Defining a Stream Restoration Body of Knowledge as a Basis for National Certification

Sue L. Niezgoda, Ph.D., P.E., M.ASCE

Associate Professor, Dept. of Civil Engineering, Gonzaga Univ., 502 E. Boone Ave., Spokane, WA 99258-0026 (corresponding author). E-mail: niezgoda@gonzaga.edu

Peter R. Wilcock, Ph.D., M.ASCE

Professor, Dept. of Geography and Environmental Engineering, Johns Hopkins Univ., 3400 N. Charles St., Baltimore, MD 21218. E-mail: wilcock@jhu.edu

Daniel W. Baker, Ph.D., A.M.ASCE

Research Scientist, Dept. of Civil and Environmental Engineering, Colorado State Univ., Campus Delivery 1372, Fort Collins, CO 80523-1372. E-mail: dan.baker@colostate.edu

Jennifer Mueller Price, Ph.D., P.E., M.ASCE

Assistant Professor, Dept. of Civil Engineering, Rose-Hulman Institute of Technology, 5500 Wabash Ave., Terre Haute, IN 47803. E-mail: muellerp@rose-hulman.edu

Janine M. Castro, Ph.D.

Geomorphologist, U.S. Fish and Wildlife Service, 2600 SE 98th Ave., Suite 100, Portland, OR 97266. E-mail: Janine_M_Castro@fws.gov

Joanna C. Curran, Ph.D., A.M.ASCE

Assistant Professor, Dept. of Civil and Environmental Engineering, Univ. of Virginia, 351 McCormick Rd., P.O. Box 400742, Charlottesville, VA 22904-1000. E-mail: curran@virginia.edu

Theresa Wynn-Thompson, Ph.D.

Associate Professor, Dept. of Biological Systems Engineering, Virginia Tech., 213 Seitz Hall, Blacksburg, VA 24061. E-mail: tthompson@vt.edu

John S. Schwartz, Ph.D., P.E., M.ASCE

Associate Professor, Dept. of Civil and Environmental Engineering, 63 Perkins Hall, Knoxville, TN 37996-2010. E-mail: jschwart@utk.edu

F. Douglas Shields Jr., Ph.D., P.E., F.ASCE

Hydraulic Engineer, Shields Engineering, 3613 Lyles Dr., Oxford, MS 38655. E-mail: doug2shields@gmail.com

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Introduction

The practice of stream restoration has become widely accepted as an essential component to improving ecosystem function and enhancing aquatic biodiversity (Wohl et al. 2005). Despite the abundance of projects being implemented, a lack of definitive training requirements, design procedures, and monitoring protocols remain for the practice of stream restoration. Given the lack of consistency, many restoration projects end in frustration, excessive costs, and poor results (e.g., Williams et al. 1995; Kondolf 1998; Johnson and Brown 2001; Roni et al. 2002; Wohl et al. 2005; Bernhardt et al. 2007; Roni et al. 2008). The fact that method and experience are both varied and even poorly defined in a new and emerging profession is not surprising; however, the combination of diverse and inconsistent training and methodology makes progress in transforming the practice of stream restoration into a mature profession difficult. The widespread practice of restoration, now a billion dollar a year industry in the United States (Bernhardt et al. 2005), coupled with highly inconsistent results, demands its conversion into a profession with broadly accepted principles and methods of tested reliability.

As a profession advances, it must have ways to assess and assure the adequacy of education and training curricula and the competency of individual professionals (Ford and Gibbs 1996; Pomeroy-Huff et al. 2009). At the core of the process of maturing a profession is the establishment of a body of knowledge (BOK), a document generated by experts to identify and delineate the concepts, facts, and skills that practitioners in that profession are expected to master (Morris et al. 2006; Pomeroy-Huff et al. 2009). For example, project management professionals saw a clear need to formulate a common and consistent set of core competencies on which they could base a project management certification and advance their emerging profession (Morris et al. 2006; Winter et al. 2006). In the emerging profession of stream restoration, a similar call exists for the establishment of consistent training standards, standards of practice, and professional certification, driven largely by the lack of agreed on criteria for judging restoration success and highly inconsistent project results (Palmer et al. 2005; Marr 2009; Kite 2009; Fischenich 2009). The development of a profession with standards of practice and/or certification first requires establishment of a training and education structure that provides consistency and can support and incorporate advances in understanding (Morris et al. 2006).

A fully effective symbiosis among research, training, and practice has yet to emerge in stream restoration; however, several attempts were made during the past 10 years to establish the current and future needs in stream restoration education and training [River Restoration Northwest (RRNW) 2003; (AFS Curriculum Working Group, unpublished data, 2003); P. Wilcock, unpublished internal report, December 2006 RRNW, in cooperation with Oregon State University and Portland State University, sought to advance the quality of the river restoration practice by identifying restoration educational needs (RRNW 2003). In 2003, RRNW and its partners implemented a survey to assess the job tasks, educational backgrounds, and training needs of professionals working on river restoration projects in the northwestern United States and Canada. The key results are as follows.

1. Available training is multidisciplinary with most university and short courses focused on ecology, fluvial geomorphology, fisheries, restoration, and soils. Fisheries biologists and civil engineers have the greatest range of training across disciplines.
2. Improved skills and competence in fluvial geomorphology, field techniques, restoration techniques, and biology/ecology were identified as important for a practicing professional.

