Academic Programs in Ecological Restoration: Recommendations for Westfield State University

Prepared for Massachusetts Division of Ecological Restoration and Westfield State University by

Dr. Cara R. Nelson, Associate Professor of Restoration Ecology, Department of Ecosystem Science and Conservation, University of Montana; Past Chair and current Vice-Chair, Society for Ecological Restoration.

Megan Keville, Research Associate, Department of Ecosystem Science and Conservation, University of Montana.

Michael Leff, Principal, Ecological Connections; Past Northeastern North America Regional Representative, Society for Ecological Restoration.

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Executive Summary

Ecological restoration – *the process of assisting in the repair of ecosystems that have been degraded, damaged or destroyed*[1] – is now a dominant activity in natural resource management, with an annual investment of over three trillion dollars worldwide[2]. With increasing investment, there is a corresponding need for trained professionals who are ready to tackle the complex problems of ecosystem repair. Universities have the responsibility of providing the education, skills, and knowledge required to meet societal and environmental challenges and, therefore, they must regularly adapt curricula to meet changing needs. Given current and anticipated growth in ecological restoration, there is a need for academic programs that serve this emerging economic sector.

To assist Westfield State University (WSU) and the Massachusetts Division of Ecological Restoration (MA-DER) in exploring the potential for collaboratively developing a degree program in ecological restoration, we assessed the distribution and growth of academic programs in this field over the last 10 years. Specifically, we searched for degree programs (undergraduate and graduate majors, minors, certificates, and diplomas) in restoration at 320 academic institutions that were previously assessed for restoration degrees in 2006[3]. In addition, to better estimate the frequency of programs in the northeast, we searched for degree programs at 33 institutions in this region that were not included in the 2006 assessment. We also assessed the educational requirements for degrees in restoration, based on average number of credits required in 43 subject areas. Based on these analyses, as well as past experience and communications with WSU faculty and MA-DER staff, we provide recommendations for degree development at WSU, including a field-learning practicum that would be implemented in partnership with MA-DER.

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[1] Society for Ecological Restoration, Science and Policy Working Group. 2004. *SER International Primer on Ecological Restoration*. Tucson, Arizona.

[2] Cunningham, S. 2002. *The Restoration Economy*. Berrett-Koehler Publishers, San Francisco, California.

[3] Nelson, C.R., T. Schoennagel, and E. Gregory. 2008. Opportunities for academic training in the science and practice of restoration within the United States and Canada. *Restoration Ecology* 16: 225-230.

Over the last 10 years, there has been tremendous growth in academic programs in ecological restoration. In 2006, only 4% of the 320 institutions surveyed offered BS, MS, or PhD programs in ecological restoration. Now that percentage has more than doubled (9%); and including minors, certificates, and diplomas (all of which were not included in the 2006 survey), there are now academic opportunities in ecological restoration at 11% of institutions surveyed. Still, this number is quite low relative to growth in jobs in the restoration sector. Furthermore, availability of programs varies by geographic region within North America. The Intermountain West, where resource extraction plays a substantial economic role, has the highest frequency of academic programs. Ecological degradation, however, is occurring throughout the United States, including in the Northeast. For example, the state of Massachusetts has more than 3,000 dams, many of which are no longer functioning for their intended purpose, creating significant opportunities for restoration. The fact that the state of Massachusetts recently created a division of restoration is evidence of the importance of restoration in the region. The Northeast, however, is the region with the lowest number and frequency of degree programs and, therefore, a region that could benefit substantially from program development. Of 97 institutions surveyed in the Northeast, we only found two that had restoration programs: Paul Smith's College (AKA College of the Adirondacks; BS) and State University of New York – Syracuse (MS, MPS, and PhD).

WSU is uniquely poised to offer a degree program in ecological restoration. Existing faculty within the biology and environmental science departments have restoration and restoration-relevant expertise and already offer many courses that could be included in a degree program. In addition, the University's existing collaborative relationship with MA-DER would expand the reach of current faculty. Restoration programs offer unique opportunities for real-world engagement and substantial interaction with project partners, especially when field practicums are required; the fact that MA-DER has an office on campus and is willing to collaborate with faculty and engage with and hire students greatly enhances both the feasibility of creating a new degree program and capacity for delivering it. Finally, the University has just constructed a new science building, which could provide necessary facilities.

Introduction

The field of ecological restoration has matured considerably over the last three decades. Restoration of degraded ecosystems has grown from a relatively minor component of natural resource management to a dominant activity in terrestrial and aquatic ecosystems across the globe. Worldwide, restoration is now an over three trillion dollar per year activity[4]. As the scope and scale of restoration increases, there is a corresponding need for increased training, technical guidance, and sharing of lessons learned, in order to achieve desired ecological and social benefits.

Effective ecological restoration involves scientific, societal, and business dimensions. Practitioners must integrate knowledge about ecological theory (e.g., assembly of ecological communities) and environmental assessment (e.g., monitoring treatment outcomes) into project design and implementation. They also must understand best practices for engaging human communities and stakeholders, given that community involvement and support often directly influences project success. In addition, business practices affect restoration outcomes, as does the ability to move scientific innovations from idea to prescription and to control for tradeoffs between ecological and social goals in project design and management. Thus, scientists and practitioners working in the realm of ecological restoration need specific training not only in the science of restoration ecology but also in societal

[4] Cunningham, S. 2002. *The Restoration Economy*. Berrett-Koehler Publishers, San Francisco, California.

values, ecological economics, restoration policy, environmental planning, law citizen involvement and public outreach, and related social and philosophical issues. This training is beyond the scope of conventional programs in the biological sciences or environmental management.

Despite an increasing need for trained professionals, there are currently relatively few opportunities to gain academic training specifically in ecological restoration. For instance, in 2006, only 4% of colleges and universities in North America identified by Nelson et al.[5] as most likely to have such programs actually offered undergraduate degrees in this emerging field, and only 1% offered graduate degrees. In order to assist Westfield State University (WSU) and the state of Massachusetts Division of Ecological Restoration (MA-DER), the *Society for Ecological Restoration* (SER) partnered with *University of Montana* (UM) and *Ecological Connections* (EC) to:

- Assess growth in academic opportunities in ecological restoration over the last decade and quantify required coursework (Section 1; Nelson and Keville);
- Provide WSU with recommendations for academic program development at the undergraduate and graduate level (Section 2; Nelson and Keville);
- Assess opportunities to engage students in MA-DER and other ecological restoration (ER) projects (Section 3; Leff); and
- Determine resources required for WSU to offer an academic program (Section 4; Nelson and Leff).

[5] Nelson, C.R., T. Schoennagel, and E. Gregory. 2008. Opportunities for academic training in the science and practice of restoration within the United States and Canada. *Restoration Ecology* 16: 225-230.

Section 1: Analysis of Academic Programs in Ecological Restoration

Methods – In order to assess growth in academic programs in ecological restoration over the last decade, in June 2016 we searched for degree programs (bachelors, masters, doctorates, minors, and certificates) in ecological restoration at the same 320 institutions that were assessed by Nelson et al.[6] in 2006. In addition to these institutions, to better estimate the frequency of programs in the northeastern US, we also searched for degree programs at 33 institutions in this region that were not included in the 2006 assessment; MA-DER selected these additional institutions. Of the 353 target institutions, we excluded 14 that did not provide academic program information in English on their websites, which reduced the total number of institutions in our survey to 339, including 97 in the Northeast. (Appendix A).

To identify degree programs, we searched the websites of each of the 339 institutions for degrees and programs that had the following partial key words in their titles: "restor*", "reclamat*", "rehabilitat*" and "remediat*". We included "rehabilitation," "reclamation," or "remediation" to capture older programs that may have been established when restoration terminology was not as well developed as it is today and because these fields are closely allied with ecological restoration. For simplicity, we refer to programs with any of these terms in their titles as "restoration" programs; actual titles are reported in results (Appendix B).

The protocol for web searches varied slightly among institutions, depending on the structure of each institution's website. Degree information often was available through an on-line "general catalog." If a general catalog was not available, we used the "degree program" link from the "academics" link on the institution's home page, or the "directories" or "index" link also commonly found on the home page. For institutions that did not provide a comprehensive listing of their curricula, we found information by searching the web pages (using the same partial keywords) of the following types of departments (exact titles varied by institution) within each institution: biology (e.g., ecology, conservation sciences, evolution, organismal biology, oceanography, plant biology, marine science, zoology), earth sciences (e.g., geology, soil science, hydrology), environmental design (e.g., architecture, bioengineering, civil engineering, landscape architecture), environmental studies (e.g., geography, environmental science, systems dynamics), natural resource management (e.g., forestry, fisheries, wildlife, range management). Degrees that included one of the search terms in the title of an emphasis, option, or focus were only counted as a restoration program if 1) the emphasis, option, etc. included required rather than suggested courses, and 2) the target term is part of the degree title on student transcripts.

For undergraduate Bachelor of Science [BS], *non-thesis* Masters [MS and MPS], and graduate certificates, we assessed curricular requirements in 43 subject areas (Appendix C) most necessary for understanding the science and practice of ecological restoration[7]. Specifically, we categorized courses into the 43 subject areas by evaluating course titles (i.e. we did not review syllabi) and then summing total credits in each of the 43 subject areas for each program. If a course title suggested that the content spanned more than one subject category, its credits were split evenly among all subject areas included

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[6] Nelson, C.R., T. Schoennagel, and E. Gregory. 2008. Opportunities for academic training in the science and practice of restoration within the United States and Canada. *Restoration Ecology* 16: 225-230.

[7] We did not assess course requirements for thesis-based masters or doctoral programs or undergraduate minors because of the limited number of credits required. We also did not assess diploma programs and undergraduate certificates because we found only two of each of these.

in the title. For example, a four-credit course entitled "Wildlife Ecology and Management" would have been categorized as two credits of "ecology" and two credits of "resource management and conservation."

Similarly, for elective requirements (i.e. when students select courses from a list of electives, rather than taking a single required course), instead of including the full credit value of each elective course, we assigned partial credit to each course on the elective list by dividing the total number of elective credits required by the number of courses in the elective list; this calculation allows for estimation of the average student experience and assumes an equal likelihood of student enrollment in any elective course on the list (i.e. the credits assigned to each course on an elective list was calculated as the total number of elective credits required divided by the number of courses in the list).

