the Future of the EES PhD Degree Program (see also Future Management of EES Program below which complements and in some ways duplicates this discussion).

1. Perhaps the easiest but perhaps not the best alternative, is to leave the “home” for management of the degree alone, continuing to have the Ecology Department handle applicants and the website. If this were the decision, then there should be a multiple department faculty committee that (a) oversees the courses listed on the website for the degree, (b) screens applicants to determine appropriate delegation to a department, and (c) develops some “content” for the program which could include interdisciplinary seminars, course requirements, etc.

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The pros to this alternative are that it (a) leaves an existing process in place that appears to be functional and acceptable to most faculty involved...essentially, “if it ain’t broke, don’t fix it”, and (b) does not intrude on other programs on campus that may find changes in management and/or promotion of the EES PhD degree threatening.

The cons to this alternative are that (a) the potential of the EES PhD program as an important cross-departmental program that emphasizes interdisciplinary research and education may never be achieved, if that is the desire of the faculty and administration at MSU, and (b) expansion and/or promotion of the degree program increasing its visibility on and off campus may never be achieved.

2. An alternative that leaves the EES PhD degree program closely aligned with the departments that primarily utilize the degree would be for the two or three departments that have the most graduate students in the degree program (i.e., LRES, Ecology and perhaps Earth Sciences) create an administrative position (probably within LRES which uses the EES degree as its only PhD degree program) that would, as a major portion of the position’s job description, manage the degree both in dealing with graduate student applications and assignments, and development of course listings and promotional web site materials.

The pro to this alternative would be that the departments that use the degree would have direct input and control over the management and promotion of the degree.

The con of this alternative is that the management effort may not receive the level of interdisciplinary support that alternative #3 would offer and, if the degree “manager” is within one department, issues similar to the present management arrangement might arise.

3. An alternative that may give the EES PhD degree new life and more visibility would be to align it with the Institute of the Environment (IOE), which would (a) manage applications and the website, (b) promote the degree both on and off campus, (c) generate funding for graduate student financial assistance, funds made available to departments and faculty that would house and mentor the students,(e.g., potential EPSCoR support of fellowships), (d) organize an EES graduate faculty to mentor students under this program and whose departments have “accepted” the EES PhD degree as a potential departmental graduate degree offering, (e) create a sense of community for faculty and graduate students under one umbrella institute, through seminars, workshops, social functions, (f) provide coordination between interdisciplinary funded activities like PIRE, EPSCoR, and the graduate experience. Under this alternative, some departments (e.g., LRES) would continue to have the EES as their (its) sole PhD program with management of their (its) students done internally. In those departments where the EES option impacts only a few

students, students could draw on the strengths of the interdisciplinary trans-departmental aspect of the IOE for advising support.

The pros to this alternative are that (a) the degree would have an identifiable home for management and website maintenance that is not aligned with any one department, (b) better advertising and promotion of the program under IoE branding would increase the university's competitiveness for recruitment and also its opportunities to obtain external funding for EES (e.g., NSF IGERT), etc., (c) there would be no "ownership" of the degree or its requirements as the unit would not offer the degree (offered by the Division of Graduate Education) and would not promote any one department, faculty, program or set of courses over any other, (d) there would be a neutral entity, interested in interdisciplinary programs, that would raise funds for the degree program, interact with the central administration relative to the program and other interdisciplinary activities on campus, and (e) IoE would organize a list of faculty "associates" to advisor/mentor students in the program beyond the capacity of a single department, and (f) IoE could organize faculty oversight to "guide" the program and develop operating guidelines, when necessary.

The cons to this alternative are that (a) it challenges keeping department allegiance to the degree, (b) placing the degree program under a university-wide unit might reduce the desirability of the degree program for potential graduate student applicants from off-campus, especially for those students looking for an "in-depth" discipline, and (c) alignment with a campus-wide entity might limit student access to department resources.

Interdisciplinary Units at Other Universities Which "Manage" and/or "Promote" Environmental Sciences or Studies Oriented Degrees and/or Research Programs

Many universities across the U.S. have developed Institutes of the Environment or similar entity, such as Centers or Schools that function in an interdisciplinary fashion on the campus. In some cases, the Institutes organize interdisciplinary activities such as research programs and seminars and may facilitate most environmental programs on campus (e.g., School of Environmental Sustainability at Colorado State University). In other universities the Institute or similar entity may coordinate or house interdisciplinary degree programs using its own faculty and courses (e.g., Bren School at UC Santa Barbara), whereas in others, the Institute or Program may direct an Environmental Studies program but have no faculty (e.g., Environmental Studies Program at University of Colorado). Additional examples of different approaches to offering and managing interdisciplinary programs by other universities are presented in Appendix D.

Faculty Support of and Affiliation with the EES PhD Program

This review proposes the development of a multi-department, multi-college listing of faculty who wish to be affiliated with the EES PhD program and who would mentor, within their departments, graduate students who wished to undertake interdisciplinary studies leading to the EES PhD degree (see EES Graduate Faculty below). As an example, at MSU there already exists a multi-department graduate program (under the Division of Graduate Education) called the Molecular Biosciences Program. This program “offers numerous graduate research and training opportunities in Basic and Applied Life Sciences. The Molecular Biosciences Program provides students with the opportunity to interact with faculty involved in life science research divided into research areas. This approach should make it easier for a prospective student to find a faculty conducting the research of most interest to them.” Interestingly, however, under this program (on the MSU website) there is also a subheading called Ecology and Environmental Sciences with a list of eleven faculty from several colleges and departments, not just Ecology and LRES. This program, under the Molecular Biosciences Program heading promotes itself as following: “Ecology & Environmental Science: Research in the ecological and environmental sciences at MSU is based on a broad and extensive collaboration among faculty in multiple departments across the university. Opportunities for graduate student research are available over a diverse array of topics in the ecological sciences. MSU’s location provides immediate access to the unparalleled natural laboratory that is the Greater Yellowstone Ecosystem. Particular program strengths include: terrestrial and aquatic ecology, environmental biogeochemistry, evolutionary biology, hydrology and watershed analysis, quantitative ecology, invasive plant ecology and management, conservation biology, land rehabilitation/restoration ecology, environmental microbiology, remote sensing and spatial sciences.” It is interesting that this broad description of an interdisciplinary degree, one that appears more aligned with Ecology and LRES should be described under a Molecular Biosciences Program.

