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RESEARCH ARTICLE

An Assessment of Introductory Restoration Courses in the United States and Canada

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Abstract

A considerable number of institutions offer courses in restoration ecology and its application, ecological restoration. We quantified the scope and structure of introductory restoration courses at 67 post-secondary institutions by reviewing institutional course catalogs and course syllabi. Most courses were available at Research-level institutions. More than half of the courses were offered within departments that focused on natural resource management, and were required or optional in a degree program. Most courses were taught in classroom settings during the academic year and were geared toward advanced students. Course titles suggested an emphasis on the science of restoration ecology over the practice of ecological restoration, and learning objectives focused primarily on concepts and less on skills and attitudes. Assessment was largely via conventional methods, notably exams. Many courses assigned readings from the primary literature; there was little consensus in terms of text selection. We conclude that restoration is being presented to students as an advanced undertaking and in largely theoretical terms. Although we were unable to consider other important elements such as thematic content, class size, or pedagogical method, our study provides a baseline assessment of introductory restoration courses that can be used to evaluate changes in restoration education or opportunities for restoration education in other countries. These results can inform the development of new introductory restoration courses, and raise important considerations in light of the development of a Practitioners' Certification Program by the Society for Ecological Restoration.

Key words: curriculum, course structure, post-secondary education, restoration education, syllabus, tertiary education.

Introduction

Post-secondary or tertiary institutions are responding to growing interest in restoration ecology and its practice, ecological restoration, by offering courses and academic programs in restoration. Although academic program availability has received some attention (Lavendel 1999; Nelson et al. 2008), the content and structure of individual restoration courses and programs have not been assessed systematically. Restoration courses are offered at a wide range of institutions, including those that do not offer restoration programs (Nelson et al. 2008). Although instructors individualize courses based on their expertise, experience, resources, and other factors, introductory courses are often expected to survey the depth and breadth of a discipline. We suggest, therefore, that introductory restoration courses provide a means of understanding how restoration is being represented to students. Assuming that these courses are one of the first opportunities for students to interact with the discipline, they may also be important for recruiting future restoration practitioners.

Many professional societies have adopted certification programs to formally recognize the credibility of practitioners. Examples include the Professional Wetland Scientist program (Society of Wetland Scientists; SWSPCP 2010), Certified Wildlife Biologist program (The Wildlife Society; TWS 2010), Professional Ecologist program (Ecological Society of America; Michener et al. 2007), and Certified Forester program (Society of American Foresters; SAF 2010). The Society for Ecological Restoration (SER) is currently developing a Practitioners' Certification Program (Bowers 2004; Stanley 2010). Although the details of this program have not been released, it is reasonable to assume that it will increase the importance of courses and of consistent curricula. The importance of these educational considerations is further magnified by the fact that restoration practitioners are distributed around the globe, work in a wide variety of ecosystems, and experience a range of economic and social circumstances, including access to higher education.

Our objective was to quantify the scope and structure of introductory courses in restoration ecology and/or ecological restoration (hereafter, RE/ER). We considered courses with respect to their institutional and departmental setting and in terms of course-specific details. We limited our focus to post-secondary institutions within the United States and Canada as we are most familiar with these countries. Educational

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terminology varies among countries; UNESCO's (2006) international standard classification of education (ISCED) provides a cross-walk between the terminology used in these and other countries. Post-secondary education in the United States and Canada corresponds to ISCED levels 4 (post-secondary non-tertiary education), 5 (first stage of tertiary education), and 6 (second stage of tertiary education).

Methods

Academic Setting

To identify RE/ER courses at academic institutions, we conducted Internet searches using "restoration ecology syllabus" and "ecological restoration syllabus" as criteria. Searches were conducted in Fall 2007 and updated in Spring 2009. We restricted our attention to institutions in the United States and Canada by restricting these searches to the .edu and .ca domains. We reviewed the first 200 results from each search to identify specific institutions and courses within them, and supplemented this list with programs from Nelson et al. (2008) and SER (2009). In total, we identified 67 institutions offering RE/ER courses. Some institutions offered more than one course in RE/ER, as our focus was on introductory courses, we chose the course targeted to the lowest academic level.