A different calculation was used if the program required a specific number of courses from an elective list rather than credits (often elective courses varied in credits). In these cases, we first calculated each course's percentage of the sum total of credits for all courses on the elective list. Then we calculated the mean number of credits per course on the list. This mean was multiplied by the number of required elective courses to determine the mean number of elective credits that a student in the program would take. Finally, we assigned credit to each elective course by multiplying its percentage of all credits in the elective list by the mean number of credits.

Credits were quantified based on semester credits. For institutions that use a quarter rather than semester system, quarter credits were converted to semester credits by multiplying credits by 0.667 (i.e. 1.5 quarter credits = 1 semester credit).

After categorizing and determining the credit value of each course within each degree program, we summed for each program the total number of credits required in each of the 43 subject areas. Then for each subject area we calculated the frequency (% of degree programs) and mean number of credits required among all institutions. To assist readers with digesting information, we consolidated the 43 subject areas into 13 general categories in the text of the report but include data on the more specific categories in Appendix C.

Three of the 37 institutions with degree programs were excluded from analyses: Trent University and University of Wisconsin because course requirements and credits associated with courses could not be determined from the institutions' website, and University of Alberta because program data were received after analyses had been completed.

Results and Discussion

We found a total of 63 programs in ecological restoration (including allied disciplines; Table 1) at 37 institutions (6 in Canada and 31 in the United States; Appendix B). The number of Bachelors, Masters and PhD programs increased from 17 in 2006 to 43 in our recent survey (more than a 250% increase), and the number of institutions offering these degrees increased from 13 to 29 (nearly a 250% increase)[8]. Despite this growth over the last decade, degree programs in restoration are still relatively uncommon; only 11% of institutions surveyed have a program. "Restoration" was much more common in degree titles than were rehabilitation, reclamation, and remediation (Table 1), with 92% of degree programs using this term. Bachelors of Science degrees were the most common type of program, representing

[8] Note that comparisons with the 2006 survey do not include data on minors, certificates or diplomas, as these were only included in the 2016 survey.

nearly half of all programs found. MS programs, graduate certificates, and undergraduate minors were the next most frequent (16%, 10%, and 12% of all programs, respectively).

Table 1. Total number of graduate and undergraduate programs identified with restoration, rehabilitation, reclamation and remediation in their titles. Some degree titles include more than one of these terms.

Level & Type	Total #	Restoration	Rehabilitation	Reclamation	Remediation
Graduate					
Phd	4	3	0	1	1
MS/MPS	10	8	1	1	1
Certificate	6	6	0	0	0
Minor	2	2	0	0	0
Undergraduate					0
BS	29	27	1	1	0
Diploma	2	2	1	0	0
Certificate	2	2	0	1	0
Minor	8	8	1	1	0
TOTAL	63	58	4	5	2

The northeast had fewer institutions that offered programs in restoration than expected, based on the percentage of institutions surveyed from this region: 28% of the institutions surveyed were in the Northeast, but only 5% of the institutions with programs were in this region (Table 2). In contrast, the percent of programs offered by institutions in the Intermountain West is nearly four times their representation in the sampling pool. The two institutions in the Northeast that had restoration programs were: Paul Smith's College (AKA College of the Adirondacks; BS) and State University of New York – Syracuse (PhD, MS, and MPS). Our survey did not include all institutions; there may be additional degree programs in restoration in the Northeast at institutions that we did not assess. Our results, however, suggest that the Northeast is the region with the lowest number and frequency of programs and, therefore, likely in greatest need of program development.

Forty-six percent (29) of the 63 degree programs were Bachelors of Science degrees. At least 16 of these were developed since the 2006 survey, which captured only 12 BS programs (SUNY-Syracuse was not included in the 2006 survey). BS programs required high credit loads, with a mean and median of 90 credits (Table 3). The large number of credits reflects the fact that restoration is a multi- and interdisciplinary endeavor: successful restoration requires not only understanding how ecosystems function and assemble and the nuts and bolts of ecosystem repair, but also the human dimensions of project success. Roughly a quarter of required credits were in the physical, earth, and environmental sciences, and another quarter were in biological sciences. Although programs required on average three courses in ecosystem or agroecosystem management, there were fewer credits required specifically in restoration: only 22% of programs required courses in *both* restoration ecology (a sub-discipline of ecology) and ecological restoration (a management practice); 19% required courses in restoration ecology but not ecological restoration; and 42% required courses in ecological restoration but not restoration ecology. Surprisingly, nearly 20% of degree programs did not require a single course with restoration in the title. Nearly all programs (93%) required some type of field learning (i.e. practicum or internship), although average credits for these experiences were low. Increasing interest in the human dimensions of restoration practice is evident in BS programs; students on average are required to take

two courses within this category. Engineering and landscape architecture, however, were only rarely included in curricula (Table 3), although both of these disciplines are considered by many to be critical components of restoration. Aquatic biology was also less frequently required than was terrestrial biology. See Appendix C for frequency and mean requirements for specific course areas.

Table 2. Distribution (number and %) of institutions assessed by region, and number and % of all institutions with restoration degree programs that are in each region. Institutions located on islands off the North American Continent (e.g., Puerto Rico) were not included in regional analyses; Alaska was included with the "West Coast" region (Appendix A).

	All institutions		Institutions with programs	
Region	n	%	n	%*
Midwest	87	26	10	27
Northeast	97	29	2	5
Intermountain West	24	7	9	24
South	88	26	8	22
West Coast	40	12	8	22

* Calculated as [number of institutions with degree programs in region/total number of institutions with degree programs].

We found a total of 22 graduate programs in ecological restoration, including eight thesis-based programs (6 MS and 4 PhDs), four non-thesis professional MS programs, six graduate certificates, and two minors (Table 1). In the 2006 survey, only five graduate programs were identified, although this earlier survey did not include certificates or minors and also did not include SUNY-Syracuse, which offers PhD, MS, and MPS degrees. Still, even when considering only the institutions and graduate programs included in both the current survey and the 2006 survey, graduate programs increased from 5 to 12 – more than a doubling in number (240%). The average number of credits in restoration-relevant courses was 30 for the non-thesis MS/MSP programs and 15 for graduate certificates. Compared to BS programs, masters and graduate certificates had a greater focus on the business of ecological restoration and ecological restoration practice (Table 3). Seventy-five percent of masters programs and 83% of graduate certificates included at least one course in restoration practice, and those that didn't have a course in ecological restoration had at least one in restoration ecology.

Table 3. For each general subject area, mean required credits and % of all required credits for BS, MS/MPS, and Graduate Certificates. See Appendix C for frequency and mean credits of specific courses.

	BS (n=27)		MS & MPS (n=4)		Gr Certificate (n=6)	
Subject	cr.	%	cr.	%	cr.	%
Biological sciences	24.2	29	3.5	16	2.8	18
Physical, earth, and environmental sciences	20.0	24	1.5	7	1.6	11
Ecosystem or agroecosystem management	9.8	12	2.6	12	1.9	12
Quantitative sciences	7.5	9	2.0	9	0.3	2
Human dimensions of resource management	7.0	8	2.1	9	0.6	4
Business of restoration practice	3.3	4	2.7	12	0.3	2
Field learning	3.0	4	1.6	7	1.2	8
Professional communication	2.7	3	0.0	0	0.1	< 1
Ecological restoration	2.6	3	5.7	25	3.4	22
Geospatial technology or tools	2.6	3	0.1	< 1	0.1	1
Restoration ecology	1.5	2	0.3	1	0.9	6
Engineering	0.2	< 1	0.5	2	1.3	9
Landscape architecture	0.2	< 1	0.0	0	0.9	6

Section 2: Recommendations for Program Development at WSU

Given that restoration degree programs are under-represented in the Northeast, the development of one or more academic training opportunities at WSU appears highly strategic. In addition to recruiting students to WSU and increasing enrollment, an academic program at WSU could improve the capacity for, and the quality of, restoration practice in the northeast by producing graduates who are uniquely prepared to tackle the complexities of ecosystem repair.

For any academic program to succeed, it must not only have the support of the faculty in the program but it must also have their engagement. Academic programs thrive when students are part of a vibrant learning community led by strong faculty mentors. For that reason, if WSU decides to move forward with an academic program, WSU faculty should drive the selection of requirements based on their areas of expertise and interests. That being said, however, restoration programs should ideally include the science, practice, and human dimensions of the field. If ecosystem management is to succeed, managers must understand the ecology and biology of the systems they are manipulating, must be able to ask and answer questions about the efficacy and effects of management interventions, and must adapt treatment prescriptions based on lessons learned from past experience. They must also understand the human framework behind restoration, including natural resource policies and human values and ethics. Furthermore, students who are interested in careers in restoration ecology and ecosystem analysis need exposure to management practices in order to develop research that can be applied to management challenges.

BS Program Suggestions

With the caveat that faculty at WSU need the freedom to develop a program that excites them, we have suggested requirements for a BS in ecological restoration (Tables 4 and 5) based on: 1) our findings from Section 1; 2) academic requirements for a soon-to-be-launched ecological restoration practitioner's certification program being developed by SER; 3) course offerings at WSU posted on the University's website; and 4) Dr. Nelson's eight years of experience directing UM's Ecological Restoration program and running its field-learning capstone. Our suggested curricula includes the courses that are required for acceptance into most MS programs in ecology, natural resource management and related fields, including genetics, evolution, and physics. In addition, we have suggested course requirements that would provide students with the credit hours needed to obtain federal jobs in natural resource science and management (i.e. qualify students for civil service jobs as ecologists, botanist, soil conservationist, and hydrologists, to name a few). WSU faculty should explicitly consider civil service job code requirements in program development.

The suggested program includes 91 credits - a much higher credit load than that required for biology and environmental science degrees at WSU (based on our review of the websites for these programs). The total required credits, however, are consistent with that of other BS programs in the field (Section 1). And even with the high credit load, some important subject areas are under-represented.

The cornerstone of the suggested BS program is a four-course field learning program (discussed in detail below). The field learning program would include an initial one-credit field-trip-based course (called a freshman seminar to match other WSU programs) followed by a three-course capstone program. In the capstone courses, students would gain direct experience in all of the general subject areas related to restoration, including ecology and its sub-disciplines, ecosystem management, human dimensions, and professional communications. This is especially important given that it was not possible to include formal courses in some of these subjects because of the need to keep the program at around 90 credits.

In addition to the field learning courses in restoration, students would take one course in ecological restoration practice and another in the science of restoration ecology (see Table 5 for a list of all suggested restoration courses and Table 6 for learning outcomes).

