
Opportunities for Academic Training in the Science and Practice of Restoration within the United States and Canada

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Abstract

With increasing interest in ecosystem restoration, there is a corresponding need for trained professionals who understand not only the science of restoration ecology but also the management practices and social factors that lead to successful project implementation. We surveyed 300 academic institutions in the United States and Canada with research programs in the ecological, conservation, and natural resource sciences to determine whether current curricula in restoration meet the needs of this growing field. Opportunities to obtain a degree specifically in the field of restoration were extremely limited: only 11 institutions (4%) offered undergraduate degrees, and only four (1%) offered graduate degrees. Half of these programs were established within the last 5 years. Only three programs required more than one course in restoration, and over half did not include any specific core courses in the

social sciences. There were more opportunities to obtain a degree relevant to restoration but not specifically restoration focused: 21% of institutions offered such undergraduate degrees and 12% offered graduate degrees. With regard to courses, only 23% of institutions offered courses that specifically focused on restoration, whereas 43% offered courses that included “restoration” in their description. These trends suggest that although training opportunities are increasing, the current pool of programs and courses that explicitly focus on restoration is not sufficient to meet current demand for qualified and experienced restorationists or to ensure that these scientists and practitioners have the training necessary to meet the complex challenges of restoring degraded ecosystems in the future.

Key words: academic programs, curricula, ecological restoration, education, restoration ecology.

Introduction

The fields of restoration ecology (“the suite of scientific practices that constitute an emergent subdiscipline of ecology”) and ecological restoration (“the ensemble of practices involved in the restoration of degraded ecosystems”) (Higgs 2005) have matured considerably over the last two decades. The Society for Ecological Restoration, established in 1988, now has circa 2,300 members from 37 countries (SERI 2007). During this time frame, restoration of degraded ecosystems has become a primary focus of natural resource management of both terrestrial and aquatic environments (e.g., Millennium Ecosystem Assessment 2005). Because an increasing number of restoration projects are implemented, there is a corresponding need for trained professionals who understand not only the science of restoration ecology but also the practice of restoring degraded ecosystems and the social factors that lead to

successful project implementation (Allen 2003; Higgs 2005). Employers interested in hiring early-career restoration scientists and practitioners look to academia to provide students with necessary training. Without this training, restorationists may not have the skills necessary to tackle the complex issues associated with recovering degraded ecosystems and, as a result, the success of restoration projects may be compromised.

We surveyed 300 academic institutions in the United States and Canada with research programs in the ecological, conservation, and natural resource sciences to determine whether the quantity and quality of academic programs in the science and practice of restoration are adequate to meet the needs of these growing fields. Specifically, we quantified the number of degree programs and courses with restoration in their title or description, compared availability of curricula among geographic regions and types of academic departments, and assessed the extent to which degree programs require training in both the natural and the social sciences.

Methods

Following the methods of Grant et al. (2007), we identified academic institutions in the United States and Canada with the greatest probability of having expertise in the

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field of restoration by searching Thomson Peterson's Guide to Graduate Schools (Peterson's 2006) using the search terms: "botany"; "conservation biology"; "ecology"; "environmental sciences"; "evolutionary biology"; "fish, game, and wildlife management"; "forestry"; "marine biology"; "marine sciences"; "zoology"; and "natural resource" ("restoration" was not a valid keyword in the database). Next, we added to this list any institutions categorized by Romero and Jones (2003) as having a "biology/ecology/conservation" or "natural resources management" focus to minimize the omission of institutions. This resulted in a database of 321 institutions with the greatest probability of offering curricula in restoration.

During November 2006, we searched the Web sites of each of the 321 institutions defined above for degree programs (bachelors, masters, and doctoral, including concentrations and options, but excluding minors and certificates which are not comprehensive training programs) and courses with the partial keyword "restor" in their title or description. The protocol for searching varied slightly depending on the structure of each institution's Web site. Degree and course information often were available through an online "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 keyword, "restor") 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), and natural resource management (e.g., forestry, fisheries, wildlife, range management). Twenty-one institutions either did not provide information on degrees and courses on their Web site or did not provide information in the English language; these institutions were excluded from consideration. Thus, 300 institutions were considered for analysis.