We characterized the academic category of each United States-based institution using the Carnegie Foundation's "Basic Classification" (Carnegie Classification 2005). This classification scheme includes seven broad categories: Associate's, Baccalaureate, Master's, Research, Special Focus, Tribal, and Not Classified. We compared the proportion of institutions offering RE/ER courses in each category to the proportion of institutions in that category across the United States. Canadian institutions were not analyzed in this way as a comparable categorization does not exist in Canada (J.-F. Laroche 2010, Statistics Canada, personal communication).

We identified the department in which each course was listed. Departments were classified into three primary disciplinary foci: natural science (e.g. biology, ecology), applied science (e.g. natural resource management, forest resources), and social science (e.g. environmental studies, policy). This classification scheme is coarser but broader than that of Nelson et al. (2008), who focused on programs in the ecological, conservation, and natural resource sciences.

Course-Specific Details

We reviewed each institution's current course catalog to obtain course-specific details. We recorded whether the course included "restoration ecology," "ecological restoration," or other restoration-related terms in its title. We identified the academic level of the course, distinguishing among five levels: freshman (first year of post-secondary education), sophomore (second year), junior (third year), senior (fourth year), and graduate (post-baccalaureate). We noted whether prerequisites were required and, if they were, in which topical areas. We determined whether the course was a regular or special topics course, whether it was required or optional in a degree program, and whether other RE/ER courses were offered in the program. Finally, we determined when the course was offered within the academic year, its duration in weeks, the number of credits, and how those credits were allocated among lectures and labs (hours per week). We calculated the number of student credit hours (SCH; hours per week $\times$ credits) to permit equitable comparisons among courses at institutions that use different academic calendars.

Many syllabi were available online; we requested those that were not via email. We received 53 syllabi prepared between 2002 and 2009 (median = 2008) and varying considerably in the level of detail and information recorded. We reviewed each syllabus to characterize the course with respect to learning objectives and course mechanics. Learning objectives summarize what the instructor hopes to accomplish in the course, and can be characterized as focusing on content, skills, or attitudes (Bloom 1956). For courses that listed them, we calculated the proportion of objectives in each category. The course mechanics we assessed were mode of delivery, assigned reading materials, and assessment. Mode of delivery was characterized as classroom, field, or online. We identified required reading materials, including the "Primer on Ecological Restoration" (SER 2004), and noted whether articles from the primary literature were also used. Finally, we focused on how student success was assessed. Assessment was characterized by allocating the grade break-down of a course into six broad categories: participation, assignments, exams, projects, research papers, and presentations.

Given the objectives of this study, most of our data were descriptive and not suitable for statistical analysis. Where appropriate, we used chi-square goodness-of-fit tests to determine whether observed proportions differed from those expected. For detailed course data, see Appendix S1 (Supporting Information).

Results

Academic Setting

Of the 67 institutions identified as offering RE/ER courses, 8 were in Canada and 59 in the United States. The American institutions spanned the range of Carnegie Classifications from Associate to Research, although a disproportionately high number of them were Research universities (Table 1; $\chi^2 = 367.8$; $df = 6$; $p < 0.001$).

More than half of the courses (57%) were offered through departments with applied science disciplinary foci, usually related to natural resource management. Few courses (12%) were offered through departments with social science foci; the rest were offered through departments with natural science foci.

Course-Specific Details

Two-thirds of courses included "restoration ecology" in the title, while only 13% included "ecological restoration" in the

Table 1. Carnegie basic classification of U.S. post-secondary institutions, and the proportion of those institutions identified as offering an introductory course in restoration ecology/ecological restoration.