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Field experience was also identified as a very important part of a restoration curriculum.

3. The additional types of professional training desired included restoration design, sediment transport, and monitoring, with a suggestion that more qualitative (i.e., case study analysis) and multidisciplinary training in restoration was also warranted.

In 2003, a committee of the American Fisheries Society (AFS) considered the curricular needs for educating future river restoration practitioners. At the graduate level, the core courses suggested by AFS (AFS Curriculum Working Group, unpublished data, 2003) include two courses in river geomorphic processes and restoration (theoretical and field application), sustainable watershed management, experimental design, field techniques, and a thesis project. Following completion of the core courses, graduate students select from multidisciplinary electives that serve to further the degree of specialization. The results provide a model curriculum for university graduate-level restoration training.

In 2006, a team from the National Center for Earth Surface Dynamics (NCED Stream Restoration Training Evaluation Team, unpublished data) examined different restoration education perspectives and developed a summary of the training requirements of the restoration profession. The group found that most restoration practitioners began their careers with a university degree in one of a number of restoration-related disciplines (e.g., civil engineering, ecology, fisheries); however, these individuals had no explicit coursework in restoration. Thus, many restoration practitioners rely on continuing education professional development to fill the gaps (P. Wilcock, unpublished internal report, December 2006). A large fraction of those currently in practice have received short course training through Wildland Hydrology (2012).

The results of the RRNW (2003) and NCED (NCED Stream Restoration Training Evaluation Team, unpublished data) work indicated a need to establish a multidisciplinary, field-based professional development curriculum. The results of the AFS (AFS Curriculum Working Group, unpublished data, 2003) working group provided such a curriculum at the graduate level; however, many universities may not have the resources available to implement this recommended curriculum. Thus, the current educational needs of restoration practitioners may best be met through a combination of university and continuing education courses. However, the current diversity of restoration-related course offerings make it difficult to determine what is taught, who is teaching, to whom it is delivered, and what is actually learned. Many short courses are offered as standalone entities, with no prerequisites and no assessment of learning. This lack of formal pedagogy can give practitioners a false sense of preparedness when, in fact, they do not fully appreciate the complexity and interdisciplinary nature of river restoration projects.

To advance the stream restoration profession and meet evergrowing professional development needs, a stream restoration educational materials task committee (TC) of the River Restoration Committee of the ASCE Environmental and Water Resource Institute (EWRI) Hydraulics and Waterways Council was formed in May 2009. Although organized within ASCE, committee members were drawn from a variety of sectors (academia, consulting, and regulation) and disciplines (engineering, fluvial geomorphology, fisheries biology, ecology, and environmental science). The primary goal of the TC was to establish a common and consistent set of core principles and methods for the practice of stream restoration that defines a formal SR-BOK for the profession. The main purposes of the SR-BOK are to

- Define the essential knowledge and skills that general stream restoration practitioners are expected to master;
- Establish a baseline for developing stream restoration courses and curricula in academia and professional development;
- Facilitate the establishment of a stream restoration certification on the basis of an established and agreed-on standard knowledge and skill set; and,
- Provide regulatory agencies and employers with a baseline for assessing the skills and capabilities of stream restoration practicing professionals.

The establishment of a SR-BOK was accomplished through three specific tasks. Task 1 was to compile educational materials from existing manuals, short courses, certificate programs, and university programs, and to examine the topics covered, the objectives and outcomes, and the instructor traits. Task 2 was a practitioner survey to assess professional development and training needs. Task 3 was to develop the SR-BOK for stream restoration education and training using the results from Tasks 1 and 2. The study also included an assessment of the potential for using the SR-BOK as a foundation for the development of a multidisciplinary national stream restoration certification.

Task 1: Existing Course and Topic Review

Review of Selected Stream Restoration Guidance Documents

To survey topics currently presented as part of stream restoration training, the committee consulted several stream restoration manuals and guidance documents, including the Federal Interagency Stream Restoration Working Group (FISRWG) (1998), the U.S. Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS) (2007), Skidmore et al. (2011), Copeland et al. (2001), and Cramer (2012). These selected manuals were chosen because they have been thoroughly reviewed, offer guidance on stream restoration and design, and provide a good representation of the variety of restoration disciplines and federal and state government perspectives involved. Table 1 summarizes different topics and the depth to which each of these topics is covered in the manuals reviewed. The content ratings in Table 1 are based on the judgment of the TC after a critical review of each document and are meant only to offer general guidance on the content coverage of the documents.