Table 4. Sample curriculum for WSU's discussion of a BS in Ecological Restoration. For each general subject area (underlined text), total number of credits and percent of required credits (and, in parentheses, average percent of required credits in each subject area, based on our review of 27 BS degrees). Suggested required courses and credits are below each general subject area. Red font indicates courses that may not be currently taught at WSU.

General Subject Area and Course	Cr.	Tot Cr.	% Cr. (average program %)
Physical, Earth, and Environmental Sciences		24	26 (22)
CHEM 0109 & 0111 General Chemistry I and II	6		
CHEM 201 Organic Chemistry I	3		
PHSC 0115 & 0117 General Physics I and II[9]	6		
Hydrology	3		
Soils	3		
GARP 0206 Climate Change	3		
Restoration Ecology		3	3 (2)
Restoration Ecology	3		
Other Biological Science		23	25 (27)
BIOL 0128 Intro to Org., Ecol., and Evol. Biology	4		
BIOL 0201 General Ecology	3		
BIOL 0230 Evolution[10]	3		
BIOL 0203 Genetics[9]	4		
BIOL 0325 Ecosystems	3		
BIOL 0211 Plant Biology OR BIOL 0219 Aquatic Biology OR BIOL 0208 Marine Biology	3		
Biology and Environmental Science Elective[11]	3		
Ecological Restoration		3	3 (3)
Ecological Restoration	3		
Other Ecosystem Management		6	7 (11)
ENVS 0225 Natural Resource Conservation and Management	3		
Ecosystem Management Elective[12]	3		

[9] Physics is included as a requirement because: 1) students need it as part of their general education in the sciences, and to gain acceptance in to most graduate programs in the sciences; 2) it is critical for understanding many types of restoration practices, and especially river restoration; and 3) it is required for the federal civil service hydrology job codes.

[10] Evolution and Genetics are included as requirements because: 1) students need these courses as part of their general education in the sciences, and to gain acceptance in to most graduate programs in the sciences; 2) understanding resilience and adaptation require knowledge of these subjects.

[11] Students would select a course relevant to their interest in restoration; depending on faculty expertise, electives could include forest science, wetland science, plant physiology, forest insects and diseases, etc. The elective list could also get pulled out of the biological sciences to be more generally science electives, and include geomorphology, geography, etc.

[12] Students would select a course relevant to their area of interest; depending on faculty expertise, electives could include topics such as forest management, wetland delineation, range management, etc. The elective list could also include GIS; even though we included GIS with the geospatial subject area for the purposes of comparing the suggested curricula to analyses in Section 1, it arguably could be nested within the ecosystem management category.

Table 4 continued

General Subject Area and Course	Cr.	Tot Cr.	% Cr. (average program %)
Ecosystem Management Elective[13]	3		
Quantitative Science		10	11 (6)
MATH 0105 Calculus I	4		
BIOL 0278 Biostatistics	3		
ENVS 0330 Environmental Data Analysis OR GARP 0246 Quantitative Methods for Social and Physical Science	3		
Geospatial technology and tools[14]		0	0 (3)
Engineering		0	0 (1<)
Landscape Architecture		0	0 (1<)
Business of restoration practice		0	0 (4)
Human Dimensions		6	7 (8)
BIOL 0233 Environmental Legislation	3		
Human dimensions elective [15]	3		
Professional Communications[16]		3	3 (4)
ENVS 0240 Writing for Environmental Science	3		
Field learning in ER		13	14 (3)
Ecological Restoration Freshman Seminar	1		
Methods for Restoration and Monitoring	4		
Restoration Practicum OR Independent Research OR Restoration Internship	6		
Ecological Restoration Senior Seminar	2		
TOTAL CREDITS	91		

[13] Students would select a course relevant to their area of interest; depending on faculty expertise, electives could include topics such as forest management, wetland delineation, range management, etc. The elective list could also include GIS; even though we included GIS with the geospatial subject area for the purposes of comparing the suggested curricula to analyses in Section 1, it arguably could be nested within the ecosystem management category.

[14] GIS was not included as a requirement because of the need to limit the overall credit load, even though many students would benefit from taking it; it could be included as an elective choice under "Ecosystem Management" (see note above).

[15] Students would select a course relevant to their area of interest; depending on faculty expertise, electives could include topics such as ethics, conflict resolution, collaboration in natural resource decision-making, traditional ecological knowledge, cultural perspectives on restoration, etc.

[16] The capstone program would emphasize professional communications, including writing proposals and manuscripts, grant writing, public speaking, and conflict resolution.

Table 5. Overview of suggested required courses in ecological restoration, including suggested semester offered and description. See Figure 1 for other details on field-learning courses. For learning objectives, see Table 6.

Semester	Course	Description
Year 1 Spring or Fall (depending on the types of projects that will visited)	Ecological Restoration Freshman Seminar (ECOREST 0180; 1 cr.)	This field learning course exposes students to the practice of ecological restoration and the WSU curriculum by providing them with an opportunity to visit projects being conducted by seniors in the program (during the first years of the program, there may not be any advanced students and other field activities would need to be substituted).
Year 2 Spring	Ecological Restoration (ECOREST 02XX; 3 cr.)	This course provides an introduction to the practice of restoration including its human dimensions. The course provides a survey of practices used to restore forests, grasslands, and aquatic ecosystems, and encourages critical evaluation of current practices.
Year 3 Fall	Restoration Ecology (ECOREST 03XX; 3 cr.)	This course is an advanced ecology course that focuses on the ecological theories that underpin ecological restoration.
Year 3 Spring	Methods for Restoration and Monitoring (ECORES 0301, 4 cr.)	*First course in the three-course capstone*. The course teaches students the nuts and bolts of designing a research, monitoring, or restoration proposal. During this course, students receive training on methods for developing a proposal and have the opportunity to fully develop a proposal for project implementation or research (in groups or individually).
Year 3 Summer and /or Year 4 Fall	Students select one of the following field learning experiences based on the work done in ECORES 0301: • Restoration Practicum (ECOREST 03XX; ≥ 6 cr.) • Independent Research (ECOREST 0399; ≥ 6 cr.) • Restoration Internship (ECOREST 0388; ≥ 6 cr.)	*Second course in the three-course capstone*. Students gain field skills by 1) working under the supervision of an outside organization and a faculty member to implement the restoration or monitoring project that they developed in ECORES0301; 2) working under the supervision of a faculty member to implement the research project that they developed in ECORES0301; or 3) working under the supervision of an outside organization to participate in an internship.
Year 4 Spring	Ecological Restoration Senior Seminar (ECOREST 0390; 2 cr.)	*Last course in the three-course capstone*. During this course, students: 1) finalize project reports summarizing the outcomes of their capstone experience; 2) lead a field visit to their project site for students enrolled in the freshman seminar as well as stakeholders, the general public, and media; and 3) give a formal presentation on their work.

Ecological Restoration Field Learning and Capstone Program - Field learning is a critically important part of any academic program in ecological restoration. By applying what they have learned in the classroom to real-world challenges, students gain a deeper understanding of the field, have an opportunity to critically evaluate restoration practice, learn the field skills that they will use during their careers, develop leadership and communication skills, and gain a professional network. Furthermore, students are more motivated to learn when the results of their efforts have a purpose beyond the classroom. WSU has a unique opportunity to continue to partner with MA-DER to deliver a field-learning program in which students could engage in priority restoration issues and projects within the region. MA-DER's location on WSU's campus allows their personnel and students to have frequent engagement and close mentoring relationships. These close relationship have already proven successful; development of a degree program would further strengthen and formalize a relationship that is already yielding benefits.

Students enroll in four courses as part of their field-learning experience, beginning spring semester of their freshman year and continuing through spring semester of their senior year (Figure 1).

All students would begin their field learning with the Ecological Restoration Freshman Seminar (ECOREST 0180; 1 cr.). During this course, students would have an opportunity to visit restoration projects and observe restoration research through a series of field trips, led by seniors in the restoration program (or faculty and MA-DER staff in the first years of the program). During the field trips, students in the first year of their program will have an opportunity to view the work of the advanced students and to network with restoration professionals engaged in these projects. Thus, in addition to introducing students to the practice of restoration and to the program, this seminar will facilitate student engagement in the local restoration community (on and off campus).

The remaining three restoration field-learning courses comprise the "Capstone" program – a three-semester program during which students directly engage in restoration, research, or monitoring (see Section 3 for suggested projects). The suggested capstone program would rely on *self-directed* and *problem-based* learning. Faculty would expose students to questions to solve and organizations with which to interact. Students would be responsible for making choices about their learning, including how and what they engage in, and for the consequences of their choices. Students would choose among internships (service-learning with an outside agency), field practicums in which they implement restoration projects or assess the efficacy of previous restoration efforts (collaborative, service-learning with an outside agency), or thesis research (independent research under the guidance of a faculty mentor). Faculty would guide student experiences, but the students would be responsible for developing their objectives, work plans, timelines, and products for evaluation.

The first course in the capstone, Methods for Restoration and Monitoring (ECORES 0301, 6 cr.) would teach students the nuts and bolts of designing a research, monitoring, or restoration proposal. Students would develop skills in reviewing scientific literature, project planning, and sampling design, as well as oral and written communication skills. In addition, they would begin to develop a professional network for their senior year project. At the end of the semester, students would turn in a formal proposal for a restoration, research, or monitoring project. Students could be encouraged to write these proposals for specific funding opportunities and, when feasible, to submit their proposals for funding. Students' choice of projects in this course would lead to different paths in the second capstone course (Internship, Practicum, or Independent Research; below and Figure 1), allowing students the flexibility to tailor their learning to their specific interests, learning style, and career goals. Having multiple options also enables faculty to focus their mentorship efforts based on students' skills and needs.

- *OPTION 1: Ecological Restoration Internships*- The Ecological Restoration Internship would allow students to obtain a hands-on experience in some aspect of ecological science and/or restoration that will help them build their professional network and broaden their career skills. Internships could be paid or volunteer and should be linked to the student's interests, expanding skill sets and knowledge base in ecological restoration. Because internships would require less faculty mentorship than the other two options, including them as an

option would allow more students to enroll in the program than if only practicums and theses were allowed. During the internship, students would be encouraged to engage with stakeholders and the public, develop volunteer events, and engage the media. Students who elect to do an internship would be required to write a paper reflecting on their internship experience and critiquing the restoration practices that they implemented. After completing their internship, students would be expected to enroll in the *Senior Seminar* in which they would revise their internship report and give an oral presentation on their experience.