Category	*% in the United States (number)*	*% in Study (number)*
Associate	41 (1814)	2 (1)
Bachelor's	18 (767)	7 (4)
Master's	15 (663)	25 (15)
Doctoral/Research	6 (283)	66 (39)
Special Focus	18 (806)	0 (0)
Tribal	<1 (32)	0 (0)
Not Classified	<1 (26)	0 (0)
Total	100 (4,391)	100 (59)

title. Half of the courses were offered at the senior level; the fewest offerings were at the freshman and sophomore levels (1 and 4%, respectively). Junior- and graduate-level courses each accounted for 22%.

Two-thirds of courses had prerequisites; those that did, required courses in one or two topical areas. Ecology was by far the most common prerequisite (67% of courses with prerequisites); other topics included general biology (16%), soils (12%), vegetation management (9%), plant biology or botany (7%), math (5%), and other topics (12%).

Most courses (90%) were regular courses. Courses were required within at least one degree program in 43% of institutions and listed as an option within at least one degree program in another 18% of institutions; many of these programs were focused on restoration. Two-thirds of institutions offered more than one RE/ER course.

Courses ranged from focused 2-week summer courses to those spanning an entire academic year (30 weeks). Most courses were offered during the academic year (91%) and delivered primarily in classroom settings (89%). Courses delivered primarily in the field (8%) were offered during the summer or fall. Only 3% of courses were offered as online distance education courses. Of those that provided meeting times on their syllabus (44 courses), the median number of SCH was 40 (range = 22–165; mean = 50). Twenty-six courses were at institutions whose course catalogs indicated how time was allocated among lectures and labs; these courses allocated an average of 73% of their time to lectures and 27% to labs.

Two-thirds of courses listed learning objectives on their syllabus. Objectives were not evenly distributed among categories ($\chi^2 = 56.0$; $df = 2$; $p < 0.001$), but focused primarily on content, less on skills, and minimally on attitudes (Table 2).

Of the 49 courses that listed reading materials, 76% relied wholly or in part on articles. Courses required up to four texts in addition to articles, but there was little consensus about text selection ($\chi^2 = 35.0$; $df = 33$; $p = 0.375$). The most commonly used texts were SER (2004; 31% of courses that listed texts), Falk et al. (2006; 14%); Whisenant (1999; 8%), Mitsch and Jorgensen (2004; 6%), Leopold (1949; 6%), and Packard and Mutel (1997; 6%). Another 29 texts were required in individual courses.

Table 2. Allocation (in percent) of learning objectives among three categories.

Category	*Minimum*	*Mean*	*Median*	*Maximum*
Content	0	65	65	100
Skills	0	31	25	100
Attitudes	0	4	0	33

Learning objectives were reported in the syllabi of 36 introductory restoration courses.

Table 3. Allocation (in percent) of assessment among six categories.

Category	*Minimum*	*Mean*	*Median*	*Maximum*
Participation	0	13	10	50
Assignments	0	18	10	85
Exams	0	38	41	90
Projects	0	17	13	80
Research Papers	0	4	0	45
Presentations	0	10	0	50

Assessment was reported in the syllabi of 48 introductory RE/ER courses.

Assessment was not evenly distributed among categories ($\chi^2 = 40.5$; $df = 5$; $p < 0.001$), but was based primarily on exams (38% of grades), and least on research papers (4%). The other categories accounted for 10–18% of the grade. However, there was considerable variation in assessment among courses (Table 3).

Discussion

Academic Setting

Our survey provides a snapshot of a key facet of RE/ER education within the post-secondary systems of the United States and Canada. Post-secondary institutions are by no means the only venues in which to learn about RE/ER. Restoration is taught to and practiced by people of many ages, including children (Cruz & Segura 2010; Hall & Bauer-Armstrong 2010) and adults (Mesquita et al. 2010; Tongway 2010). Restoration is also taught in other contexts that were not a focus of our survey, such as workshops targeted at personnel within an organization or agency. However, we suggest that students who obtain formal education in RE/ER are more likely to become recognized as experts in the field.