On campus development of EES degree potential

A. EES Graduate Faculty

Montana State University does not have a graduate faculty, however, most departments when presenting aspects of their graduate programs refer to a departmental “graduate faculty” which, one assumes, are those faculty who are qualified to mentor graduate students in that department.

Because the EES PhD degree program is by definition an interdisciplinary degree program, the faculty who mentor students in this degree program potentially can come from several departments. Faculty who wish to mentor graduate students under the EES PhD degree program should be associated with departments that approve use of the EES PhD for some or all of their doctoral graduate students. Presently, only a few departments utilize the EES PhD degree program and one assumes that the “graduate faculty” in those departments could be considered

“EES Graduate Faculty”. Considering that some graduate faculty in departments that do not presently offer the EES PhD degree might wish to mentor graduate students under that degree heading, it should be possible for those faculty to petition their departments to accept the use of the EES PhD degree program for some of their graduate students. With departmental approval, those graduate faculty in that department could list themselves as members of the EES Graduate Faculty, this listing to be maintained by both the entity managing the EES PhD degree program and the Division of Graduate Education at MSU. These EES Graduate Faculty members would (a) help with promotion of the EES PhD degree program, (b) be involved with possible future curriculum and seminar development in the program, and (c) help with fund raising and decisions related to support of graduate assistants in the program.

B. EES Oriented Courses

Graduate courses across Montana State University potentially fit programs designed to satisfy interdisciplinary and interdepartmental course requirements for the EES PhD degree. Appendix C lists most, if not all, 400 and 500 level graduate courses that presently might be used for the Program of Study for an EES PhD degree graduate program. This list is continuously changing as departments modify their programs. Consequently, it is suggested that this list be updated in the current EES PhD web site presently maintained by the Ecology Department. This role would fall with the entity that becomes, or continues to be, the “home” of the EES PhD degree program.

Future Management Options for the EES PhD Degree (this discussion complements an earlier discussion on the potential home and future development of the EES PhD degree program).

The several options for future management and direction of the EES PhD degree at Montana State University follow patterns for degrees of this type at universities across the country. Consequently, there is no one better model as other universities, each with its own academic format, have fielded interdisciplinary, integrated cross-departmental graduate programs successfully for years.

1. Unchanged from present management.

The Ecology Department continues to manage the degree, course listing, student applications and the degree web site, with no change. Ecology, LRES, Earth Sciences and perhaps a few other departments use the degree for their PhD students. There is no promotion of the degree locally, no national visibility of the program, and no financial resources made available for development of the degree. This model may not be easy to maintain if the pending EPSCoR grant is successful which has support for interdisciplinary graduate research students.

2. Management by an on-campus interdisciplinary unit.

An interdisciplinary unit on campus such as the new Institute of the Environment takes over the day to day management of the degree from the Ecology Department allowing more “independent” development of the web site and all of its components (e.g., class listings that are appropriate for the degree). IoE works closely with Ecology, LRES, Earth Sciences and other departments to make sure the program meets departmental standards and needs. The EES PhD degree program would essentially remain the same, in that committee members ensure the quality of the student program in terms of depth and breadth. Students applying for PhD graduate work who have not already communicated with faculty from departments aligned with the degree would apply through the interdisciplinary unit. Once in the EES program, students would be part of an interdisciplinary community of faculty, students, and external partners but also aligned with the department in which the student is studying.

The interdisciplinary unit (e.g., IoE) would develop promotional material for the degree to be distributed locally and nationally. The interdisciplinary unit would also develop a list of associated faculty who wish, with the approval of their departments in cases where the degree is not presently utilized, to mentor graduate students under the EES PhD degree listing. The unit would work with departments for funding for graduate students in the EES PhD program. Coordination of the program would be undertaken by EES faculty members or a committee.

3. Management and coordination of an integrated EES PhD degree program.

This option would go well beyond that proposed in #2 and would give the interdisciplinary unit (e.g., IoE) pseudo-department or school status. In this model, the unit would (a) offer appropriate courses in cooperation with departments and associated faculty for a EES PhD degree, (b) have a core of part-time faculty associated with the unit who would be primary mentors for many of the EES PhD degree students, and (c) work directly with the Division of Graduate Education in promoting, funding, and developing future directions for the degree. This plan is not envisioned as potentially operational for at least five years if ever.

Report Appendices

Appendix A. Examples of Environmental Degree Programs at Western Land Grant Universities.

Appendix B. Proposal for a Doctor of Philosophy Degree Program in Ecology and Environmental Sciences at Montana State University.

Appendix C. List of courses that might be used by EES PhD degree Graduate Students.

Appendix D. Examples of Environmental Institutes or Equivalent that “Manage and/or Offer” Environment Oriented Graduate Degrees and/or Research Programs (see also listing of Western Land Grant Institutions – Appendix A).