- *OPTION 2: Ecological Restoration Practicum* - The goal of the practicum would be for students to gain real-world experience in the practice of ecological restoration through direct creative engagement with local organizations and agencies. Students would collaboratively design and implement aspects of a restoration, monitoring or research plan as a service-learning project for a community partner (private entity, nonprofit group, management agency or other sponsor). The scope of work for the practicum would be developed in collaboration with a potential sponsor (ideally as the final project for the Methods course) and could include any aspect of restoration work or restoration-relevant research. The faculty mentor would provide advice on potential practicum projects, but final responsibility for collaborating with the community partner, and for establishing meeting times and locations, would rest with the students. Students would only be able to register after faculty and community partner approval of their proposal. The practicum could be done in summer (especially for projects were student support is available) or fall and could continue for more than one semester. Students would be encouraged to lead community volunteer events at their practicum sites and to engage the media. After completing all practicum credits, students would be expected to enroll in the *Senior Seminar* in which they would write and revise their practicum report and give an oral presentation on the outcomes of their practicum experience.
- *OPTION 3: Ecological Restoration Independent Research* - A student enrolled for Independent Research credit would conduct independent study with the approval of a faculty mentor. Independent Research is reserved for students who show evidence of a high capacity for scholarship in ecosystem and restoration ecology, and their project should help them achieve related goals. Student projects would be question-oriented and students who elect this option should want to work independently to solve a problem. Student research could involve analysis of either original or secondary data, and could involve natural science, social science, policy or economic themes. Ideally the work should be targeted for publication; even if not all student projects meet this standard, all students would learn about the scientific process by trying to achieve this goal. After completing all research credits, students would be expected to enroll in the *Senior Seminar* in which they would write and revise a research paper and give an oral presentation summarizing their findings.

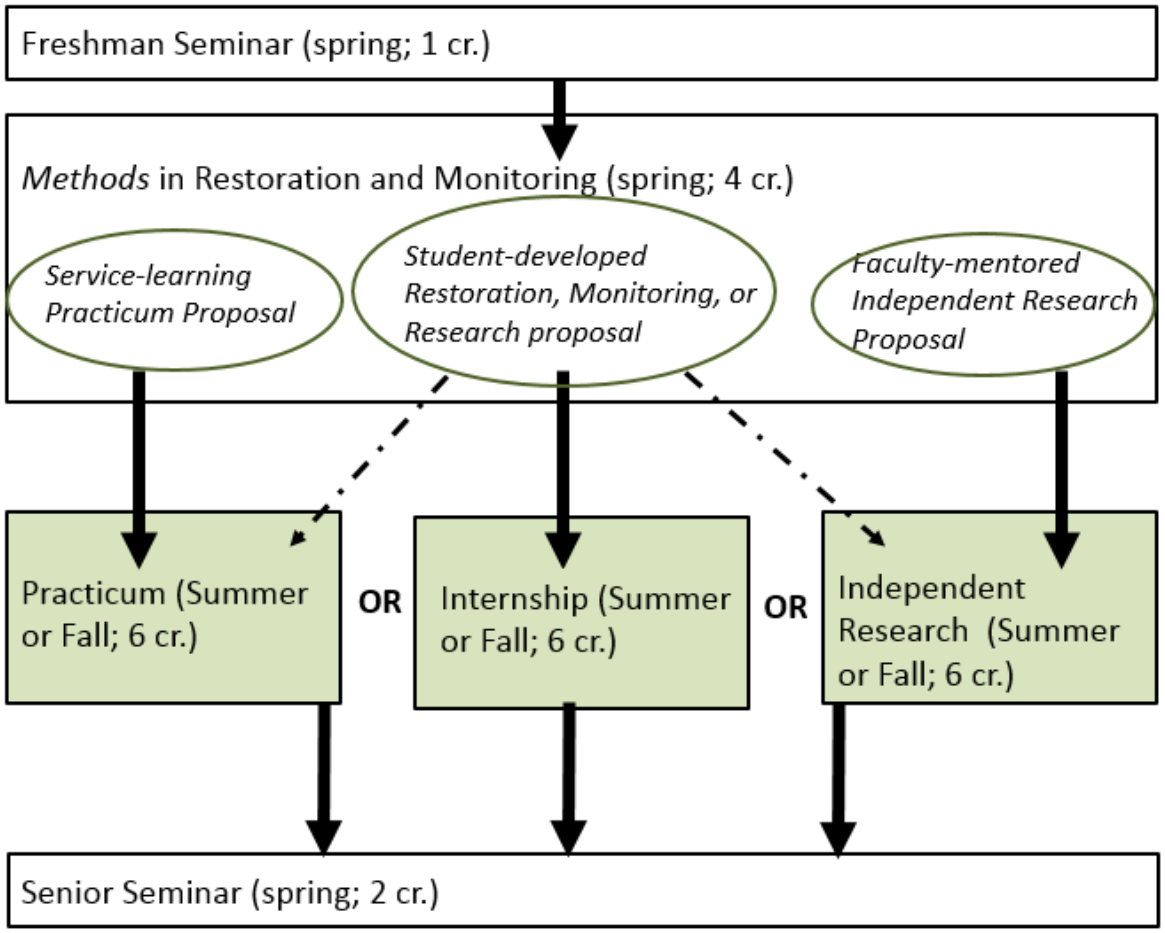
In spring of senior year, students would come back together as a group for a senior seminar in which they share their experiences and findings and give presentations to the freshman students and community members.

Because the capstone experience involves rigorous scholarship, WSU faculty may want to consider having GPA requirements for participation in the program or in program elements such as practicum or research experiences. Similarly, faculty may want to consider running elements of the program through an Honors Program.

Table 6. Learning outcomes associated with ecological restoration courses. I= introduced; D= Developed; and M=mastered.

Learning Objectives	Freshman Seminar	Ecological Restoration	Restoration Ecology	Restoration Capstone				
				Methods for Restoration and Monitoring	Practicum	Independent Research	Internship	Senior Seminar
Develop a learning community and professional network	I	I	I	I	D	D	D	M
Understand the current practice of ecological restoration	I	D			D		D	M
Critically evaluate natural resource management practices		I		D	D,M		D,M	
Develop field skills	I			D	M	M	M	
Understand the scientific theories that underpin restoration practice		I	D	D	D	M	D	D/M
Evaluate research proposals and project plans developed by others		I		D				
Write research, monitoring, or project implementation proposals				D				
Identify potential funding sources and submit proposals				I, D, M				
Submit a professional-level job application				I, D, M				
Effectively manage time associated with executing a project				I	M	M	M	M
Use peer-reviewed literature appropriately, including reference software		I	D	D	D	D	D	M
Develop experimental and sampling methods				I, D		M	M	
Implement ecosystem management projects					D	D,M		
Implement a research, monitoring, or management project						D, M	D, M	
Analyze and summarize data				I		D, M	D, M	M
Archive research and monitoring data using best practices				I		D	D	M
Organize, lead, and engage students and the public in field tours and activities					I, D	I, D	I, D	M
Communicate results to the public via social or earned media (press)					I, D	I, D	I, D	M
Work effectively as part of a team				I, D	M		M	
Participate in service learning					M			
Deliver a professional scientific or management presentation				I, D				M
Engage in a professional manner with natural resource scientists and professionals	I	I		D	D	D	D	M
Summarize research findings, project results, or state of knowledge in the field					D	D	D	M

Figure 1. Potential student paths through the field learning courses, based on the type of proposal (green shaded ovals) developed in Methods for Restoration and Monitoring (ECORES 0301). Each box represents a single course. Students take only one of the three courses in the green shaded boxes. Solid arrows represent primary pathways; dashed arrows indicate alternate routes.



Other Undergraduate Program Options

Instead of an undergraduate degree program, WSU could develop an undergraduate minor or certificate. A minor would allow students to gain basic competency in ecological restoration while pursuing another degree at WSU, and could be developed in addition to or instead of a BS Program. A certificate would require students to participate in a two-year concentrated focus (1/2 of all credits during the two-year period would be devoted to fulfilling certificate requirements). In our view, it would not make sense to run both a certificate and a BS program at the same institution.

Suggested Requirements for a Minor (21 credits)

- Biological and Environmental Sciences (12 cr.)
    - BIOL 0325 Ecosystems (3 cr.)
    - Restoration Ecology (3 cr.)
    - GARP 0206 Climate Change or Soils or Hydrology (3 cr.)
    - Biology Elective (3 cr.)
- Ecosystem Management (6 cr.)
    - Ecological Restoration (3 credit)
    - Ecosystem Management Elective (3 cr.)
- Human Dimensions (3 cr.)
    - Human Dimensions Elective (3 cr.)

Suggested Requirements for Certificate (30 credits)

- Biological and Environmental Sciences (9 cr.)
    - BIOL 0325 Ecosystems (3 cr.)
    - Restoration Ecology (3 cr.)
    - GARP 0206 Climate Change or Soils or Hydrology (3 cr.)
- Ecosystem Management (6 cr.)
    - Ecological Restoration (3 credit)
    - Ecosystem Management Elective (3 cr.)
- Human Dimensions (3 cr.)
    - Human Dimensions Elective (3 cr.)
- Restoration Capstone Program (12 cr.)
    - Methods for Restoration and Monitoring (ECORES 0301, 4 cr.)
    - Restoration Practicum (ECOREST 03XX; ≥ 6 cr.)
    - Ecological Restoration Senior Seminar (ECOREST 0390; 2 cr.)

Many of the suggested required courses for a minor or certificate would count toward existing WSU degrees in environmental science and biology, allowing students in either of these programs to easily add the minor or certificate to their program of study.

MS Program

In addition to or instead of an undergraduate program, WSU could develop a conventional thesis-based MS program or a professional non-thesis program. Suggestions in this section are for a non-thesis

program, as thesis-based programs are largely driven by the recommendations of the students' graduate advising committees, with only a handful of required courses.

Students should only be admitted to WSU's MS program in restoration if they have completed an undergraduate degree in biology, ecology, natural resource management, or a related field. Otherwise, they will have too many pre-requisites to advance through the program. If students arrive with backgrounds in science and management, the MS program could focus specifically on the restoration content.

Core Courses. Students would take the following core courses.