Within the post-secondary system of the United States, research universities accounted for a much higher proportion of the surveyed courses than expected. Our results might be biased if large institutions are more likely to have a strong presence on the Web or if faculty at these institutions are more likely to publish their syllabi electronically, although we do not have data to address these possibilities. Research universities tend to be much larger than the other types of institutions and account for 28% of post-secondary student enrollment within the United States (Carnegie Classification 2005). Given their large enrollment, courses at these institutions are potentially accessible to a significant proportion of the student population.

A single introductory course is not intended to be adequate preparation for a restoration practitioner. We are encouraged that many institutions offered multiple RE/ER courses, that many of the courses were directly associated with degree programs, and that most surveyed courses were regularly scheduled, suggesting some permanence and frequency in their offering. Some of the programs were established within the last few years and, although they focus on restoration, were not included in the survey by Nelson et al. (2008), which was conducted in Autumn 2006.

Nelson et al. (2008) found that natural resource management departments were more likely to offer restoration than restoration-relevant courses (as determined by whether the partial keyword "restor" was present in the titles or descriptions, respectively, of all courses in these departments). Our results extend theirs by demonstrating that such departments are much more likely to offer introductory RE/ER courses. In addition, our simple analysis of course titles suggests that introductory courses focus on the science of restoration ecology rather than the practice of ecological restoration. This focus makes sense given the general expertise of faculty within natural resource management departments. Restoration ecology is also more clearly defined and thus may be more easily covered in an introductory course than a sprawling, interdisciplinary theme such as ecological restoration (Higgs 2005; Clewell & Aronson 2007), although there definitely are courses that do the latter. Overall, when this focus on restoration ecology is combined with the fact that ecology was the most common prerequisite, we conclude that introductory restoration courses are emphasizing science over practice when presenting the discipline to students.

Consideration of the balance between restoration ecology and ecological restoration requires an assessment of entire programs (including institutionally offered certificates; e.g. SC 2010) rather than single courses; such an assessment was beyond the scope of our study. It would be worthwhile to update the programmatic survey undertaken by Nelson et al. (2008) by documenting and assessing new restoration programs. It would also be informative to know whether the breadth of topics covered differs among programs offered through departments that vary in disciplinary focus. For example, are the social science elements of ecological restoration given the same amount of attention in courses offered through natural science departments as in courses offered through social science departments?

Our survey was not intended to be a comprehensive assessment of the full range of RE/ER courses available. Our use of web-based search methods may bias our results if, for example, special topics courses are less likely to have Web sites. Similarly, independent study opportunities and other individualized courses are highly unlikely to have a web presence and were not encountered in our survey, though by design they would only affect a small number of students. In spite of these limitations, our results provide a benchmark that can be expanded upon in several ways. For example, our methodology could be repeated in the future to compare changes over time. More immediately, it would be valuable to compare restoration education in the United States and Canada with opportunities at institutions in other countries (SER 2009; Aronson et al. 2010; Rey Benayas et al. 2010).

Course-Specific Details

A course syllabus cannot fully represent a course. For example, we did not quantify thematic content or enrollment. In addition, the nuances of student-driven class discussions, professorial influence, and the effectiveness of dynamic guest lecturers cannot be weighted through this method. Indeed, the personal elements that are so important to education are unobservable in this type of assessment. Nevertheless, we feel that this preliminary analysis provides the broad strokes of our continental effort to educate students about this highly diverse discipline.

One of the common themes we identified was that introductory RE/ER courses were generally taught in classroom settings during the academic year. Given that we conducted a web-based search, we were surprised at how few online restoration courses were identified. When and where a course is taught unavoidably constrain course content and mode of delivery. In northern regions, for example, it is difficult to incorporate field components into a course taught during the winter. This is unfortunate, as field work can positively affect student attitudes and behaviors (Bowler et al. 1999).