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Appendix A

Examples of Environmental Degree Programs at Western Land Grant Universities

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Western land grant Universities	Name of PhD degree	MS offered?	Institute, School, College, etc?	Depts involved.
University of Alaska	Natural Resources and Sustainability (joint)	Natural resource mngmt, Natural resource Mngmt and geography	School of Natural Resources and Agricultural Sciences	
			School of Management	
University of Arizona	Natural Resources	yes	School of Natural Resources and the Environment	
University of California, Berkeley	Environmental Science, Policy, and Management	Forestry, Range Mngmt	Dept of Environmental Science, Policy and Management	
Colorado State University	Ecology	Ecology	School of Global Environmental Sustainability	all
University of Hawaii	In individual depts - EECS is umbrella inst	individual depts	Ecology, Evolution, and Conservation Biology	anthropology botany marine biology medicine plant and environ protection zoology more...
University of Idaho	Environmental Science	yes	Environmental Science	
Montana State University System	Ecology and Environmental Science	no	umbrella degree	Ecology, LRES, ESCI
University of Nevada, Reno	Ecology Evolution and Conservation Biology	Natural Resources and Environmental Science	Natural Resources and Environmental Sciences	Biochemistry & Molecular Biology, Cell and Molecular Biology, Environmental Science and Health, and Hydrologic Sciences
New Mexico State University	Plant and Environmental Sciences		Dept of Plant and environmental Sci	
North Dakota State University	Environmental and Conservational Sciences	yes	Multi - Environmental and Conservational Sciences	anthropology geosciences entomology Agriculture economics biology engineering, more...
Oregon State University	Environmental Sciences	yes	Dept of Environmental Sciences	
South Dakota State University	Biology - not relevant			
Texas A&M University	Forestry or Rangeland Mngmt	Forestry or Rangeland Mngmt	Dept of Ecosystem Science and Management	
Utah State University		Environmental Sciences	Dept	
Washington State University	Environmental and Naturall Resources Sciences		Natural Resource Sciences Dept	Earth and Environmental Sci, others...
University of Wyoming	Only offers a minor - PhD earned in primary major	DbI major option	Haub School of Environ and Natural Resources affiliated with Ruckelhaus Inst of Envir and Nat Res	Botany Science and Mathematics Plant Sciences Geography Law Economics Poly Sci Zoology Agriculture more...

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Appendix B.

**PROPOSAL FOR A DOCTOR OF PHILOSOPHY DEGREE PROGRAM IN ECOLOGY
AND ENVIRONMENTAL SCIENCES AT MONTANA STATE UNIVERSITY**

A Proposal by the

Department of Ecology and Department of Land Resources and Environmental Sciences,
Montana State University

Implementation date: November, 2006

Objective

The objective of the program is to meet the emerging requirements for an advanced degree in ecology and environmental sciences that is broadly interdisciplinary, and that provides advanced training in areas of critical interest to management of the State's land and resources. Specifically, we seek to combine separate PhD degrees in two departments in different colleges into a single broadly defined degree. By offering a joint Doctor of Philosophy degree in Ecology and Environmental Sciences we seek to synthesize and leverage the broad offerings currently available at Montana State University into a unified degree program. This degree will replace the Doctor of Philosophy in Biological Sciences currently offered by the Department of Ecology, and the Doctor of Philosophy in Land Resources and Environmental Sciences currently offered in the Department of Land Resources and Environmental Sciences.

Faculty, Facilities, Equipment and Library Holdings

Faculty

Faculty for this program already reside at Montana State University in several departments on campus. The principal participants will be drawn from the Department of Ecology in the College of Letters and Science, and the Department of Land Resources and Environmental Sciences (LRES) in the College of Agriculture. In addition, some faculty in Earth Science (ESCI), Plant Science and Plant Pathology (PSPP), and Animal and Range Science (A&RS) are also expected to participate. Multiple additional collaborators and potential Ph.D. student co-advisors from the USGS - Northern Rocky Mountains Science Center, the USDA Forest Service Rocky Mountain Experiment Station, and the US Fish and Wildlife Service located on- and off-campus have expressed strong support and interest in the proposed joint doctoral degree program. A letter of support from the Director of the USGS-RMSC is included along with the Level II proposal documents.

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We do not anticipate the need for any additional faculty specifically to support this program. Departmental faculty currently at Montana State University include:

Ecology: Scott Creel (PhD, Purdue University, 1991), Sharon Eversman (PhD, Arizona State University, 1981), Robert Garrott (PhD, University of Minnesota, 1990), Daniel Goodman, (PhD, Ohio State University, 1972), Christopher Guy (PhD, South Dakota State University, 1993), Andrew Hansen (PhD, University of Tennessee, 1984), Steven Kalinowski (PhD, Arizona State University, 1999), Billie Kerans (PhD, Ohio State University, 1989), Thomas McMahon (PhD, University of Arizona, 1984), David Roberts (PhD, University of Wisconsin-Madison, 1984), Jay Rotella (PhD, University of Idaho, 1990), Mark Taper (PhD, University of California-San Diego, 1984), Tad Weaver (PhD, Duke University, 1969), David Willey (PhD, Colorado State University, 1998), Al Zale (PhD, University of Florida, 1984).

Land Resources and Environmental Sciences: James Bauder (PhD, Utah State University, 1974), David Brown (PhD, University of Wisconsin-Madison, 2002), Rick Engel (PhD, University of Minnesota, 1983), Lisa Graumlich (PhD, University of Washington, 1985), Bill Inskeep (PhD, University of Minnesota, 1985), Clain Jones (PhD, Montana State University, 1998), Rick Lawrence (PhD, Oregon State University, 1998), Rich Macur (PhD, Montana State University, 2004), Lucy Marshall (PhD, University of New South Wales, 2006), Bruce Maxwell (PhD, Oregon State University, 1990), Timothy McDermott (PhD, University of Minnesota, 1989), Brian McGlynn (PhD, State University of New York College of Environmental Science and Forestry, 2002), Fabian Menalled (PhD, University of Massachusetts, 1996), Perry Miller (PhD, University of Minnesota, 1992), Clifford Montagne (PhD, Montana State University, 1976), Wendell Morrill (PhD, University of Florida, 1972), Dennis Neuman (MS, Montana State University, 1972), Kevin O'Neill (PhD, Colorado State University, 1981), Duncan Patten (PhD, Duke University, 1962), Robert Peterson (PhD, University of Nebraska-Lincoln, 1995), John Priscu (PhD, University of California-Davis, 1982), Lisa Rew (PhD, University of Reading, 1993), Sharlene Sing (PhD, Montana State University, 2001), Dave Ward (PhD, University of Wisconsin, 1975), David Weaver (PhD, McGill University, 1990), Jon Wraith (PhD, Utah State University, 1989), Cathy Zabinski (PhD, University of Minnesota, 1991); one tenurable faculty search process in Reclamation Science underway.