- A course on ecological restoration that covers the goals and objectives of ecological restoration and a survey of practices
- A course on restoration ecology that covers the ecological theory behind the practice
- A sampling design course
- A course on human dimensions of restoration
- A course on the business of restoration

Practicum courses. The practicum program, described for the BS program above, could be converted to a MS program. Students would take a methods course during the first semester, in which they would develop a proposal. The next two semesters would involve implementing a practicum project, and the final semester would involve reporting.

Electives. Students would have the opportunity take three electives related to their capstone project during their program.

Graduate seminars. Students would enroll in two graduate seminars during their program.

- The first graduate seminar (fall semester of the first year) would include presentations by guests associated with the practicum projects being run that year.
- The second seminar (spring second year) would feature student presentations.

Table 7. Two-year plan for a MS program in ecological restoration.

Year	Fall Semester	Spring Semester
First	1. Ecological Restoration (3 cr.) 2. Practicum 1: Methods for Restoration and Monitoring (5 cr.) 3. Sampling design (3 cr.) 4. Graduate seminar (1 cr.)	1. Restoration Ecology (3 cr.) 2. Practicum 2: Implementation (6 cr.) 3. Elective 1
Second	1. Human dimensions (3 cr.) 2. Practicum 3: Implementation (6 cr.) 3. Elective 2 (3 cr.)	1. Business of Restoration (3 cr.) 2. Practicum 4: Reporting (5 cr.) 3. Elective 3 (3 cr.) 4. Graduate seminar (1 cr.)

Student Engagement in the Society for Ecological Restoration

Students in a restoration degree program at WSU would have multiple opportunities for engagement with the Society for Ecological Restoration (www.ser.org) — an organization of scientists and practitioners from

over 70 countries dedicated to promoting ecological restoration as a means of sustaining the diversity of life on Earth and re-establishing an ecologically healthy relationship between nature and culture. As the primary professional society for the field, SER plays an important role in increasing capacity for ecological restoration by providing technical guidance documents, such as its *Primer on Ecological Restoration*, journal *Restoration Ecology*, and Island Press Book Series, *The Science and Practice of Ecological Restoration*. The Society also plays an important role in facilitating the sharing of lessons learned and in assisting the global restoration community in filling gaps in knowledge about the effects and efficacy of restoration interventions through its chapter and conference programs. SER has regional chapters; WSU falls within the geographic scope of the Society's New England Chapter (http://chapter.ser.org/newengland/).

SER is finalizing a new Practitioner Certification program to advance the practice of ecological restoration. The program, expected to launch in December 2016, will recognize both new and seasoned professionals who have the knowledge, training, and experience necessary to implement high-quality restoration projects. Certification will be based on a combination of academic credentials, field experience (5 years) and peer references. The curriculum proposed for WSU would provide students with the needed academic requirements to apply for SER's Certified Ecological Restoration Practitioner-in-Training (CERPiT) status. Thus, students from WSU would be immediately eligible to participate upon graduation. Upon achieving five years of experience, CERPiT's can apply to upgrade to Certified Ecological Restoration Practitioner (CERP) status. SER is already working with land managers, consulting firms and other large employers to build recognition for this certification.

In addition, SER has an active Student Association Program (www.ser.org/membership/student-associations), which provides opportunities for students interested in ecological restoration to engage in SER's global network, participate in SER conferences and events, and take advantage of SER resources. Organized and run entirely by the students themselves, student associations can be formed at any accredited academic institution, and provide a means for those students to come together in a like-minded group. SER also has regular internship projects through its headquarters (though remote internships are common).

Regardless of whether WSU develops a program in ecological restoration, WSU students would benefit from the development of a SER student association. Involvement in SER would provide WSU students with career-advancing opportunities, including access to experts within the New England Chapter of SER and opportunities to participate in chapter conferences, leadership, and activities. Not only do student associations connect budding restoration professionals with SER's global community, they also provide a means for students to organize hands-on activities in their own communities and pursue professional development opportunities as a collective. Existing SER student associations have organized volunteer and social events, native plant sales, restoration projects, workshops, roundtable discussions, career fairs, and fundraising activities, among others. At these events, students are able to learn about emerging issues and ideas, share their knowledge and experiences, network with other students, and interact with restoration experts from around the world. In addition, SER internships are promoted/circulated to Student Chapters and student members first, before circulating more broadly on internship exchanges.

Section 3. Field-learning Opportunities in Ecological Restoration – Practicums, Internships, and Research

The organizations and initiatives listed below are just a sampling of those that could offer students valuable opportunities in all three field-learning areas: **Practicums (P), Internships (I)** and **Research (R)**. Many of these possibilities are aligned with the goals and principles of MA-DER's "Priority Projects", with potential focus in three target projects areas: (1) river and wetland restoration, (2) urban river and river corridor revitalization, and (3) in-stream flow restoration. Opportunities abound for field learning that matches DER's priorities of restoring natural processes, establishing connectivity, and improving habitat and ecosystem function, with an eye toward increased public access and urban vitality.

MA-DER's office on the WSU campus allows DER staff to be highly involved with students – as classroom instructors, as well as facilitators of field-learning opportunities. Development of an ecological restoration degree program, with an emphasis on field learning, will build on and formalize this existing relationship between WSU and MA-DER. As described in DER's 2014 Annual Report, "The [WSU] location has many advantages with the most exciting being a blossoming partnership between the school, its students and DER to undertake real world research and stewardship throughout the Westfield River Watershed."

MA-DER's existing **Dam Removal Independent Study** practicum at UMass Amherst, which allows students to "better understand the dam removal process and careers in the river restoration field by participating in the technical teams for selected projects," could serve as a model for developing student practicums at WSU. The technical teams for this practicum include staff from MA-DER, U.S. Fish and Wildlife Service, consulting engineers, and nonprofits like The Nature Conservancy, Trout Unlimited, and American Rivers. Over two semesters, students develop their own independent projects and participate in site visits, team meetings, and review of technical products (e.g., hydrologic and hydraulic models, sediment testing data, scopes of work, and engineering plans). This model would fit well into the field learning capstone program explained above. This sort of in-depth exposure to actual projects and professionals in the field provides invaluable understanding of real-world restoration and career opportunities. Finally, as MA-DER determines its future strategic direction and research needs, it can partner with a WSU ecological restoration degree program to help direct student research, including graduate level research, to answer critical programmatic questions. A close MA-DER/WSU partnership could, for example, lead to the development of a high-quality, focused, field-based laboratory for posing and answering applied questions to improve the design, implementation and overall effectiveness of ecological restoration in the state of Massachusetts and beyond.

Most of the opportunities described below already involve MA-DER staff leadership and virtually all of them have the potential for MA-DER involvement – especially in collaboration with WSU faculty and students.

- **USFWS Urban Wildlife Refuge Partnership,** active in Springfield MA. The partnership focuses on restoration planned for the Abbey Brook Conservation Area. It is in an urban core setting, with numerous cross-sector partners – including MA-DER staff based at WSU. Workgroups are focused on habitat restoration, environmental education, and community revitalization. (https://www.fws.gov/urban/partnerships.php) [Opportunities: P/I/R]
- **USFWS Northeast Regional Office,** located in Hadley MA, as well as **USFWS Conte Refuge,** based in Sunderland MA and extending across entire four-state Connecticut River Watershed. USFWS is also a key partner in the **North Atlantic Landscape Conservation Cooperative (LCC),** which "works together to identify common science needs, share scientific capacity and information, and coordinate natural resource conservation actions across the region," as well as in the **North Atlantic Aquatic Connectivity Collaborative,** which is administered in Massachusetts by DER staff at WSU.

(https://www.fws.gov/northeast/maps/massachusetts.html)
(https://www.fws.gov/refuge/silvio_o_conte/) (http://northatlanticlcc.org/)
(www.streamcontinuity.org) [Opportunities: P/I/R]

- **Kinne Brook Restoration,** an ongoing DER Priority Project led by Trout Unlimited in Chester MA. This initiative involves WSU students in conducting river assessment, pre-restoration surveys, and post-restoration monitoring. There is interest in expanding this "living laboratory" program to other sites, pending increased faculty capacity. (http://www.tu.org/tu-projects/kinne-brook-restoration-project) [Opportunities: I/R]
- **Westfield River Watershed Association,** established in 1953 "to protect and improve the natural resources of the Watershed, as well as to expand recreational and other land use opportunities for people's enjoyment and for sound ecology." In collaboration with MA-DER staff and WSU faculty, students have secured WRWA internships to perform research and monitoring activities – including collecting water samples during high- and low-flow conditions and test for dissolved oxygen, pH, temperature, and several metals. (www.westfieldriver.org) [Opportunities: I/R]
- **Wild & Scenic Westfield River Committee,** directs programs aimed at restoration, monitoring, and research. In partnership with MA-DER, WSU student interns are conducting GIS mapping, surveys of tributaries, stream inventories, and research on historical and geological attributes of streams. (http://www.westfieldriverwildscenic.org/programs.html) [Opportunities: P/I/R]
- **Westfield River Watershed Invasive Species Partnership (WISP),** a group of cross-sector organizations – including WSU, DER, The Nature Conservancy, MA Audubon, and numerous other partners – which "promotes cooperative efforts to manage invasive species through an integrated approach of protecting and restoring desired native plant communities at the watershed level through education, early detection, eradication, and management." (http://www.westfieldriver.org/invasives.html) [Opportunities: P/I/R]
- **Long Island Sound Watershed Regional Conservation Partnership Program (LISW-RCPP),** supporting extensive preservation and restoration work throughout Connecticut River Watershed (CT, MA, VT, NH) aimed primarily at preventing sedimentation due to streambank erosion and land use practices. (http://www.lisw-rcpp.com/) [Opportunities: P]
- **RCP Network (Regional Conservation Partnerships),** coordinated by Wildlands & Woodlands, includes 44 organizations in New England, with many located across Western Massachusetts. There is increasing interest in bringing a restoration approach to preservation activities. (http://www.wildlandsandwoodlands.org/rcpnetwork) [Opportunities: P/I/R]
- **The Harvard Forest,** with headquarters in Petersham MA, hosts a Long Term Ecological Research (LTER) program that "examines ecological dynamics in the New England region resulting from natural disturbances, environmental change, and human impacts." Among many other works, Harvard Forest has also produced the ground-breaking report, "Changes to the Land: Four Scenarios for the Future of the Massachusetts Landscape." (http://harvardforest.fas.harvard.edu/research) [Opportunities: R]
- **VT-DEC Ecosystem Restoration Program (ERP),** which has a backlog of projects queued up for implementation, including several in Southern Vermont. (http://dec.vermont.gov/watershed/funding) [Opportunities: P]
- **SER New England Chapter,** including Laderman Student Grant program and possible launch of Student Association at WSU. (http://chapter.ser.org/newengland/) [Opportunities: I/R]

Section 4. Staffing and Funding Recommendations[17]

WSU already has many of the necessary elements in place for a degree program in ecological restoration. The University has just constructed a new science building, which will offer all facilities needed. In addition, faculty within the biology and environmental science departments already offer many courses that could be included in a degree program, as outlined above. These faculty also have the expertise necessary to mentor students. Existing administrative staff are also in place to assist faculty and students. Restoration programs require substantial interaction with project partners, especially when field practicums are required; the fact that MA-DER has an office on campus and is willing to collaborate with faculty and engage with and hire students greatly enhances the feasibility of creating a new degree program.