Review of Existing Courses

Educational materials from existing courses and certificate programs were also compiled and evaluated by the task committee members. Online searches, postings on listserves, and announcements were used to find relevant stream restoration-related courses. The committee compiled the final list into groupings on the basis of the following course types:

1. University graduate degree programs—Formal graduate program designed to confer a degree (M.Eng., M.S., or Ph.D.) in a stream restoration discipline. Typically, courses are a semester long and are taken concurrently, and participants are full-time graduate students, although the courses are also made available to professionals.
2. University professional programs—Professional development courses sponsored by a university to serve the training needs of stream restoration professionals. Typically, the courses are short (day- or week-long) and are taken concurrently to complete a certificate or course sequence. Participants are typically full-time professionals seeking to earn a certificate or continuing education credits/professional development hours (CEC/PDH).
3. Non-University professional courses and course sequences—Professional development courses sponsored by a non-university entity (e.g., government agency, private organization, nonprofit) to serve the training needs of stream restoration professionals. Typically, individual courses are

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Table 1. Listing of Stream Restoration Topics and Manuals Referenced with Depth of Content for each Topic Identified

Topic (outcome)	Content coverage				
	USDA-NRCS (2007)	FISRWG (1998)	Skidmore et al. (2011)	Copeland et al. (2001)	Cramer (2012)
Bank mechanics/stabilization	1	1	1	1	0
Fish biology	0	0	0	0	1
Fluvial geomorphology	2	3	3	1	3
Habitat structure and function	1	2	2	0	3
Hydraulics	3	2	1	3	3
Hydrology	3	2	2	3	3
Construction implementation	2	2	1	0	3
Project management	1	2	2	0	1
Restoration design	3	2	0	3	2
Sediment transport	3	1	1	2	3
Stream classification	1	1	2	1	1
Stream ecology	1	2	2	1	2
Stream stability	1	1	1	1	1
Uncertainty and risk	2	1	3	2	0
Vegetation/riparian dynamics	1	1	0	1	2
Water quality	1	2	0	0	2
Watershed analysis/modeling	1	1	1	0	0

Note: 0 = no coverage; 1 = mentioned briefly; 2 = discussed but no in-depth analysis or tools provided; 3 = in-depth discussion, tools provided, or case studies described.

short (day- or week-long) whereas sequences are typically week-long courses taken concurrently. Participants are typically full-time government employees or private professionals looking to earn CEC/PDH.

Information was gathered for each of 92 courses, and included course titles and organizers, course objectives and topics covered (syllabi and outlines), instructor(s) and their discipline(s) and work sector(s), costs, and student outcomes. Table 2 summarizes the information gathered and is provided to offer a general summary (not a comparison) of types and content of existing courses available to practitioners. For the topics in Table 2, a topic was credited as covered if it was listed in the course objectives or outlines. Fig. 1 illustrates the frequency that a restoration topic is covered in the selected courses. After a review of Table 1 and Fig. 1, the TC compiled a list of common topics that may be considered part of a SR-BOK. Table 3 provides the final list of 18 topics, each with subtopics. Because of the multidisciplinary nature of stream restoration, some topics and subtopics are interrelated.

Summary and Synthesis

A review of existing stream restoration guidance documents and manuals was completed to generate a preliminary list of topics considered important to the practice of stream restoration. From this review, a listing of preliminary topics was generated (see Table 1) that included the major disciplines involved with stream restoration: engineering, fluvial geomorphology, fisheries biology, and stream ecology. A review of existing stream restoration professional development programs and courses was also conducted to further identify the topics important to restoration education and training (Table 2). In addition, a review of the type of learning assessment used in each course examined was also completed through a review of the course outlines and descriptions. A summary of the key points related to the current state of stream restoration education is as follows.

1. The most common topics covered include sediment transport, bank mechanics/stabilization, fluvial geomorphology, and habitat structure and function.
2. The least common topics covered include construction implementation, project management, stream stability, surveying, uncertainty and risk, and water quality.
3. Graduate degree programs and university certificate programs offer the greatest variety of topics and require learning assessment.
4. The majority of university and non-university professional courses examined are taught by a combination of faculty members (theory and fundamentals) and practitioners (design and implementation), with a few courses taught by government personnel (regulatory issues and project management). University graduate degree program courses are taught primarily by academic faculty.
5. University professional programs appear to offer the largest number of different discipline experts serving as instructors.
6. Three outcomes may be available at the completion of the stream restoration programs and courses: graduate degree, a professional certificate, or CEC/PDH.
7. A few courses cover a variety of topics and disciplines but are taught by instructors with expertise in only one or a few of these disciplines. One individual cannot be an expert in all stream restoration disciplines; thus, having a variety of discipline experts as instructors is beneficial to effectively teach the nuances of a topic and to relate it to practical experience.
8. Although course objectives were clearly identified for all of the course offerings, determining whether the course instructors assessed whether course learning objectives were met is difficult. Definitions of clear course objectives that achieve higher levels of cognitive achievement and implementation of a learning assessment plan would result in improved learning.

Task 2: Practitioner Survey

Task 2 clarified the education and training needs of restoration professionals using a practitioner survey of the knowledge required for the practice of stream restoration. The survey included 17 questions designed to assess respondent demographics (6), the development of a SR-BOK (8), and the possible role of professional certification in restoration (3). The survey was distributed to attendees of the 2009 Mid-Atlantic Stream Restoration Conference, the 2010 Northwest Stream Restoration Symposium, and the 2010 Upper

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Table 2. Summary of Programs and Courses Reviewed to Identify Common Stream Restoration Topics