Earth Science: Stephan Custer (PhD, University of Montana, 1976), Dave Mogk (PhD, University of Washington, 1984), Mark Skidmore (PhD, University of Alberta, 2001), Cathy Whitlock (PhD, University of Washington 1983).

Plant Science and Plant Pathology: Catherine Cripps (PhD, Virginia Polytechnic Institute and State University, 1995), Michael Ivie (PhD, Ohio State University, 1985), Mathew Lavin (PhD, University of Texas-Austin, 1986), Adam Richman (PhD, University of Nebraska-Lincoln, 1991).

Animal and Range Science: Clayton Marlow (PhD, University of Wyoming, 1978), Jeffrey Mosely (PhD, Texas Tech University, 1987), Bret Olson (PhD, Utah State University, 1987),

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Bok Sowell (PhD, New Mexico State University, 1989), Carl Wamboldt (PhD, University of Wyoming, 1971).

Facilities

No additional facilities are required for implementation of this program. The Departments of Ecology, LRES and other participating departments maintain adequate laboratory, office and administrative facilities for their existing research and graduate programs, and simply re-organizing the existing degree programs should not require additional facilities. Significant growth in the number of doctoral students enrolled would require additional space, graduate research and teaching assistantships, and related resources. The two lead departments have robust extramurally-funded research programs which bring in substantial resources to help support the graduate programs. During FY2006 the LRES Department expended \$8.8 million in research dollars and the Ecology Department had \$2.1 million in research expenditures. The long term strategic vision for Ecology and Environmental Sciences at MSU includes plans for a field station to closely integrate research and teaching activities, but this is not required to implement the change in doctoral degrees.

Equipment

No new equipment is required to implement this program. The participating departments and colleges have substantial and appropriate equipment that serves the current research and instructional programs, including some capacity for growth.

Library Holdings

The current library holdings are sufficient for the related doctoral degrees already offered in the participating departments, and will similarly be adequate for the proposed degree program. The Dean of Libraries at MSU Bozeman regards ecology and environment as a growth area for the Renne Library. Recent BOR actions in addressing inflationary pressures have enhanced the MSU Libraries' abilities to provide appropriate resources in support of our academic programs.

Expected Number of Degrees to Be Granted

The Department of Ecology and the Department of Land Resources and Environmental Sciences each currently grant three to four Doctor of Philosophy degrees each year, in Biological Sciences and in Land Resources and Environmental Sciences, respectively. In addition, some graduate students who currently receive PhD degrees in Animal and Range Science, Plant Science, or Earth Science may opt for the proposed new doctoral degree in Ecology and Environmental Sciences depending on the focus of their research and the makeup of their graduate committee. We anticipate the new joint degree program will result in significantly increasing numbers of graduate students in the program, and that the total number of PhD degrees granted each year should reach approximately ten in five years.

Course Requirements for the Degrees

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In keeping with the current practices of the respective departments, as well as of the broadly multidisciplinary nature of the participating faculty programs, the course requirements for the degree will be determined by the graduate committees of individual students and consistent with requirements as set forth by the MSU Division of Graduate Education. To maximize the potential for the interdisciplinary nature of the degree programs no specific core courses will be required for all students in the degree program.

In keeping with requirements of the Division of Graduate Education, general requirements for the Doctor of Philosophy degree will include:

A minimum of 30 credits beyond the masters degree, 18 of which must be dissertation research credits;

A qualifying examination may be written, oral, or both;

A written and oral comprehensive exam following completion of at least 2/3 of the required coursework;

An oral dissertation defense.

No new courses are proposed in support of this degree at this time. We anticipate that some existing graduate courses may be revised to better target the more interdisciplinary audience, and any new faculty hires will offer courses that contribute to the EES graduate program.

Interdepartmental Implications

Doctoral students currently enrolled in the respective PhD programs in the Ecology and LRES departments take coursework in a variety of campus departments. Given additional enrollments in the new degree program beyond current levels, we anticipate modest increases in course enrollments in Ecology, LRES, and other rubrics, but do not expect significant impacts requiring additional resources in the short term, as noted above. Any longer term impacts can be accommodated through the usual budgeting and allocation process within the two departments and colleges, and through potential targeting of institutional resources.

Planning Process and Recommendation to Submit

In 2004 the Department of Ecology, the Land Resources and Environmental Sciences Department, and the Big Sky Institute were challenged by Provost David Dooley to develop a strategic plan for Ecology and Environmental Sciences at Montana State University. The plan developed in response to that request included consideration of research priorities, program building, and curricular issues. Faculty in Ecology, Land Resources and Environmental Sciences, Earth Science, Plant Science and Plant Pathology, and Animal and Range Science were

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solicited broadly to participate in the planning process and the development of the planning document.

As part of that planning process, it was identified that the existing Doctoral degrees offered by Ecology and by Land Resources and Environmental Sciences could be strengthened by combining the degrees into a single interdisciplinary degree program. To emphasize the interdisciplinary nature of much of the research in these fields, and to increase the critical mass of Doctoral students in residence, it was decided that a single joint degree program would be more effective.