For each degree program and course with "restor" in the title or description, we recorded the department type, degree or course title, and whether "restor" was found in the title or description. Hereafter, we use the terms "restoration degree program" and "restoration course" to refer to those with "restor" in their title, and "restoration relevant" to refer to those that include "restor" in their description, but not in their title. In three instances, we found degree programs with "rehabilitation" or "reclamation" in their titles. In all three instances (1) the programs were established at least 15 years ago when restoration terminology was not as well developed as it is today and (2) the sponsoring institutions consider these terms to be functional syno-

nyms of "restoration"; thus, we categorized these as "restoration" programs. Although the fields of "restoration ecology" and "ecological restoration" are distinct, because these terms are often used interchangeably (Higgs 2005), we do not track them separately or attempt a comparison.

To confirm the findings from the Web searches and ensure that we did not overlook any degree programs, we sent e-mails to the chairs of the Biology and/or Natural Resources departments asking whether their institution offered a degree with "restoration" in the title. Individuals who did not respond to our first request for information were sent a second e-mail 1 month after the initial contact. Of 473 individuals that were contacted via e-mail, 282 (60%) responded from 189 (62%) institutions. In addition, for each restoration degree program identified through our Web searches and e-mail queries, we spoke via telephone with the program contact listed on the Web site to obtain the following information: the year the program was established, the number of required courses with "restoration" in the title, and whether curricula included specific core courses in the social sciences.

In order to assess geographic differences in availability of restoration curricula, we categorized the location of each institution by region: Midwest, Northeast, Rocky Mountains, South, West Coast, and Other (Alaska, Hawaii, Guam, and Puerto Rico) (see Fig. 1 for regions). We then summed the number of degrees and courses by region and calculated (1) the percentage of institutions surveyed in each region; (2) the percentage of all restoration degrees and courses that were offered in each region; and (3) the percentage of institutions within each region that offer restoration and restoration-relevant degrees and restoration courses. We also compared the percentage of restoration and restoration-relevant courses offered among types of academic departments.

Results

Opportunities to obtain an academic degree in restoration are extremely limited. We found that only 11 institutions of the 300 sampled offered degrees at the undergraduate level and only four offered graduate degrees (Table 1). In addition, less than 20% of the undergraduate degree programs required more than a single specific course in restoration and only 50% required specific core courses in the social sciences related to restoration practice. Sixty-four institutions (22% of those surveyed) offered undergraduate degree programs that were described as restoration relevant, although restoration was not in the title. Similarly, 37 institutions (12% of those searched) offered graduate degrees that were described as relevant to restoration.

Of the 13 institutions with restoration degree programs (Table 1), five (38%) were located in the Rocky Mountain region and four (31%) each in the Midwest and the South (Table 2). Although the total number of institutions with restoration degree programs was similar across these three regions, the percent of institutions within each region that

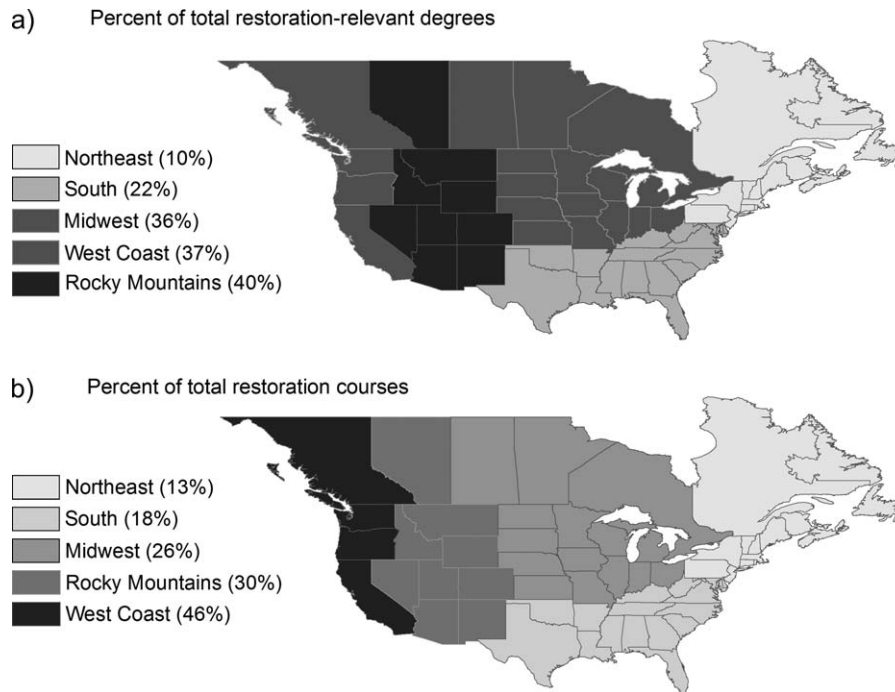


Figure 1. Percent of academic institutions surveyed in each region with (a) restoration-relevant degree programs and (b) restoration courses (see Methods for definitions).