Program or course	Number of courses offered	Topics covered[a]	Number of instructors	Instructor's sectors and disciplines	Course length	Cost (2012 USD)	Student outcome	References
University graduate degree programs								
Colorado State University—Graduate Study in Stream Restoration	19 required and elective	1, 3–7, 9–18	13	Faculty in Civil Engineering, Geomorphology, Fisheries Biology, Ecology, Statistics	Semester-long series of courses	$1,517.92 per course[b]	Graduate Degree (M.S. or Ph.D.) in Civil Engineering	Julien 2012
University of Minnesota Stream Restoration Certificate Program	11 required and elective	1, 3–7, 9–13, 15–18	7	Faculty in Civil Engineering, Ecology, Environmental Science, Watershed Science	Semester-long series of courses	$3,642.51 per course[c]	Graduate Degree (M.S. or Ph.D.) in Civil Engineering	Voller 2012
University professional programs								
North Carolina State University Stream Restoration Program	12	1–2, 4–13, 15–18	11	Faculty, Practitioners in Ag and Civil Engineering, Fisheries Biology, Ecology, Environmental Science, Construction Management	Short courses (one to three days)	$100–$700	CEC/PDH	Doll 2012
Portland State University River Restoration Professional Certificate Program	Five core, four stream electives, 12 wetland electives	All	30	Faculty, Regulators, Practitioners in Construction Management, Civil Engineering, Ecology, Geomorphology, Fisheries Biology, Soils/Wetlands	Short courses (one day to one week); Field Institute (one month)	$200–$1,000;	River Restoration Professional Certificate (five core + two electives) or CEC/PDH	PSU-EPP 2012
University at Buffalo Summer Stream Ecosystem Restoration Workshops and Professional Certificate Program	Five core, six electives	1–13, 15, 18	15	Faculty, Regulators, Practitioners in Geomorphology, Geography, Civil Engineering, Wildlife Biology, Geology, Ecology, Entomology, Fisheries Biology	Month-long series of one- to two-day short courses	$400–$600	Certificate in Stream Restoration (five core + five electives) or CEC/PDH	UAB-ERIE 2012
University of California, Berkeley-Sagehen	1	3–7, 10–12, 15–16, 18	13	Faculty, Regulators, Practitioners in Engineering, Geomorphology, Ecology, Geology, Fisheries Biology	Week-long short course	$2,100	CEC/PDH	Berkeley-Sagehen 2012
University of New Brunswick—Canadian Rivers Institute	6	2–9, 11–12, 15–18	6	Faculty, Research Scientists in Engineering, Hydrology, Geomorphology, Ecology, Zoology, Fisheries Biology	Online, short courses (two to eight days)	$300–$1,400	Field Course—3 credits, Short Courses—CEC/PDH	UNB-CRI 2012
Utah State University Intermountain Center for River Rehabilitation and Restoration	5	3–7, 9–12, 14–15, 17–18	12	Faculty, Practitioners, Regulators, Research Scientists in Engineering, Geomorphology, Ecology, Fisheries Biology, Environmental Science, Geography, Landscape Architecture	Short courses (three to four days)	$1,000–$1,600	CEC/PDH	Schmidt 2012

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Table 2. (*Continued.*)

Program or course	Number of courses offered	Topics covered[a]	Number of instructors	Instructor's sectors and disciplines	Course length	Cost (2012 USD)	Student outcome	References
Non-university professional courses and course sequences								
Wildland Hydrology	6 core, 1 elective	1, 2, 4–10, 12–13, 17–18	6	Faculty, Practitioners, Regulators in Hydrology, Construction Management, Geography	Short courses (two to ten days)	\$400–\$2,800	CEC/PDH	Wildland Hydrology 2012
U.S. Fish and Wildlife Service	11	3–7, 9, 11, 15, 18	Unknown	Unknown (not provided in course descriptions)	Multiday, week short courses	Varies	CEC/PDH	USFWS 2012

[a]Topics: (1) bank mechanics and stabilization; (2) construction implementation; (3) fish biology; (4) fluvial geomorphology; (5) habitat structure and function; (6) hydraulics; (7) hydrology; (8) project management; (9) restoration design; (10) sediment transport; (11) stream ecology; (12) stream stability; (13) surveying/hydrometry; (14) uncertainty and risk; (15) vegetation/riparian dynamics; (16) water quality; (17) modeling; (18) restoration monitoring.

[b]On the basis of the first three credit hours of graduate courses and fees per semester in 2012–2013; in-state tuition levels are from http://registrar.colostate.edu/Data/Sites/1/graduate_base_tuition_and_fees.pdf.

[c]On the basis of the first three credit hours of graduate courses and fees per semester in 2012–1013; in-state tuition levels are from http://onestop.umn.edu/finances/costs_and_tuition/tuition_and_fees/graduate_school_tuition.html.

Mid-West Stream Restoration Symposium; the 152 responses are summarized as follows.

Demographic Information

The majority of respondents listed engineering (24%), fluvial geomorphology (18%), ecology (14%), fisheries biology (11%), project management (8%), and environmental science (6%) as the restoration disciplines that best characterize their areas of expertise. A majority of respondents (66%) had more than four years of experience in their restoration discipline in the private and government sectors. Of these, 37% (the largest percentage) were in the consulting field, indicating that responses from this survey should provide a useful view of the training needed by the practicing professional (both government and private). A majority of respondents (65%) indicated that they obtained their restoration education as a combination of college courses and professional short courses. The remaining respondents found training through conference attendance, on-the-job, and independent learning.