An existing Doctoral degree in Ecology is titled “Biological Sciences,” and remains from the former Biology Department before the split of Ecology and Cell Biology and Neuroscience. This degree title does not adequately reflect the focus of the graduate program in Ecology. Doctoral degrees in other departments are also sometimes too narrow to reflect the nature of the research conducted, and the joint degree is viewed as an appropriate option for some students in several departments. Doctoral students having degree programs underway at the time the new degree title is implemented will be given the option of completing their programs under their original title, or of converting to the proposed new PhD degree program.

The proposed new doctoral degree program, and the inherent implications for the existing doctoral degrees in LRES and Biological Sciences, have been evaluated and approved through the respective curricula review processes in the departments of Ecology and Land Resources and Environmental Sciences. This request, including the associated cross-college logistics and continued resource allocation, is strongly supported by the Deans of the Colleges of Agriculture and Letters and Sciences. Provision and allocation of graduate research and teaching assistantships, tuition waivers, and other direct programmatic support is expected to be of similar magnitude, and handled in substantially the same manner, as is presently done by the two colleges.

The Division of Biological Sciences at the University of Montana offers related doctoral degrees in Integrative Microbiology and Biochemistry, and Organismal Biology and Ecology. Their students may specialize in a broad array of subjects including avian biology, biochemistry, conservation biology, ecology and behavior, evolutionary genetics, microbial ecology, microbiology (environmental and medical), molecular biology and others. The existing Biological Sciences doctoral degree offered through the Ecology Department at MSU currently emphasizes terrestrial and aquatic population, community, evolutionary and quantitative ecology as well as landscape ecology. The current MSU Land Resources and Environmental Sciences doctoral program features environmental chemistry, microbiology, and biophysics; hydrology, water quality, and watershed modeling; invasive species science and management; reclamation and restoration science; climate change delineation and impacts; remote sensing and spatial analysis; environmental controls on trace gas emissions; soil nutrient management; agroecology and cropping systems science. Therefore the proposed combined doctoral degree in Ecology and Environmental Sciences is complementary to, but not duplicative of, the related doctoral degree

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programs offered by the University of Montana. Because the marketplace for attracting outstanding doctoral students in the natural resources and environmental sciences disciplines extends to national and international arenas rather than being primarily in-state, we do not foresee any increased competition for the same students, over and above that which may already exist as a result of our respective high quality graduate programs in related areas.

Employment prospects from graduates of this Doctoral program are very solid, in academia, state and federal agencies, and the private sector. Graduates in the related existing doctoral degree programs are very competitive, and we anticipate that the joint degree program with its novel integrative components will be received in a highly positive manner by potential employers.

Appendix C.

List of courses that might be used by EES PhD degree Graduate Students

Current and Potential EES course listings

*bold denotes courses currently listed on EES web page

Department	Prefix	Course number	Course Name
LRES	LRES	401	Integrated Pest Management
	LRES	407	Environmental Risk Assessment
	BIOM	415	Microbial Diversity, Ecology and Evolution
	LRES	421	Holistic Thought and Management
	LRES	426	Remote Sensing and Digital Image Processing
	LRES	428	Cropping Systems and Sustainable Agriculture
	LRES	430	Natural Resource law
	LRES	443	Weed Ecology and Management
	LRES	444	Watershed Hydrology
	LRES	445	Watershed Analysis
	LRES	448	Stream Restoration Ecology
	BIOM	452	Soil and Environmental Microbiology
	LRES	453	Soil and Environmental Physics
	LRES	454	Landscape Pedology
	LRES	457	Advanced GPS Mapping for GIS
	LRES	460	Soil Remediation
	LRES	461	Restoration Ecology
	LRES	507	Environmental Risk Assessment
	LRES	*515	Microbial Ecology
	LRES	*525	Applied Remote Sensing
	LRES	528	Bridging Principles and Practices of Sustainable Cropping Systems
	LRES	529	Cropping Systems and Sustainable Agriculture
	LRES	530	Natural Resource Law
	LRES	*535	Techniques of Spatial Analysis
	LRES	*543	Agroecology/Applied Plant Ecology
	LRES	545	Watershed Analysis
	LRES	546	Quantitative methods for Environmental Modeling
	LRES	*552	Advanced Soil and Environmental Microbiology
	LRES	553	Plant and Soil Water Relationships
	LRES	*554	Soil Landscape Modeling
	LRES	555	Aqueous Geochemistry
	LRES	556	Energetics in Aquatic Systems

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	LRES	557	Thermal Biology in Yellowstone National Park
	LRES	560	Environmental Regulation and land Reclamation Design Analysis
	LRES	*561	Belowground Plant Ecology
	LRES	562	Land Rehabilitation Field Programs
	LRES	569	Ecology of Invasive Plants in the GYE
Animal and Range Sciences	ARNR	322	Principles of Animal Breeding and Genetics
	ARNR	325	Wildlife-Livestock Range Nutrition
	ARNR	345	Riparian Ecology and Management
	ARNR	350	Vegetation of Western Wildlands
	ARNR	351	Biomes of Western Wildlands
	ARNR	353	Grazing Ecology and Management
	ARNR	354	Fire Ecology and Management
	ARNR	355	Wildlife-Livestock Habitat Restoration
	ARNR	410	Veterinary Entomology
	ARNR	426	Wildlife Habitat Management
	ARNR	438	Wildlife Habitat Ecology
	ARNR	453	Habitat Inventory and Analysis
	ARNR	*541	Range Ecophysiology
Ecology	BIOB	412	Hybridomas
	BIOB	413	Flow Cytometry
	BIOB	414	Advanced Microscopy
	BIOB	415	Advanced Immunology
	BIOB	420	Evolution
	BIOB	424	Ethical Practice of Science
	BIOB	425	Adv Cell and Molecular Biology
	BIOB	428	Molecular Evolution
	BIOB	430	Plant Biotechnology
	BIOB	438	Developmental Mechanisms
	BIOB	475	Genome Science
	BIOB	478	Functional Gene Expression
	BIOB	480	Conservation Genetics
	BIOB	484	Population Genetics
	BIOB	453R	Biomimetric Intelligent Systems
	BIOB	476R	Gene Construction
	BIOE	405	Behavioral and Evolutionary Ecology
	BIOE	408	Rocky Mountain Vegetation
	BIOE	424	Ecology of Fungi
	BIOE	427	Aquatic Field Ecology
	BIOE	428	Freshwater Ecology