offered restoration degrees varied considerably: 25% of 20 institutions in the Rocky Mountain region compared to 5% of 84 institutions and 3% of 90 institutions in the Midwest and South, respectively. We found no degrees with restoration in the title at institutions located in the West Coast or Northeast regions (Table 1). Restoration-relevant degree programs were available in each region of the United States and Canada. However, there was variability in the percentage of institutions within each region that offered these programs: the Rocky Mountain region had the greatest percentage of institutions with restoration-relevant degree programs and the Northeast the lowest (Fig. 1a).

Only 23% of all institutions included in our survey offered specific courses in restoration, whereas 43% offered restoration-relevant courses. The West Coast and Rocky Mountain regions had the highest percentage of institutions that offered restoration courses, 46 and 30% respectively (Fig. 1b). The West Coast and Midwest had the greatest total number of restoration courses offered in the region (49 and 44 courses, respectively) (Table 2). Interestingly, the South and the Midwest both had the highest number of institutions surveyed, but the South offered less than half as many restoration courses as the Midwest (21 vs. 44, respectively).

Natural Resource Management departments offered more courses with restoration in the title than other types of departments, although Biology was a close second (Fig. 2a). However, courses with restoration only in the description were more likely to be offered through Biology rather than Natural Resource Management departments (32 vs. 20%, respectively) (Fig. 2b).

Discussion

Restoration scientists and practitioners need specific training not only in the science of restoration ecology but also in the economic, political, and philosophical factors necessary for effective ecological restoration. These skills are beyond the scope of general academic courses within the ecological or conservation sciences. Although the foundations of restoration ecology come from theoretical and applied ecology, as well as soil science, hydrology, horticulture, landscape architecture, and engineering, the building blocks derived from these fields need to be modified and reframed in order to link their scientific principles with the practice of restoration (Hobbs 2007). Furthermore, ecologically sound restoration projects may fail without adequate planning, policy support, or public outreach (e.g., Miller and Hobbs 2002; Palamar 2004; Marler et al. 2005). 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 values about appropriate targets and end points for restoration, ecological economics and valuation of nature, restoration policy, environmental planning, citizen involvement and public outreach, and related social and philosophical issues (Allen 2003; Higgs 2005). This training cannot be covered in a single course but rather requires comprehensive, well-integrated curricula, including multiple courses emphasizing the foundations of restoration ecology and ecological restoration, core courses in the social sciences, and, ideally, thesis, capstone, or practicum projects.

Table 1. Institutions that offer degree programs in restoration, including departmental affiliation, degree program, year established, and number of required courses with “restoration” in the title.

<i>Institution</i>	<i>Department</i>	<i>Program</i>	<i>Yr</i>	<i>Restoration Courses</i>
Colorado State University (U.S.A.)	Natural Resources	BS Rangeland Ecology, Restoration Ecology Concentration	2003	1
Defiance College (Ohio, U.S.A.)	Sciences and Mathematics	BS Restoration Ecology	1999	3
Laurentian University (Ontario, Canada)	Biology	BS Biology, Conservation and Restoration Option	1990	1
Louisiana State University (U.S.A.)	Renewable Natural Resources	BS Natural Resource Ecology and Management, Ecological Restoration Concentration	2003	0
Montana State University (U.S.A.)	Land Resources and Environmental Sciences	BS Land Rehabilitation	1992	1
		MS Land Rehabilitation	<1981	2
North Carolina State University (U.S.A.)	Forestry and Environmental Resources	MS Natural Resources, Ecological Restoration Technical Option	2003	1
Texas A and M (U.S.A.)	Ecosystem Science and Management	BS Ecological Restoration	2007	*
University of Alberta (Canada)	Renewable Resources	BS Environmental and Conservation Sciences, Land Reclamation Major	1993	1
		MS Land Reclamation, Remediation, and Restoration	1993	1
		PhD Land Reclamation, Remediation, and Restoration	1993	1
University of Montana (U.S.A.)	Ecosystem and Conservation Sciences	BS Wildland Restoration	2007	3
	Forestry	BS Forestry, Forest Operations, and Applied Restoration Option	2006	1
University of Nebraska (U.S.A.)	Natural Resources	BS Environmental Restoration Sciences	2006	0
University of New Orleans (Louisiana, U.S.A.)	Earth and Environmental Sciences	MS Coastal and Restoration Science	2005	0
University of Wisconsin—Stevens Point (U.S.A.)	Forestry	BS Forest Ecosystem Restoration and Management	2001	1
Utah State University (U.S.A.)	Wildland Resources	BS Conservation and Restoration Ecology	2003	1

* Curriculum not finalized at time of data collection.