The respondents self-identified with five professional responsibilities: (1) monitoring/assessment, (2) planning/implementation, (3) design, (4) project management, and (5) regulatory review (Tables 4 and 5). All responsibilities are defined from the practitioner responses and do not reflect all of the possible disciplines and responsibilities (Table 4). Primary and secondary responsibilities were defined (Table 5) on the basis of the percentage of discipline-specific respondents that identified with a given responsibility. The largest percentages in each discipline were considered as that discipline's primary responsibility (P), whereas all remaining responsibilities were considered secondary (S). The specific responsibilities shown in Table 5 are useful for defining a discipline-specific SR-BOK.

SR-BOK—Suggested Topics and Suggested Level of Learning

Survey participants were asked to evaluate a summary of SR-BOK topics created by the TC on the basis of Task 1. The topics were grouped into five general areas: physical processes, ecological and biological processes, stream restoration assessment and monitoring, restoration design, and restoration project management (Table 6). Practitioner survey respondents agreed (average rating of 3.33 out of 4, on a scale of 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree) that all of the topics in Table 6 belong in a SR-BOK. Respondents also suggested additional courses including geographic information systems (GIS), soils and soil mechanics, adaptive management, water quality analysis, and ethics.

Survey respondents were asked to indicate the minimum level of learning that should result from a course in a given topic. The minimum levels of knowledge were developed using materials suggested for technical specialization from ASCE's second edition BOK report (ASCE 2008) on the basis of the levels of cognitive achievement as defined in Table 7. As Table 6 shows, the average level of learning in the topics surveyed was application and problem solving (Level 3). However, respondents also indicated that design requires at a minimum an analysis level of learning (Level 4) (Table 6). Additionally, the more experienced subset of respondents (more than eight years) also identified the need for an analysis level of learning for fluvial geomorphology and a synthesis level of learning for design. The general consensus was that practitioners should achieve at least an application level of learning when striving for an analysis level in fluvial geomorphology and a synthesis level in design.

Summary and Synthesis

The key findings of the practitioner survey are the following:

1. The educational background and areas of expertise of practicing professionals is inherently multidisciplinary and

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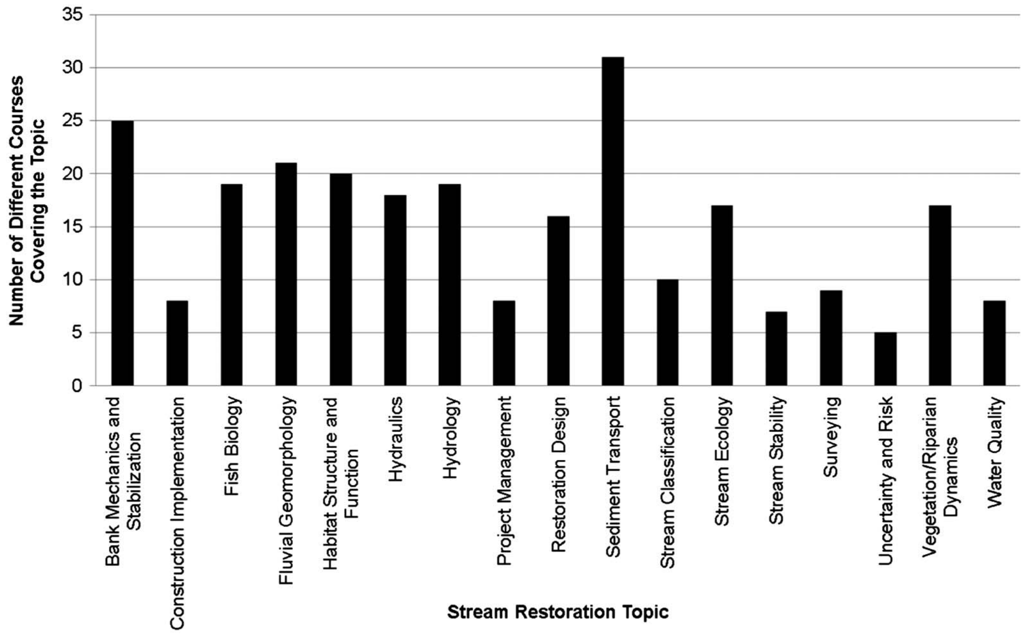

Fig. 1. Stream restoration topics and total number of courses that cover the topic