Given the current infrastructure at WSU, the annual costs of operating a new degree program with existing faculty would be relatively low. The primary expenses would be (Table 8):

- An additional lab technician to support the field-learning program. According to public records, annual salary for a WSU Lab Technician II is $48,129.
- Compensation for a faculty program director, who would serve as the administrative chair of the program and also coordinate field learning experiences. Robert Thompson (Director, Westfield River Environmental Center, Biology Department, WSU) indicated that at WSU director stipends could be equivalent to as much as 50% of a professor's annual salary. According to public records, average annual salary for a WSU Assistant Professor is $68,000; thus, $34,000 or more could be needed as compensation.
- Supplies and equipment = ca. $5,000/year.
- Program events = ca. $1,500/year.

Table 8. Potential costs of operating a BS, MS, or Certificate Program in Restoration. Costs are rough estimates only.

Item	$/yr.
Salary	
Lab tech	$48,000
Benefits	
Lab tech	$15,000
Total Salary and Benefits	$63,000
Administrative Stipend for Program Director (50% of salary)	$34,000
Supplies and Equipment	$5,000
Program Events	$1,500
TOTAL	$103,500

[17] Content in this section is based on information provided by Robert Thompson (Director, Westfield River Environmental Center, Biology Department, WSU), WSU's website, and public records posted on the Massachusetts Open Checkbook website (http://opencheckbook.itd.state.ma.us/analytics/saw.dll?Dashboard&PortalPath=%2Fshared%2FTransparency%2F_portal%2FAdditional%20Spending&Page=Payroll).

In order to be able to implement the program without hiring new faculty, it might be necessary to consider cross listing courses with other Massachusetts state institutions. This would also could have the advantage of increasing engagement from students at other campuses in WSU courses.

If existing faculty and courses are not currently adequate to deliver the program, the University would need to consider new faculty hires. Based on a review of the Environmental Science and Biology Department websites, we suggest the following faculty lines might be needed (listed in order of priority).

1) A new faculty member might be needed with expertise specifically in the practice of ecological restoration, including planning and project implementation.

2) Although there are already several faculty members with expertise in ecology, these faculty members likely already have full teaching loads and a new faculty member may be needed to teach restoration ecology. Within the broad field of restoration ecology, the University could search for a faculty member with expertise specifically related to the issues and ecosystems identified in the state's restoration agenda.

3) If funds are available, we suggest a third new hire in the human dimensions of restoration (social science, business, ethics, policy, collaboration).

According to public records, average annual salary for an Assistant Professor at WSU is $68,000. In addition, any new faculty would require a start-up package. In our experience, these can range from $50,000-$500,000/faculty member.

Conclusion

Our review of academic programs in the field of ecological restoration suggest growth of over 200% in the last decade in both the number of programs and the number of institutions that offer programs. Still, with programs at only 11% of the institutions surveyed, academic opportunities are remain relatively rare. This is particular true in the northeastern United States, where we only found programs at 2 of 97 institutions surveyed. WSU is well situated to offer a degree in ecological restoration, given its existing programs in both biology and environmental science, and its pre-existing relationship with MA-DER. If developed, this program could attract a new population of students to WSU and could increase capacity in the region for effective ecological restoration.

Appendix A

The name and location of each institution included in the survey of academic programs (sorted alphabetically by region, country, state and name) and whether the institution was one of the 32 suggested by MA-DER ("MA-DER ADDITION").

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
University of Alberta	Intermountain West	CAN	ALB	
Arizona State University	Intermountain West	USA	AZ	
Grand Canyon University	Intermountain West	USA	AZ	
Northern Arizona University	Intermountain West	USA	AZ	
Prescott College	Intermountain West	USA	AZ	
University of Arizona	Intermountain West	USA	AZ	
Colorado School of Mines	Intermountain West	USA	CO	
Colorado State University	Intermountain West	USA	CO	
University of Colorado at Boulder	Intermountain West	USA	CO	
University of Colorado at Colorado Springs	Intermountain West	USA	CO	
University of Colorado at Denver	Intermountain West	USA	CO	
Idaho State University	Intermountain West	USA	ID	
University of Idaho	Intermountain West	USA	ID	
Montana State University	Intermountain West	USA	MT	
Rocky Mountain College	Intermountain West	USA	MT	
University of Montana, Missoula	Intermountain West	USA	MT	
New Mexico State University	Intermountain West	USA	NM	
Sierra Nevada College	Intermountain West	USA	NV	
University of Nevada, Las Vegas	Intermountain West	USA	NV	
University of Nevada, Reno	Intermountain West	USA	NV	
Brigham Young University	Intermountain West	USA	UT	
University of Utah	Intermountain West	USA	UT	
Utah State University	Intermountain West	USA	UT	
University of Wyoming	Intermountain West	USA	WY	
University of Lethbridge	Midwest	CAN	ALB	
University of Calgary	Midwest	CAN	ALB	
University of Manitoba	Midwest	CAN	MB	
University of Winnipeg	Midwest	CAN	MB	

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
Brock University	Midwest	CAN	ON	
Carleton University	Midwest	CAN	ON	
Lakehead University	Midwest	CAN	ON	
Laurentian University	Midwest	CAN	ON	
McMaster University	Midwest	CAN	ON	
Queen's University	Midwest	CAN	ON	
Royal Military College of Canada	Midwest	CAN	ON	
Trent University	Midwest	CAN	ON	
University of Guelph	Midwest	CAN	ON	
University of Ottawa	Midwest	CAN	ON	
University of Toronto	Midwest	CAN	ON	
University of Waterloo	Midwest	CAN	ON	
University of Western Ontario	Midwest	CAN	ON	
University of Windsor	Midwest	CAN	ON	
York University	Midwest	CAN	ON	
University of Regina	Midwest	CAN	SK	
University of Saskatchewan	Midwest	CAN	SK	
Iowa State University	Midwest	USA	IA	
Luther College	Midwest	USA	IA	
University of Iowa	Midwest	USA	IA	
University of Northern Iowa	Midwest	USA	IA	
Eastern Illinois University	Midwest	USA	IL	
Governors State University	Midwest	USA	IL	
Greenville College	Midwest	USA	IL	
llinois State University	Midwest	USA	IL	
Loyola University Chicago	Midwest	USA	IL	
Northwestern University	Midwest	USA	IL	
Principia College	Midwest	USA	IL	
Southern Illinois University, Carbondale	Midwest	USA	IL	
Southern Illinois University, Edwardsville	Midwest	USA	IL	
University of Chicago	Midwest	USA	IL	
University of Illinois at Chicago	Midwest	USA	IL	

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
University of Illinois at Springfield	Midwest	USA	IL	
University of Illinois at Urbana–Champaign	Midwest	USA	IL	
Western Illinois University	Midwest	USA	IL	
Indiana State University	Midwest	USA	IN	
Indiana University Bloomington	Midwest	USA	IN	
Purdue University	Midwest	USA	IN	
Taylor University	Midwest	USA	IN	
University of Notre Dame	Midwest	USA	IN	
Bethel College	Midwest	USA	KS	
Emporia State University	Midwest	USA	KS	
Kansas State University	Midwest	USA	KS	
University of Kansas	Midwest	USA	KS	
Wichita State University	Midwest	USA	KS	
Central Michigan University	Midwest	USA	MI	
Ferris State University	Midwest	USA	MI	
Michigan State University	Midwest	USA	MI	
Michigan Technological University	Midwest	USA	MI	
Oakland University	Midwest	USA	MI	
University of Michigan	Midwest	USA	MI	
University of Michigan, Dearborn	Midwest	USA	MI	
Western Michigan University	Midwest	USA	MI	
Minnesota State University Mankato	Midwest	USA	MN	
Saint Mary's University of Minnesota	Midwest	USA	MN	
University of Minnesota, Twin Cities Campus	Midwest	USA	MN	
Southwest Missouri State University	Midwest	USA	MO	
Stephens College	Midwest	USA	MO	
University of Missouri, Columbia	Midwest	USA	MO	
University of Missouri, St. Louis	Midwest	USA	MO	
Washington University in St. Louis	Midwest	USA	MO	
North Dakota State University	Midwest	USA	ND	
University of North Dakota	Midwest	USA	ND	
Chadron State College	Midwest	USA	NE	

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
University of Nebraska	Midwest	USA	NE	
Cleveland State University	Midwest	USA	OH	
Defiance College	Midwest	USA	OH	
Heidelberg College	Midwest	USA	OH	
Kent State University	Midwest	USA	OH	
Miami University	Midwest	USA	OH	
Mount Union College	Midwest	USA	OH	
Ohio State University	Midwest	USA	OH	
Ohio University	Midwest	USA	OH	
University of Cincinnati	Midwest	USA	OH	
University of Dayton	Midwest	USA	OH	
University of Toledo	Midwest	USA	OH	
Wright State University	Midwest	USA	OH	
South Dakota State University	Midwest	USA	SD	
Beloit College	Midwest	USA	WI	
Marquette University	Midwest	USA	WI	
University of Wisconsin, La Crosse	Midwest	USA	WI	
University of Wisconsin, Madison	Midwest	USA	WI	
University of Wisconsin, Oshkosh	Midwest	USA	WI	
Mount Allison University	Northeast	CAN	NB	
University of New Brunswick	Northeast	CAN	NB	
Memorial University of Newfoundland	Northeast	CAN	NF	
Acadia University	Northeast	CAN	NS	
Dalhousie University	Northeast	CAN	NS	
Saint Francis Xavier University	Northeast	CAN	NS	
Saint Mary's University	Northeast	CAN	NS	
University of Prince Edward Island	Northeast	CAN	PEI	
Concordia University	Northeast	CAN	QB	
McGill University	Northeast	CAN	QB	
Connecticut College	Northeast	USA	CT	
Quinnipiac University	Northeast	USA	CT	X
Sacred Heart University	Northeast	USA	CT	X