Table 2. Regional distribution of institutions surveyed, restoration degrees, and restoration courses.

	<i>Institutions Surveyed, n (%)*</i>	<i>Restoration Degrees, no. (%)*</i>	<i>Restoration Courses, no. (%)*</i>
Midwest	84 (28)	4 (31)	44 (33)
Northeast	67 (22)	0 (0)	12 (9)
Rocky Mountains	20 (7)	5 (38)	7 (5)
South	90 (30)	4 (31)	21 (16)
West Coast	35 (12)	0 (0)	49 (37)
Other	4 (1)	0 (0)	1 (<1)
Total	300	13	134

* Percent within a given region of total.

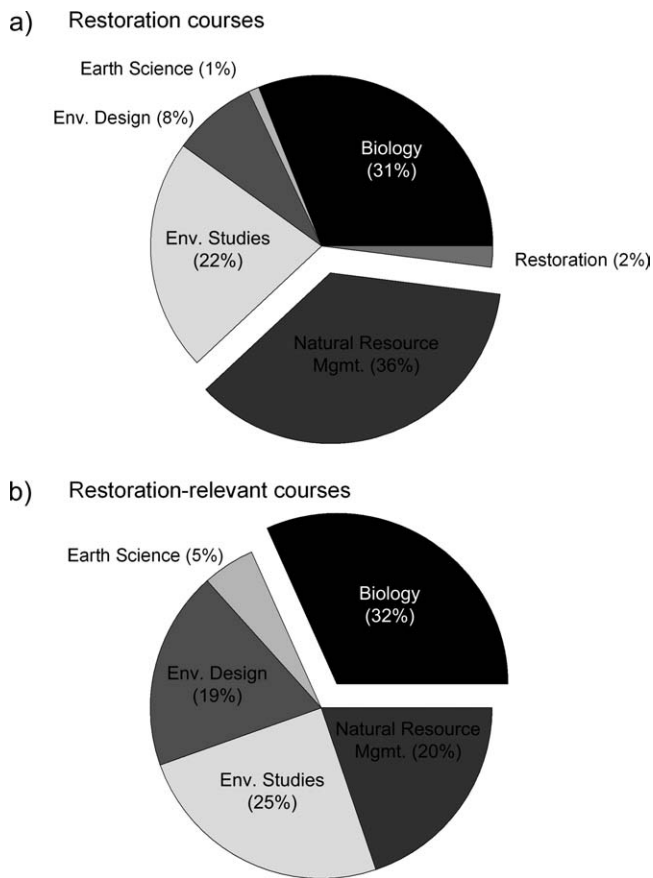


Figure 2. Distribution among academic departments of (a) restoration courses and (b) restoration-relevant courses (see Methods for definitions). Departments are: biology includes ecology, conservation sciences, evolution, organismal biology, oceanography, plant biology, marine science, zoology, and related fields; Earth sciences includes geology, soil science, hydrology and related fields; environmental design includes architecture, bioengineering, civil engineering, landscape architecture, and related fields; environmental studies includes geography, environmental science, systems dynamics, and related fields; and natural resource management includes forestry, fisheries, wildlife, range management, and related fields.

Despite the need for restoration-focused curricula, we found that academic opportunities in the field of restoration are lacking. Of 300 institutions with expertise in ecology, conservation science, and natural resource management, only 4% offer degree programs in restoration and less than 25% offer even one course devoted to the science or practice of restoration. Not surprisingly, Natural Resource Management departments were most likely to offer restoration courses (those with restoration explicitly in the course title). These departments attract students interested in management and likely to pursue careers that involve the practice of restoration.

Opportunities for academic training in restoration vary substantially by geographic region. Over a quarter of the schools in the Rocky Mountain region offered degrees in restoration compared to 5% or less in all other regions.