According to the learning objectives published in syllabi, RE/ER courses are focused primarily on concepts. Although this may reflect the conventional pedagogical style and emphasis of post-secondary institutions, we find this worrisome as restoration practitioners need to go beyond theory and acquire relevant skills (e.g. Van Nest 2004; Gold et al. 2006). Furthermore, attitudinal objectives may be important because introductory courses provide an opportunity to engage students and promote attitudes and perspectives that may shape their lives and lifestyles regardless of whether they become restoration practitioners. Finally, we note that many courses did not list any learning objectives; we urge instructors to give careful thought to the development of learning objectives for their courses. Thinking about how people learn (D'Avanzo 2003) may be particularly helpful in this context.

Courses were assessed primarily via conventional means, particularly exams. Again, this may reflect the conventional assessment methods in post-secondary education, particularly in the sciences (Bransford et al. 2000), although there was considerable variation among courses in every assessment category. Skills and attitudes are difficult to assess through these kinds of measures. We did not assess academic rigor or student understanding.

One of the most striking sources of variation among courses was in text selection. The single most commonly required item was the SER primer (2004), which is concise and written in general terms for widespread applicability. Textbook selection and the usage of articles from the primary literature may

reflect instructor's personal preferences, including decisions to focus on the restoration of particular ecosystems (e.g. Packard & Mutel 1997). Depending on a text's content and how closely it is followed in a course, text selection can influence the subject matter covered in a course. Texts and articles may also be accompanied by online educational resources about restoration (e.g. Lundholm & Larson 2004; Pratt et al. 2006). Although ecology education resources are available through the Teaching Issues and Experiments in Ecology Web site (http://www.tiee.ecoed.net/; D'Avanzo et al. 2006) and the EcoEd Digital Library (http://www.ecoed.net/; Klemow et al. 2009), comparable resources are not currently available through the SER Web site.

Conclusions

This research provided insight into the structure of introductory RE/ER courses in the United States and Canada. Although courses differed considerably in metrics such as duration, SCHs, text, and assessment method, a common structure was clearly identified. Courses were generally offered through departments with applied science foci within doctoral-level institutions, focused on restoration ecology more than ecological restoration, were geared toward advanced undergraduate and graduate students, and emphasized concepts over skills and attitudes. We conclude that restoration is being presented to students as an advanced undertaking and in largely theoretical terms. This study could inform the development of new restoration courses and provides a benchmark against which to assess the development of restoration education in the future. A particularly valuable extension of this work would be to conduct similar studies in other countries to understand how opportunities for restoration education vary globally.

A single introductory course is inadequate preparation for a restoration practitioner. In our opinion, the most significant issue raised, but not answered, by this research is how much RE/ER education should be required of restoration practitioners. Should participation be restricted to those students who have taken particular prerequisites? If so, how should those prerequisites be chosen? Is it appropriate that most undergraduate students are nearing completion of their programs before they are able to take an introductory course in RE/ER, or should introductory courses be targeted to earlier academic levels? How important is formal restoration education compared to practical on-the-job experience? This issue is particularly pertinent in light of SER's development of a Practitioners' Certification Program (Bowers 2004; Stanley 2010). If such a program is adopted, we suggest that it will be necessary to establish standardized criteria and guidelines to equitably assess students trained at different institutions. Such assessments should be made, of course, on the basis of the academic background provided by a full academic program rather than a single course. The global interest in restoration means that certification will also have to account for potential differences in educational programs among countries.

Implications for Practice

- At present, most introductory restoration courses in the United States and Canada are being offered by departments that focus on natural resource management (applied science) within doctoral-level institutions.
- Restoration generally appears to be taught as an advanced undertaking and from a relatively theoretical perspective, with an emphasis on content over skills and on science over practice.
- Most courses are taught in classroom settings during the academic year, and are assessed by conventional means, particularly exams.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Detailed data collected about introductory restoration courses. Institution names are repeated in the left-hand column on each page, and headings at the top of each page. Metadata describing columns are provided at end.

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