Table 3. Potential SR- BOK Topics Developed from Review of Manuals and Courses

Topics	Subtopics
Bank mechanics and stabilization	Fluvial erosion, geotechnical failure, stability modeling, bioengineering, bank stabilization methods and techniques
Construction implementation	Planning, contracts/bidding, installation, construction methods, equipment selection, contacting procedures, construction staging, erosion and sediment control
Fish biology	Fish life history and species traits, community structure, fish passage, indicators of biotic integrity, invasive species
Fluvial geomorphology	Stream classification, open channel flow, channel adjustment (aggradation/degradation), hydraulic geometry, channel incision, meanders and other planforms, bed and water surface slope, bank retreat, floodplain processes, valley morphology
Habitat structure and function	Surveys, classification, function, suitability and species preferences, modeling (e.g., PHABSIM, River2D), fish passage
Hydraulics	Conservation of mass, energy, and momentum, stream power, water surface profiles, hydraulic jumps, ecohydraulics, grade control
Hydrology	Flood frequency analysis, flow duration, modeling, channel forming flow
Project management	Funding, communication, stakeholder participation, permitting
Restoration design	Threshold and alluvial design, regime, analogy approaches, extremal hypotheses, analytical approaches, sediment effects, natural channel design, planform, urban constraints
Sediment transport	Incipient motion, bed stability, threshold versus alluvial, equilibrium slope, rating curves, budgets, transport capacity, sediment dynamics, mixed size sediment transport, sediment control, bedload, suspended, scour
Stream ecology	Biological diversity, macroinvertebrates, river continuum concept, riparian function, floodplains, wetlands, invasive species, natural flow regime (environmental flows)
Stream stability	Rapid geomorphic assessments, stability indicators, disturbance response, channel evolution model
Surveying/hydrometry	Channel morphology, flow measurement, channel roughness, sediment transport measurement, water quality sampling
Uncertainty and risk	Sources of uncertainty, failure modes and costs, risk
Vegetation/riparian dynamics	Plant communities, riparian zones, bioengineering, water quality effects, biological and ecological interactions
Water quality	Physical and chemical characteristics, nutrient cycling, hyporheic exchange, turbidity and suspended sediment concentration, biological impairment, state standards
Modeling	Geospatial (e.g., AutoCAD, GIS), hydrologic (e.g., HEC-HMS), hydraulic (e.g., HEC-RAS), sediment transport, sediment effect analysis
Restoration monitoring	Planning (parameters, design, funding), monitoring types and methods (baseline, status, trend, effectiveness, validation), biomonitoring (fish and macroinvertebrates), water quality, equipment, data and statistics

diverse, and most obtained their education through a combination of college classes, short courses, and on-the-job training.

2. A restoration curriculum needs to be multidisciplinary and should contain courses in physical processes, ecological and biological processes, monitoring and assessment, restoration design, and restoration project management (Table 6).
3. A minimum level of learning in the suggested topics should be at the application (Level 3) level of Bloom's Taxonomy (Bloom et al. 1956).

Table 4. Survey Responses: Stream Restoration Responsibilities and Associated Duties

Stream restoration responsibility	Description of duties
Project management	Build multi-agency and interdisciplinary teams
	Create internal and public communication plans
	Stakeholder assessment, management, and compliance
	Identify project levels, structures, schedules, and budgets
	Manage designers, contractors, and volunteers
Monitoring/assessment	Collect information on baseline, current, and future channel and bank condition and in-stream structures
	Conduct assessments to provide elements that may be needed to meet restoration objectives or to determine whether objectives have been met
Design	Evaluate design of a river system, component, or process and assess compliance with guidelines and constraints
	Create a restoration design that combines habitat, flood protection, and traditional engineering goals and employ a multi-step engineering design process
Planning/implementation	Address permitting issues and work to secure funding for project implementation
	Implement project elements when working closely with construction equipment operators
	Modify planned actions onsite to achieve project outcomes
	Rapidly assess changing conditions and effectively communicate plan deviations to equipment operators
Regulatory review	Review problem identification, goals and objectives, physical and biological processes in relation to project effects, assessing project risks, post-project appraisal, and compliance and effectiveness monitoring
	Evaluate projects within a range of regulatory contexts for their potential effect on protected species or the stream processes, habitat, or ecosystem on which they depend
	Measure project success relative to goals and objectives

Table 5. Practitioner-Identified Responsibilities of Various Stream Restoration Disciplines

Responsibility/discipline	Ecology (%) ($N = 17$)	Engineering (%) ($N = 53$)	Environmental science (%) ($N = 7$)	Fisheries biology (%) ($N = 16$)	Fluvial geomorphology (%) ($N = 16$)
Project management	P (29)	S (28)	S (29)	P (31)	S (6)
Monitoring/assessment	S (17)	S (8)	P (43)	S (19)	S (25)
Design	S (24)	P (40)	S (14)	S (19)	P (44)
Planning/implementation	S (24)	S (12)	S (14)	S (25)	S (19)
Regulatory review	S (6)	S (12)	S (0)	S (6)	S (6)

Note: P = primary responsibility; S = secondary responsibility.

Table 6. Suggested Topics for SR-BOK and Average Minimum Level of Learning for each Topic as Suggested by Survey Respondents

Physical processes fundamentals topics	Ecological and biological fundamental topics	Stream restoration assessment and monitoring topics	Restoration design topics	Restoration project management topics
Watershed processes/ hydrology (3.34)	Stream ecology (3.20)	Surveying (3.08)	Design approaches/ fundamentals (4.01)	Project development (3.54)
Open channel flow (3.25)	Habitat structure and function (3.50)	Watershed analysis (3.52)	Alternatives analysis (3.95)	Risk and uncertainty (3.44)
Fluvial geomorphology (3.46)	Fish and wildlife biology (2.94)	Geomorphic/habitat assessment (3.58)	Analytical techniques (3.73)	Communication (3.63)
Sediment transport (3.26)	Plant ecology/riparian dynamics (3.14)	Biomonitoring/bioassessment (3.12)	Ecohydraulics (3.15)	Construction management (3.56)

Note: See Table 7 for levels.