Institutions located in the West Coast and Midwest regions, along with those in the Rocky Mountains, were more likely to offer courses in restoration and restoration-relevant degree programs than those located in the Northeast and South. Observed differences among regions could be due to unequal distribution of public lands, where large-scale restoration activities are more likely to occur. For example, federal and state initiatives to restore fire-adapted forests and salmon habitat on public lands in the Rocky Mountains and western states (e.g., U.S. Senate 2004; Bernhardt et al. 2005) may contribute to greater interest in restoration training in these regions. However, there are a relatively large number of institutions with restoration curricula in the Midwest despite limited land in public ownership. The emphasis on restoration in this region may be related to the long history of interest in, and experimentation with, prairie restoration (e.g., Cottam & Wilson 1966) or to increasing requirements for restoration and mitigation of sensitive wetland habitats which are more prevalent in the Midwest than in other regions.

Although restoration is a relatively young field, there has been ample time to develop appropriate curricula. For example, despite only 3 years of difference in the establishment of their professional organizations, there are considerably more degree programs in conservation biology than in ecological restoration. In 1990, just 5 years after the establishment of the Society for Conservation Biology and 4 years after the inception of its journal, there were already more than 16 graduate-level degree programs (Jacobson 1990). Although an assessment of the current number of programs in conservation biology was outside the scope of the current study, a quick search of the Society for Conservation Biology's Web site revealed that 29 (circa 10%) of the 300 institutions that we assessed advertised degrees in conservation biology (<http://www.conbio.org/Resources/Programs/>; accessed 23 May 2007). Because submission of information to the Society's Web site is voluntary (and perhaps unsolicited), this number most likely vastly underestimates the total number of these institutions that offer degrees in conservation biology. By comparison, nearly 20 years after the establishment of the Society for Ecological Restoration and 15 years after the establishment of its journal, we found only 13 institutions with degree programs in restoration (4%). Thus, the field of restoration is lagging behind that of conservation biology in providing training opportunities to students and professionals.

Our measure of available curricula in restoration is undoubtedly conservative because we included only those degree programs for which the restoration curricula were comprehensive (integral to the entire degree requirement); thus, we did not track opportunities to receive a minor or certificate in restoration, although there are several well-recognized programs (e.g., minor in Landscape Restoration at University of California at Davis; certificate programs in Restoration of Natural Systems at University of Victoria and through University of Washington's Restoration Ecology Network [Gold et al. 2007]). In addition, we did not

survey every academic institution in the United States and Canada. However, the schools included in our survey (those with excellence in the ecological, conservation, and natural resource sciences) have the greatest likelihood of offering curricula in restoration and attracting students likely to pursue careers in this field. Thus, our findings suggest a general lack of academic opportunities to study restoration in the United States and Canada at the university level.

Fifty percent of the degree programs identified through our survey were established within the past 5 years, suggesting that more educational opportunities will be available in the future. Humboldt State University, Oregon State University, University of California—Davis, and Trent University were either waiting for approval for or in the process of developing new restoration degrees during our data collection period. We expect that other institutions also may be in the process of degree program development. Still, with existing programs at only 4% of institutions at the undergraduate level and 1% at the graduate level, there is plenty of room and need for growth. Furthermore, although we did not assess the status of restoration programs outside the United States and Canada, we expect that formal educational opportunities in restoration have not kept pace with growing restoration needs in other regions of the world. Development of additional training opportunities in restoration is critical both to keep in step with the increasing demand for qualified and experienced restorationists and to ensure that these scientists and practitioners have the background and training necessary to meet the complex challenges of restoring degraded ecosystems in the decades to come.

Implications for Practice

- Academic curricula in the field of restoration are extremely limited in North America.
- Although training opportunities are increasing, the rate of increase is not fast enough to meet current demand for qualified and experienced restoration scientists and practitioners.
- As institutions reassess their priorities for the coming decade, they should consider including or expanding their educational opportunities in restoration.
- In order to ensure that students are introduced to the diverse elements of the field of restoration, degree programs should require courses in both the natural and the social sciences.
- Academic institutions should work with restoration practitioners and other interested parties to ensure curricula are relevant to real-world restoration activities and problems.

Curriculum Updates

To obtain the most current information about restoration and restoration-relevant degree programs (including

those listed in this article), please visit the Global Restoration Network's Education site: <http://www.globalrestorationnetwork.org/education>. To post information on an institution's restoration curriculum, please visit: <http://www.globalrestorationnetwork.org/contact-us>.

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