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BIOE	439	Stream Ecology
BIOE	440	Conservation Biology
BIOE	455	Plant Ecology
BIOH	422	Genes and Cancer
BIOH	430	Neuroethology
BIOH	435	Cognitive Neuroscience
BIOH	455	Molecular Medicine
BIOL	395	Human Pathophysiology
BIOL	420	Field Ornithology
BIOL	421	Yellowstone Wildlife Ecology
BIOL	*502	Advanced Limnology
BIOL	*504	Quantitative Biology
BIOL	*505	Environmental Analysis
BIOL	*506	Population Dynamics
BIOL	*518	Parameter Estimation for Ecological Models
BIOL	*521	Conservation Biology
BIOL	*524	Frontiers in Landscape Ecology
BIOL	*532	Physiological Plant Ecology
BIOL	*533	Physiological Plant Ecology Lab
BIOL	*534	Vegetation Ecology
BIOL	*540	Analysis of Ecological Communities
BIOL	*542	Community Ecology
BIOL	*548	Conservation Genetics
BIOL	501	Evolutionary Genetics
BIOL	503	Paleobiology
BIOL	509	Introduction to Practical Modeling
BIOL	513	Terrestrial Ecology of Plains and Prairies
BIOL	515	Landscape Ecology and Management
BIOL	516	Terrestrial Ecology of the Northern Rocky Mtns.
BIOL	519	Biology of Riparian Zones and Wetlands
BIOL	520	Biology of Riparian Zones and Wetlands
BIOL	522	Birds of Prey in the GYE
BIOL	523	Wildlife Ecology of the Northern Rocky Mtns.
BIOL	525	Research Methods and the Scientific Process
BIOM	400	Medical Microbiology
BIOM	421	Concepts of Plant Pathology
BIOM	423	Mycology
BIOM	453	Veterinary Virology
BIOO	412	Animal Physiology
BIOO	415	Ichthyology

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	BIOO	433	Plant Physiology
	BIOO	435	Plant Systematics
	BIOO	437	Plant Development
	BIOO	458	Plant Cell Physiology
	BIOO	460	Plant Metabolism
	BIOO	465	Insect Identification
	BIOO	470	Ornithology
	BIOO	475	Mammology
	BIOO	431R	Plant Propagation
	F&WL	401	Fish and Wildlife Topics
	F&WL	510	Fisheries Science
	F&WL	513	Fisheries Habitat Management
	F&WL	548	Research Perspectives
	F&WL	*501	Applied Population Ecology
	F&WL	*502	Analysis of Population & Habitat Data
	F&WL	*511	Advanced Stream Ecology
	F&WL	*525	Human Dimensions of F&WL Management
Earth Sciences	GEO	411	Vertebrate Paleontology
	GEO	413	Macroevolution/Fossil Record
	GEO	417	Taphonomy:Fossil Preservation
	GEO	419	Field Paleontology
	GEO	429	Field Geology
	GEO	433	Global Tectonics
	GEO	439	Geophysics
	GEO	440	Volcanology
	GEO	445	Glacial Geology
	GEO	420	Hydrogeology
	GEO	591-01	Carbonate Lab Methods
	ERTH	432R	Surface Water Resources
	ERTH	450R	Snow Dynamics and Accumulation
	ERTH	455	Physiography of the United States
	ERTH	*505	Geomicrobiology
	ERTH	512	Mountains and Plains Riparian Processes
	ERTH	519	Hydrology of Streams and Lakes
	ERTH	551	Snow Science Seminar
	ERTH	*582	Quaternary Paleoecology and Vegetation History
	ERTH	*583	Topics in Paleoecology
	ERTH	*584	Quaternary Environments of the Western US
	ERTH	*585	Advances in Geobiology

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	GPHY	411	Biogeography
	GPHY	425	Geographic Thought
	GPHY	431	Historical Geography
	GPHY	441R	Mountain Geography
	GPHY	445	Regional Geography
	GPHY	446	East Asia in the Global System
	GPHY	461	Tourism Planning
	GPHY	484R	Applied GIS and Spatial Analysis
	GPHY	501	GIS and Environmental Modeling
	GPHY	504	GIS Research Fundamentals
	GPHY	*505	Bioclimatography
	GPHY	520	Land Use Planning
Chemistry	CHMY	401	Advanced Inorganic Chemistry
	CHMY	417	Synthetic Chemistry
	CHMY	421	Advanced Instrument Analysis
	CHMY	422	Advanced Instrument Analysis Laboratory
	CHMY	505	Critical Concepts in Chemistry
	CHMY	507	Modern Organic and Biochemistry
	CHMY	515	Structure and Bonding in Inorganic Chemistry
	CHMY	516	Mechanisms and Dynamics in Inorganic Chemistry
	CHMY	523	Organic Reaction Mechanisms
	CHMY	524	Mass Spectrometry
	CHMY	525	Chemical Reactions and Transport in Analytical Methods
	CHMY	526	Advanced Protein NMR Spectroscopy
	CHMY	527	Optical Spectroscopy
	CHMY	533	Physical Organic Chemistry
	CHMY	535	Reagent Chemistry
	CHMY	540	Organic Synthesis
	CHMY	551	Organic Structure Elucidation
	CHMY	554	Organometallic Chemistry
	CHMY	557	Quantum Mechanics
	CHMY	558	Classical and Statistical Thermodynamics
	CHMY	559	Kinetics and Dynamics
	CHMY	560	Symmetry, Orbitals and Spectroscopy
	CHMY	564	Advanced Quantum Chemistry
BioChemistry	BCH	441	Biochemistry of Macromolecules
	BCH	442	Metabolic Regulation
	BCH	444R	Biochemistry and Molecular Biology
	BCH	524	Mass Spectrometry
	BCH	544	Molecular Biology
	BCH	545	Advanced Physical Biochemistry
	BCH	550	Principles of Structure Determination by X-Ray Crystallography