4. University faculty are most appropriate for covering physical processes and ecological and biological processes and their application to design, whereas professional practitioners are most appropriate for covering restoration design, monitoring and assessment, and project management.

Task 3: Development of the Stream Restoration Body of Knowledge

The previous tasks laid the groundwork for developing the SR-BOK. The SR-BOK is not intended to be a comprehensive overview of the entire field of stream restoration, nor is it meant to exhaustively delineate every detail of the various disciplines involved with stream restoration. Rather, the overarching purpose is to define the competencies, knowledge areas, and key concepts and skills that constitute the core knowledge (Pomeroy-Huff et al. 2009) in the stream restoration field (i.e., define the minimum level of knowledge necessary to practice).

Using the results of Tasks 1 and 2, and in a manner similar to ASCE (2008), outcomes were developed to define the knowledge and skills that a general practitioner of stream restoration must acquire through appropriate education, training, and practical experience. A wide array of disciplines and responsibilities are involved with a stream restoration project (Table 5). As a result, almost all

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Table 7. Taxonomy and Associated Action Verbs

Level of learning	Definition	Suggested action verbs
Knowledge	Remembering previously learned material	Arrange, define, label, describe, reproduce
Comprehension	Grasp meaning of material and interpret in a different way	Classify, defend, identify, predict, summarize
Application	Use in new situations; apply tools, laws, concepts, and principles	Apply, choose, demonstrate, predict, prepare, solve
Analysis	Break down into parts, understand content and form	Analyze, calculate, compare, examine, select, test
Synthesis	Conceive, plan, and synthesize parts into a new whole	Compose, design, develop, integrate, synthesize
Evaluation	Judge the value of the material on the basis of given criteria	Assess, evaluate, judge, justify, interpret, support

Note: Data from Bloom et al. (1956).

stream restoration projects require a multidisciplinary restoration team. Thus, a general practitioner is defined as having the following key characteristics: (1) holds expertise in at least one of the primary disciplines of stream restoration; (2) can accomplish at least one of the major responsibilities defined in Table 4; and (3) can work effectively as part of a multidisciplinary restoration team. In addition, a general practitioner has the following prerequisite knowledge:

1. BS degree in science or engineering (chemistry; geology; biology; soil science; ecology/environmental science; civil, biological, environmental, chemical, or mechanical engineering);
2. Competence in geometry, algebra, trigonometry, and probability and statistics; competence in calculus and differential equations is not universal, but is necessary for hydrology, hydraulics, sediment transport, and dynamic biological modeling; and,
3. Competence in spreadsheets or other computational software.

Overall, a general practitioner is expected to have the necessary *depth* of knowledge in his or her discipline of stream restoration (on the basis of his or her prerequisite knowledge and advanced specialization) to be able to complete the assigned responsibilities (Tables 4 and 5). The general practitioner must also have the necessary *breadth* of knowledge in all disciplines of stream restoration to effectively communicate and work as part of a multidisciplinary team.

The development of the SR-BOK focused on identifying outcomes without consideration for specific courses, instructor expectations, and logistical aspects of teaching the requisite knowledge. For example, topics listed in the outcomes appear in more than one course, one course may achieve many of the outcomes, and one outcome may be the goal of an entire course (ASCE 2008). Many of the outcomes can and will be partially achieved as part of practical experience. Indeed, practical experience is highly valued as an educational tool in stream restoration. The minimum learning expectations in the SR-BOK are based on what is considered necessary for anyone practicing stream restoration (regardless of discipline) and were established on the basis of a summary of existing course topics, practitioner survey results, and a consensus of expert opinion. The SR-BOK is not a hypothetical minimum; rather, it is proposed as an initial industry standard that will inevitably be updated.

Table 8 introduces the SR-BOK and defines 21 foundational, technical, and professional outcomes and the minimum level of learning required for a general stream restoration practitioner. Table 8 communicates the following SR-BOK characteristics:

1. The 21 outcomes are categorized as foundational, technical, or professional and, within each category, are organized in approximate pedagogical order that does not reflect relative importance.
2. The recommended minimum level of learning that a general practitioner must demonstrate for each outcome to effectively communicate and practice stream restoration at the professional level is shown as dark grey-shaded cells.
3. Levels of achievement beyond the suggested minimum that a general practitioner may wish to achieve are also identified.

All stream restoration practitioners should reach, at a minimum, the application level of learning for all 21 outcomes, which may be accomplished through any type of training (Task 1). In addition, we recommended that an analysis level of learning be achieved for eight of the outcomes (1, 2, 3, 4, 10, 13, 14, and 15). Finally, anyone practicing stream restoration is expected to display an evaluative level of ethical responsibility because their duty to the profession is to understand and uphold the moral standards of the practice to protect the health, safety, and welfare of the public (Slate et al. 2007).

Guidance for Engineers: A Stream Restoration Engineer BOK

Stream restoration practitioners are immersed in an ever-evolving field within which becoming overwhelmed with the required knowledge is easy. Practitioners, particularly those holding professional licenses, must embrace lifelong learning and are highly encouraged to review the SR-BOK to provide a foundation or road-map for training.