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
University of Connecticut	Northeast	USA	CT	
University of New Haven	Northeast	USA	CT	
Wesleyan University	Northeast	USA	CT	
Western Connecticut State University	Northeast	USA	CT	
Yale University	Northeast	USA	CT	
Amherst College	Northeast	USA	MA	X
Boston College	Northeast	USA	MA	X
Boston University	Northeast	USA	MA	X
Clark University	Northeast	USA	MA	X
College of the Holy Cross	Northeast	USA	MA	X
Harvard University	Northeast	USA	MA	
Lesley University	Northeast	USA	MA	
Massachusetts College of Liberal Arts	Northeast	USA	MA	X
Massachusetts Institute of Technology	Northeast	USA	MA	
Mount Holyoke	Northeast	USA	MA	X
Salem State	Northeast	USA	MA	X
Smith College	Northeast	USA	MA	X
Tufts University	Northeast	USA	MA	
University of Massachusetts, Amherst	Northeast	USA	MA	
University of Massachusetts, Boston	Northeast	USA	MA	
University of Massachusetts, Conway	Northeast	USA	MA	X
University of Massachusetts, Dartmouth	Northeast	USA	MA	
University of Massachusetts, Lowell	Northeast	USA	MA	
Williams	Northeast	USA	MA	X
Worcester Polytechnic Institute	Northeast	USA	MA	
Bates	Northeast	USA	ME	X
Bowdoin	Northeast	USA	ME	X
Colby College	Northeast	USA	ME	
College of the Atlantic	Northeast	USA	ME	
New England University	Northeast	USA	ME	X
Unity College	Northeast	USA	ME	X
University of Maine	Northeast	USA	ME	

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
University of Southern Maine	Northeast	USA	ME	X
Antioch New England Graduate School	Northeast	USA	NH	
Dartmouth College	Northeast	USA	NH	
Keene State	Northeast	USA	NH	X
Plymouth State College	Northeast	USA	NH	
University of New Hampshire	Northeast	USA	NH	
Montclair State University	Northeast	USA	NJ	
New Jersey Institute of Technology	Northeast	USA	NJ	
Princeton University	Northeast	USA	NJ	
Rowan University	Northeast	USA	NJ	X
Rutgers, The State University of New Jersey, Newark	Northeast	USA	NJ	
Seton Hall University	Northeast	USA	NJ	X
William Paterson University of New Jersey	Northeast	USA	NJ	
Brooklyn College	Northeast	USA	NY	X
Clarkson University	Northeast	USA	NY	
Colgate University	Northeast	USA	NY	X
Columbia University	Northeast	USA	NY	
Cornell University	Northeast	USA	NY	
Daemen College	Northeast	USA	NY	
Fordham University	Northeast	USA	NY	
Long Island University	Northeast	USA	NY	
New York Institute of Technology	Northeast	USA	NY	
New York University	Northeast	USA	NY	
Pace University	Northeast	USA	NY	
Paul Smith's College (AKA College of the Adirondacks)	Northeast	USA	NY	X
Polytechnic University, Brooklyn Campus	Northeast	USA	NY	
Rensselaer Polytechnic Institute	Northeast	USA	NY	
Rochester Institute of Technology	Northeast	USA	NY	
Sarah Lawrence College	Northeast	USA	NY	X
State University of New York, College of Environmental Science and Forestry (SUNY-ESF)	Northeast	USA	NY	X
State University of New York, Albany	Northeast	USA	NY	

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
State University of New York, Buffalo	Northeast	USA	NY	
Stony Brook University, State University of New York	Northeast	USA	NY	
Syracuse University	Northeast	USA	NY	X
University of Rochester	Northeast	USA	NY	
Vassar	Northeast	USA	NY	X
Carnegie Mellon University	Northeast	USA	PA	X
Drexel University	Northeast	USA	PA	
Duquesne University	Northeast	USA	PA	
Edinboro University of Pennsylvania	Northeast	USA	PA	
Lehigh University	Northeast	USA	PA	
Pennsylvania State University	Northeast	USA	PA	
Saint Francis College	Northeast	USA	PA	
Shippensburg University	Northeast	USA	PA	
Temple University	Northeast	USA	PA	X
University of Pittsburgh	Northeast	USA	PA	
Brown University	Northeast	USA	RI	
Roger Williams University	Northeast	USA	RI	X
Salve Regina University	Northeast	USA	RI	X
University of Rhode Island	Northeast	USA	RI	
University of Vermont	Northeast	USA	VT	
Vermont Law	Northeast	USA	VT	X
Alaska Pacific University	Other	USA	AK	
University of Alaska Anchorage	Other	USA	AK	
University of Alaska Fairbanks	Other	USA	AK	
University of Guam	Other	USA	GU	
University of Hawaii at Manoa	Other	USA	HI	
Universidad Interamericana de Puerto Rico	Other	USA	PR	
University of Arkansas	South	USA	AK	
Alabama Agricultural and Mechanical University	South	USA	AL	
Auburn University	South	USA	AL	
Tuskegee University	South	USA	AL	
University of Alabama	South	USA	AL	

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
University of South Alabama	South	USA	AL	
Arkansas State University	South	USA	AR	
Arkansas Tech University	South	USA	AR	
American University	South	USA	DC	
Howard University	South	USA	DC	
University of Delaware	South	USA	DE	
Wesley College	South	USA	DE	
Florida Atlantic University	South	USA	FL	
Florida Gulf Coast University	South	USA	FL	
Florida International University	South	USA	FL	
Florida State University	South	USA	FL	
Nova Southeastern University	South	USA	FL	
Stetson University	South	USA	FL	
University of Central Florida	South	USA	FL	
University of Florida	South	USA	FL	
University of Miami	South	USA	FL	
University of South Florida	South	USA	FL	
University of West Florida	South	USA	FL	
Columbus State University	South	USA	GA	
Emory University	South	USA	GA	
Georgia Institute of Technology	South	USA	GA	
Savannah State University	South	USA	GA	
Shorter College	South	USA	GA	
University of Georgia, Athens	South	USA	GA	
Eastern Kentucky University	South	USA	KY	
Murray State University	South	USA	KY	
University of Kentucky	South	USA	KY	
University of Louisville	South	USA	KY	
Louisiana State University	South	USA	LA	
McNeese State University	South	USA	LA	
Southern University and Agricultural and Mechanical College	South	USA	LA	
University of Louisiana at Lafayette	South	USA	LA	

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
University of New Orleans	South	USA	LA	
Frostburg State University	South	USA	MD	
Johns Hopkins University	South	USA	MD	
Towson University	South	USA	MD	
University of Maryland	South	USA	MD	
University of Maryland, Baltimore County	South	USA	MD	
University of Maryland, Eastern Shore	South	USA	MD	
Jackson State University	South	USA	MS	
Mississippi State University	South	USA	MS	
University of Southern Mississippi	South	USA	MS	
Duke University	South	USA	NC	
North Carolina Agricultural and Technical State University	South	USA	NC	
North Carolina State University	South	USA	NC	
University of North Carolina at Chapel Hill	South	USA	NC	
University of North Carolina, Wilmington	South	USA	NC	
Wingate University	South	USA	NC	
Oklahoma State University	South	USA	OK	
University of Oklahoma	South	USA	OK	
Clemson University	South	USA	SC	
Coastal Carolina University	South	USA	SC	
College of Charleston	South	USA	SC	
University of South Carolina	South	USA	SC	
Tennessee Technological University	South	USA	TN	
University of Tennessee	South	USA	TN	
University of Tennessee, Chattanooga	South	USA	TN	
Vanderbilt University	South	USA	TN	
Rice University	South	USA	TX	
Southern Methodist University	South	USA	TX	
Stephen F. Austin State University	South	USA	TX	
Sul Ross State University	South	USA	TX	
Tarleton State University	South	USA	TX	
Texas A&M University	South	USA	TX	

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
Texas Christian University	South	USA	TX	
Texas State University	South	USA	TX	
Texas Tech University	South	USA	TX	
University of Houston	South	USA	TX	
University of North Texas	South	USA	TX	
University of Texas at Austin	South	USA	TX	
University of Texas at El Paso	South	USA	TX	
University of Texas at San Antonio	South	USA	TX	
West Texas A&M University	South	USA	TX	
Christopher Newport University	South	USA	VA	
College of William and Mary	South	USA	VA	
George Mason University	South	USA	VA	
Marymount University	South	USA	VA	
Old Dominion University	South	USA	VA	
Sweet Briar College	South	USA	VA	
University of Virginia	South	USA	VA	
Virginia Commonwealth University	South	USA	VA	
Virginia Polytechnic Institute and State University	South	USA	VA	
West Virginia University	South	USA	WV	
Simon Fraser University	West Coast	CAN	BC	
Trinity Western University	West Coast	CAN	BC	
University of British Columbia	West Coast	CAN	BC	
University of Northern British Columbia	West Coast	CAN	BC	
University of Victoria	West Coast	CAN	BC	
California Polytechnic State University, San Luis Obispo	West Coast	USA	CA	
California State Polytechnic University, Pomona	West Coast	USA	CA	
California State University, Chico	West Coast	USA	CA	
California State University, East Bay	West Coast	USA	CA	
California State University, Fresno	West Coast	USA	CA	
California State University, Fullerton	West Coast	USA	CA	
Claremont Graduate University	West Coast	USA	CA	
Humboldt State University	West Coast	USA	CA	

INSTITUTION	REGION	COUNTRY	STATE/PROV.	MA-DER ADDITION
Loyola Marymount University	West Coast	USA	CA	
San Diego State University	West Coast	USA	CA	
San Francisco State University	West Coast	USA	CA	
San Jose State University	West Coast	USA	CA	
Stanford University	West Coast	USA	CA	
University of California, Berkeley	West Coast	USA	CA	
University of California, Davis	West Coast	USA	CA	
University of California, Irvine	West Coast	USA	CA	
University of California, Los Angeles	West Coast	USA	CA	
University of California, Riverside	West Coast	USA	CA	
University of California, San Diego	West Coast	USA	CA	
University of California, Santa Barbara	West Coast	USA	CA	
University of California, Santa Cruz	West Coast	USA	CA	
University of La Verne	West Coast	USA	CA	
University of Southern California	West Coast	USA	CA	
Oregon State University	West Coast	USA	OR	
Portland State University	West Coast	USA	OR	
University of Oregon	West Coast	USA	OR	
Eastern Washington University	West Coast	USA	WA	
University of Washington	West Coast	USA	WA	
Washington State University	West Coast	USA	WA	
Washington State University, Tri-Cities	West Coast	USA	WA	
Washington State University, Vancouver	West Coast	USA	WA	
Western Washington University	West Coast	USA	WA	

Appendix B

Name of institutions with degree programs in restoration, rehabilitation, reclamation, and remediation, and their location (country, geographic region), and type and title of program. UG = Undergraduate; G = Graduate.