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Economics	ECNS	332	Economics of Natural Resources
Entomology	ENTO	510	Insect Ecology
	ENTO	*514	Behavioral Ecology
	ENTO	516	Biosystematics
	ENTO	520	Insect Physiology
	ENTO	525	Insect Morphology
Environmental Engineering	ENVE	440	Water Chemistry for Environmental Engineers
	ENVE	443	Air Pollution Control
	ENVE	444	Hazardous Waste Management
	ENVE	445	Hazardous Waste Treatment
	ENVE	534	Environmental Engineering Investigations
	ENVE	535	Hazardous Waste Management
	ENVE	560	Environmental Engineering Processes
	ENVE	562	Water Treatment Processes and Design
	ENVE	563	Wastewater treatment processes and Design
	ENVE	565	Chemical Sensors and Instrumentation for Environmental Biotechnology
	ENVE	566	Fundamentals of Biofilm Engineering
History	HIST	417	Sci, Tech, and Society 1500-1800
	HIST	419	Modern Science
	HIST	445	Science, Technology and Environment in Japan
	HIST	446	Science and Medicine in China
	HIST	484	World Environmental History
	HIST	504	Topics in Environmental History
	HIST	506	Topics in History of Science Technology and Society
Microbiology	MB	515	Advanced Microbial Ecology
	MB	542	Microbial Ecology
	MB	552	Advanced Soil and Environmental Microbiology
Philosophy	PHL	322	Philosophy and Environmental Ethics
	PHL	345	Philosophy of Science
Political Sci	PSCI	362	Natural Resource Policy
	PSCI	408	Environmental Politics
	PSPP	422	Plant Disease Control
	PSPP	431	Tough Plants in Tough Places
	PSPP	441	Plant Breeding and Genetics
	PSPP	447	Advanced Plant Propagation

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Plant Sciences	PSPP	454	Agrostology
	PSPP	465R	Health, Agriculture, Poverty: Concepts and Action Research
	PSPP	518	Plant Virus Diseases
	PSPP	519	Plant Virus Diseases Lab
	PSPP	524	Advanced Plant Pathology
	PSPP	536	Plant Bacterial Diseases
	PSPP	527	Plant Bacterial Diseases Lab
	PSPP	541	Advanced Plant Genetics
	PSPP	542	Genetic Plant Improvement
	PSPP	546	Herbicide Physiology
	PSPP	552	Advanced Soil and Environmental Microbiology
	PSPP	553	Plant Fungal Disease
	PSPP	554	Plant Fungal Disease Lab
Sociology	SOCI	470	Environmental Sociology
Computer Science (numbering has changed)	SE	422	Advanced Software Engineering
	CSCI	432	Advanced Algorithm Topics
	CSCI	440	Database Systems
	CSCI	441	Computer Graphics
	CSCI	442	Computer Vision: Robot Vision
	CSCI	446	Artificial Intelligence
	CSCI	451	Computational Biology
	CSCI	455	Embedded Systems: Robotics
	CSCI	460	Operating Systems
	CSCI	466	Networks
	CSCI	468	Compilers
	CSCI	476	Computer Security
	CSCI	477	Simulation
	CSCI	481	Program Assessment
	CSCI	482R	Interdisciplinary Project Instruction
	CSCI	483R	Interdisciplinary Project (new course)
	CSCI	520	Parallel and Distributed Computing
	CSCI	532	Algorithms
	CSCI	538	Computability
	CSCI	540	Advanced Database Systems
	CSCI	541	Computer Graphics
	CSCI	547	Machine Learning
	CSCI	550	Data Mining
	CSCI	560	Advanced Operating Systems Topics
	CSCI	566	Advanced Networking
	CSCI	568	Advanced Compilers Topics

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	CSCI	575	Computational Research Topics
Math/Statistics	STAT	401	Statistics for Researchers
	STAT	408	Statistical Computing and Graphical Analysis
	STAT	410	Methods for Data Analysis I
	STAT	412	Methods for Data Analysis II
	STAT	421	Probability Theory
	STAT	422	Mathematical Statistics
	STAT	431	Nonparametric Statistics
	STAT	436	Introduction to Time Series Analysis
	STAT	437	Introduction to Applied Multivariate Analysis
	STAT	439	Introduction to Catagorical Data Analysis
	STAT	446	Sampling
	STAT	448	Mixed Effects Models
	STAT	501	Intermediate Probability and Statistics
	STAT	502	Intermediate Mathematical Statistics
	STAT	505	Linear Models
	STAT	506	Advanced Regression Analysis
	STAT	509	Stochastic Processes
	STAT	510	Statistical Consulting Seminar
	STAT	511	Methods of Data Analysis I
	STAT	512	Methods of Data Analysis II
	STAT	520	Topics in Applied Statistics
	STAT	524	Biostatistics
	STAT	526	Experimental Design
	STAT	528	Statistical Quality Control
	STAT	532	Bayesian Data Analysis
	STAT	534	Spatial Data Analysis'
	STAT	536	Introduction to Time Series Analysis
	STAT	537	Multivariate Analysis I
	STAT	538	Multivariate Analysis II
	STAT	539	Generalized Linear Models
STAT	550	Advanced Mathematical Statistics	

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Appendix D.