Institution Name	Country	Region	Type	Title
California Polytechnic State Univ. San Luis Obispo	USA	West Coast	UG Minor	Land **Rehabilitation** and **Restoration** Ecology
Colorado State University	USA	Intermountain West	MS	Natural Resources Stewardship - Ecological **Restoration** Specialization
			BS	Rangeland Ecology - Concentration in **Restoration** Ecology
			BS	Soil and Crop Sciences - Concentration in Soil **Restoration** and Conservation
			UG Minor	Ecological **Restoration**
Defiance College	USA	Midwest	BS	B. S. **Restoration** Ecology
Florida Atlantic University	USA	South	G Certificate	Environmental **Restoration**
Humboldt State University	USA	West Coast	BS	Environmental Science - Ecological **Restoration** Option
			UG Minor	Ecological **Restoration**
Iowa State University	USA	Midwest	BS	Foresty - Natural Resource Conservation and **Restoration**
Laurentian University	CAN	Midwest	BS	**Restoration** Biology
Louisiana State University	USA	South	BS	Natural Resource Ecology and Management - Ecological **Restoration** Option
Loyola University Chicago	USA	Midwest	BS	Conservation and **Restoration** Ecology
Montana State University	USA	Intermountain West	MS	Land **Rehabilitation**
			BS	Environmental Sciences - Land **Rehabilitation** Option
North Carolina State University	USA	South	G Certificate	Design and Analysis of Environmental Systems: Watershed Assessment and **Restoration**
Northern Arizona University	USA	Intermountain West	UG Certificate	Forest Health and Ecological **Restoration**
Oregon State University	USA	West Coast	BS	Natural Resources - Ecological **Restoration** Option
Paul Smith's College (AKA College of the Adirondacks)[4]	USA	Northeast	BS	Ecological **Restoration**
San Jose State University	USA	West Coast	BS	Environmental Studies - Concentration in Environmental **Restoration** and Resource Management
Simon Fraser University	CAN	West Coast	MS	Ecological **Restoration**

Institution Name	Country	Region	Type	Title
State University of New York (SUNY-ESF)*	USA	Northeast	PhD	Ecosystem **Restoration**
			MS	Ecosystem **Restoration**
			MPS	Ecosystem **Restoration**
Texas A&M University	USA	South	BS	Ecological **Restoration**
Trent University	CAN	Midwest	BS	Ecological **Restoration**
University of Alberta	CAN	Intermountain West	PhD	Land **Reclamation** and **Remediation**
			MS	Land **Reclamation** and **Remediation**
			BS	Land R**eclamation**
University of Arizona	USA	Intermountain West	PhD	Natural Resources - Ecology, Management and **Restoration** of Rangelands Option
			MS	Natural Resources - Ecology, Management and **Restoration** of Rangelands Option
			BS	Natural Resources - Ecology, Managementand **Restoration** of Rangelands Emphasis
University of California, Davis	USA	West Coast	BS	Ecological Management and **Restoration**
			BS	Environmental Horticulture and Urban Forestry - Plant Biodiversity/**Restoration** Option
			UG Minor	Landscape **Restoration**
University of Florida	USA	South	PhD	Forest Resources and Conservation - Concentration in Ecological **Restoration**
			MS	Ecological **Restoration**
			G Certificate	Ecological **Restoration**
			BS	Plant Science - specialization in **Restoration** Horticulture
University of Idaho	USA	Intermountain West	G Certificate	**Restoration** Ecology
University of Illinois at Urbana–Champaign	USA	Midwest	BS	Natural Resources and Environmental Science - Concentration in Resource Conservation and **Restoration** Ecology
University of Maryland	USA	South	BS	Environmental Science and Policy - Concentration in Environmental Geosciences and **Restoration**
University of Minnesota, Twin Cities Campus	USA	Midwest	MS	Environmental **Restoration** Engineering and Science
			G Minor	Graduate minor in Environmental **Restoration** Engineering and Science
			G Minor	Ecological **Restoration** in Landscape Architecture
			G Certificate	Stream **Restoration** Science and Engineering

Institution Name	Country	Region	Type	Title
University of Montana, Missoula	USA	Intermountain West	BS	Ecosystem Science and **Restoration -** Aquatic Option
			BS	Ecosystem Science and **Restoration** - Terrestrial Option
			UG Minor	Ecological **Restoration**
University of Nebraska	USA	Midwest	BS	Environmental **Restoration** Science - Lake and Stream Restoration Option
			BS	Environmental **Restoration** Science - Soil Science Option
			UG Minor	Environmental **Restoration** Science
University of Tennessee	USA	South	BS	**Restoration** and Conservation Science Concentration
University of Texas at San Antonio	USA	South	BS	Environmental Science - Conservation and **Restoration** Ecology Area of Study
University of Victoria	CAN	West Coast	G Certificate	Ecological **Restoration** Professional Specialization
			Diploma	**Restoration** of Natural Systems
University of Washington	USA	West Coast	BS	Environmental Science and Terrestrial Resource Management - **Restoration** Ecology and Environmental Horticulture Option
			UG Minor	Ecological **Restoration**
University of Waterloo	CAN	Midwest	Diploma	Ecological **Restoration** and **Rehabilitation**
University of Wisconsin, Madison	USA	Midwest	MS	Ecological **Restoration**
University of Wyoming	USA	Intermountain West	UG Certificate	**Reclamation** and **Restoration** Ecology
			UG Minor	**Reclamation** and **Restoration** Ecology
Utah State University	USA	Intermountain West	BS	Conservation and **Restoration** Ecology

Appendix C.

For B.S., M.S./M.P.S and Graduate Certificates, frequency (percent of degree programs) of requirements and mean credits required in restoration-relevant subject areas.

	B.S. (n=27)		Prof. M.S. (n=4)		Gr. Certificate (n=6)	
Subject	freq (%)	mean cr.	freq (%)	mean cr.	freq (%)	mean cr.
Biological sciences						
Introductory biology	81.5	6.8	0.0	0.0	0.0	0.0
Cellular and molecular bioloy	7.4	4.0	0.0	0.0	0.0	0.0
Genetics and evolution	33.3	2.6	0.0	0.0	0.0	0.0
Ecology	92.6	8.8	75.0	3.3	66.7	2.9
Plant identification	66.7	6.0	0.0	0.0	16.7	0.8
Plant physiology	33.3	1.2	0.0	0.0	0.0	0.0
Additional plant sciences	48.1	4.0	0.0	0.0	0.0	0.0
Entomology	18.5	1.0	0.0	0.0	0.0	0.0
Wildlife biology	22.2	1.8	0.0	0.0	0.0	0.0
Aquatic biology	18.5	1.4	25.0	0.5	0.0	0.0
Other biological sciences	55.6	3.9	50.0	1.8	16.7	4.3
Business of restoration						
Planning project management	40.7	2.9	75.0	2.1	33.3	0.5
Business	7.4	0.4	25.0	0.1	0.0	0.0
Economics	63.0	3.4	75.0	1.4	16.7	1.0
Ecosystem and agroecosystem management						
Resource management and conservation	88.9	9.8	75.0	3.4	83.3	1.8
Horticulture	18.5	4.8	0.0	0.0	0.0	0.0
Agriculture	14.8	1.2	0.0	0.0	16.7	2.3
Engineering						
Engineering	11.1	1.7	25.0	2.1	50.0	2.7
Field learning						
Capstone or Practicum	51.9	3.8	50.0	1.7	33.3	2.0
Internship	40.7	2.5	25.0	3.0	16.7	3.0
Geospatial technology and tools						
Geospatial technology	37.0	2.0	0.0	0.0	0.0	0.0
GIS	74.1	2.5	25.0	0.3	16.7	0.5
Human dimensions						
Natural resource and environmental policy	74.1	2.8	75.0	1.1	50.0	0.7
Environmental ethics	29.6	2.6	25.0	0.2	0.0	0.0
Cultural perspectives on natural resources	14.8	1.4	0.0	0.0	0.0	0.0
Traditional ecological knowledge	7.4	1.1	25.0	3.0	0.0	0.0
Other restoration-relevant social sciences	77.8	5.0	25.0	1.9	16.7	1.5
Landscape architecture						
Landscape architecture	7.4	2.9	0.0	0.0	16.7	5.2
Physical, earth, and environmental sciences						
General chemistry	92.6	6.6	0.0	0.0	0.0	0.0
Organic chemistry	33.3	2.8	0.0	0.0	0.0	0.0
Physics	40.7	4.3	0.0	0.0	0.0	0.0

Subject	B.S. (n=27) freq (%)	B.S. (n=27) mean cr.	Prof. M.S. (n=4) freq (%)	Prof. M.S. (n=4) mean cr.	Gr. Certificate (n=6) freq (%)	Gr. Certificate (n=6) mean cr.
Earth science	66.7	3.4	75.0	0.8	16.7	0.9
Soil science	88.9	5.7	50.0	0.6	0.0	0.0
Hydrologic sciences	55.6	3.3	25.0	1.7	50.0	1.9
Atmospheric sciences	40.7	1.6	0.0	0.0	0.0	0.0
Other environmental sciences	40.7	3.4	25.0	0.9	50.0	1.0
Professional communication						
Technical writing	48.1	2.6	0.0	0.0	0.0	0.0
Public speaking and communication	33.3	4.0	0.0	0.0	0.0	0.0
Conflict resolution	11.1	1.4	25.0	0.2	16.7	0.4
Quantitative sciences						
Calculus	48.1	4.6	0.0	0.0	0.0	0.0
Quantitative methods and sampling design	92.6	5.7	75.0	2.6	33.3	1.0
Restoration science and practice						
Restoration ecology	40.7	3.7	25.0	1.2	33.3	2.8
Ecological restoration	63.0	4.1	75.0	7.6	83.3	4.1