**Examples of Environmental Institutes or Equivalent that “Manage and/or Offer”
Environment Oriented Graduate Degrees and/or Research Programs (see also listing of
Western Land Grant Institutions – Appendix A).**

Arizona

Institute of the Environment at University of Arizona

As part of the University of Arizona's Graduate Interdisciplinary Programs (GIDP), the Committee on Global Change within the Institute offers a global change PhD minor. Most other graduate interdisciplinary programs at University of Arizona are handled within GIDP while most PhD programs are departmental.

School of Sustainability at Arizona State University

The School offers the Master of Arts, Master of Science, and Doctor of Philosophy degree programs in sustainability are flexible, interdisciplinary, problem-oriented. The Ph.D. in Sustainability engages scientists and leaders in research to investigate the urgent sustainability challenges of the 21st century. The flexible, interdisciplinary nature of the program allows students to focus on problems of interest to them, drawing upon relevant knowledge from a variety of disciplines. The program mostly uses courses from the School and the faculty are both aligned within the school or are associates aligned with other departments on campus.

California

The Institute on the Environment and Sustainability at UCLA

The Institute offers together with the Departments of Atmospheric and Oceanic Sciences, Civil and Environmental Engineering, Earth and Space Sciences, Ecology and Evolutionary Biology, Environmental Health Sciences and Geography, offers an innovative dual-component degree program in Environmental Science.

**Bren School of Environmental Science and Management, University of California,
Santa Barbara**

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The PhD of Environmental Science is offered by the School. Advisors come from Bren School faculty while courses may come from across campus. The only course requirement within a normal program is taking one of several interdisciplinary seminar courses.

Berkeley Institute of the Environment at UC Berkeley

The institute is greening the UC Berkeley curriculum by adding environment-themed minors and specializations for students all across campus, in addition to the many existing majors with an environmental focus. We are also providing opportunities for students to launch their own research, get involved in on-the-ground learning experiences, and intern with the most effective environmental organizations around. The Institute does not offer graduate degrees per se but supports interdisciplinary graduate student research on the campus.

Woods Institute for the Environment at Stanford

The Woods Institute does not offer or closely coordinate any graduate degree program; however, the Institute for the Environment at Stanford University harnesses the expertise and imagination of leading academics and decision-makers to create practical solutions for people and the planet. In the same spirit that inspired Stanford's role in Silicon Valley's high-tech revolution, the Woods Institute is pioneering innovative approaches to meet the environmental challenges of the 21st century – from climate change to sustainable food supplies to ocean conservation. The Woods Institute carries out its mission by: a. Sponsoring research that leads to new solutions to global environmental sustainability issues. b. Infusing science into policies and practices of the business, government, and NGO communities. c. Developing strong environmental leaders for today and the future and d. Serving as a catalyst and a hub for the university's interdisciplinary work in environmental research, education, and action.

Colorado

Environmental Studies Program at University of Colorado, Boulder

The PhD degree in Environmental Studies is directed by the ES program but is dependent on courses, advisors, etc. from over 30 departments, Centers, etc.

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School of Global Environmental Sustainability at Colorado State University

The School of Global Environmental Sustainability is an umbrella organization that encompasses all environmental education and research at the university. It is basically a facilitating organization. Colorado State University has two programs offering graduate degrees in ecology and the environment. The Graduate Degree Program in Ecology (GDPE) at Colorado State University is one of the leading programs in graduate ecology education in the U.S. and the world. The Human Dimensions of Natural Resources Program at CSU is also offering a new graduate specialization focusing on developing the conservation leaders of tomorrow. The GDPE program has 150 faculty members from all across CSU's campus and by members of a large number of government agencies.

Michigan

School of Natural Resources and Environment at University of Michigan

Doctoral degree programs in Natural Resources and Environment and Landscape Architecture. The School has its own faculty and graduate courses.

North Carolina

Institute of the Environment University of North Carolina, Chapel Hill

The UNC Institute for the Environment helps individual departments and centers join together in interdisciplinary research, education and engagement, and creates new areas of study in response to some of our most pressing environmental challenges. The Curriculum for the Environment and Ecology in the College of Arts and Sciences administers graduate (MS and PhD) and undergraduate degrees to students interested in the ecological and environmental sciences. The Curriculum draws its strength from an interdisciplinary approach to the study of the problems and processes of our natural world.

Ohio

The Institute for the Environment and Sustainability at Miami University of Ohio

The Institute for the Environment and Sustainability (IES) offers graduate programs in environmental science (M.En.) and ecology, evolution, and environmental biology

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(Ph.D.). Ecology, Evolution, and Environmental Biology (EEEEB) is a multidisciplinary, interdepartmental program of study and research leading to a Ph.D. degree. Students earn a degree in EEEB but closely interact with one or more departments. The program involves several departments and centers, and over 40 participating faculty, and takes advantage of Miami's spirit of collaboration and excellent facilities. Students interested in applying to the EEEB program should review the research interests of the faculty associates, each of whom can serve as a dissertation advisor. All students are supported with teaching assistantships, research assistantships, or fellowships.

Wisconsin

The Nelson Institute for Environmental Studies at University of Wisconsin, Madison

Graduate Degrees in “Conservation Biology and Sustainable Development”, “Environment and Resources”, and “Water Resources Management”.

Students design a unique study plan with a faculty advisor who is associated with the institute but also has a departmental home. Courses are selected from the following areas: Natural Sciences, Humanities/Social Sciences, and Measurement and Analysis. Courses are offered by departments.

Wyoming

Helga Otto Hause School of Environment and Natural Resources at University of Wyoming

Only a graduate minor in Environment and Natural Resources (ENR) available to most graduate students. Courses are taken from several departments within the following categories: ENR Policy, Economics and Law; ENR Science and Engineering; Human Dimensions.