On the basis of the different responsibilities presented in Table 4, professionals with certain responsibilities may require different levels of training beyond the suggested minimum levels of the SR-BOK. A discipline-specific SR-BOK builds off the foundation presented in Table 8 and provides a more specialized BOK related to a given discipline. As an example, a specialized stream restoration engineer BOK (SRE-BOK) has been developed (Table 9). Other disciplines with different primary responsibilities are able to use this example as guidance for creating their own recommended and specialized training path.

Table 9 introduces the SRE-BOK for a stream restoration engineer and defines 22 foundational, technical, and professional outcomes, and the minimum level of learning required for practice. An engineer is identified as a civil, biological, hydraulic, water resources, and/or environmental engineer with responsibilities as identified in Table 5. Because the engineer legally stamps the restoration plans and is responsible for the results, a more specialized SR-BOK is warranted (Slate et al. 2007). The SRE-BOK was developed on the basis of the assumption that the engineer is a licensed professional engineer with a focus on water resources and has a Bachelor's degree.

By fulfilling the SRE-BOK shown in Table 9, a practicing engineer will have earned the specialized level of knowledge needed to improve restoration design, communicate across disciplines, and manage projects. The highlights of the SRE-BOK include the following.

1. A construction management outcome (21) was added for a practicing engineer given the engineer's direct role in the design and construction process. Having an analysis level of understanding of construction management practices is critical

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Table 8. General Practitioner Stream Restoration Body of Knowledge (SR-BOK)

Foundational outcomes number and title	Minimum level of learning L1	L2	L3	L4	L5	L6	Outcome definition
Hydrology	X	X	X	X			Solve physics problems related to hydrologic processes and apply this knowledge to analyze runoff generation, plant-soil water relations, and coevolution of fluvial geomorphology and hydrologic response
Hydraulics	X	X	X	X			Solve natural channel flow problems using mass, momentum, and energy, and analyze uniform, gradually and rapidly varied flow, flow resistance, flood routing
Fluvial geomorphology	X	X	X	X			Analyze fluvial processes and morphological responses in different types of dynamic rivers, including channel response to change and channel patterns. Apply geomorphological approach to river channel management and restoration
Sediment transport	X	X	X	X			Understand sediment transport principles and apply strategies for estimating sediment transport in rivers, including incipient motion, mixed size sediments, and alluvial transport. Calculate sediment transport for channel design alternatives and determine when transport rates are not important
Stream ecology	X	X	X				Understand basic concepts of river ecology (hydrologic, biogeochemical, biological) to determine structure and function of freshwater lotic ecosystems with an emphasis on solving problems involving stream/habitat/hyporheic restoration of water resources to maintain environmental flows
Habitat structure and function	X	X	X				Apply methods to assess stream physical habitat characteristics (e.g., mesohabitat types, velocity, depth, substrate type, riparian vegetation) as they apply to in-stream flow, monitoring, habitat quality, and fish-habitat studies
Fish biology	X	X	X				Understand the comparative biology of fishes, species traits, and habitat preferences; identify common/economically important species and apply knowledge to examine the effect of restoration actions on concerned species (i.e., increased in-stream flows, dam removal, and in-channel restoration)
Plant ecology and riparian dynamics	X	X	X				Understand plant community dynamics and apply ecological techniques (e.g., riparian habitat mapping, riparian dynamics modeling, plant surveys/monitoring) to examine different restoration scenarios, predict riparian vegetation recruitment, and develop effective revegetation designs
Surveying/hydrometry	X	X	X				Understand river field measurement techniques. Apply techniques and utilize equipment to survey stream morphology and collect water quality and quantity and sediment transport data as it relates to stream stability assessment
Watershed analysis	X	X	X	X			Characterize connections between natural landscape properties, human activities, and ecosystem services related to soil, sediment, water resources, and aquatic ecosystems and analyze the main processes that control water quantity, water quality, sediment transport, and aquatic habitat
Geomorphic and habitat assessment	X	X	X				Apply rapid geomorphic assessment and rapid habitat assessment to assess stream condition using multiple data types across scales ranging from a single cross section to an entire watershed. Use the results to identify how channel, floodplain and watershed scale stressors effect hydrological processes and alter the physical and ecological structure and habitat values of streams
Biomonitoring/bioassessment	X	X	X				Understand rationale for biomonitoring and the use of benthic invertebrates as indicators of water quality and overall stream health. Apply bioassessment methods to identify benthic invertebrates using the visual description of diagnostic characters for sensitive groups (i.e., EPT index)
Alternatives analysis	X	X	X	X			Analyze scientific information to place restoration alternatives in context of fluvial geomorphology, hydrology, and sediment transport in light of stream processes overlain with biologic goals and human values
Analytical techniques	X	X	X	X			Apply analytical tools to characterize flood discharge and stage, sediment budgets and transport conditions, bank mechanics and erosion, and fish habitat and passage (e.g., HEC-HMS, HEC-RAS, BSTEM, BAGGS, River2D, FishXing)

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Table 8. (*Continued*.)

Foundational outcomes number and title	Minimum level of learning L1	L2	L3	L4	L5	L6	Outcome definition
Restoration design	X	X	X	X			Analyze stream restoration design approaches that integrate geology, soils, and hydrology with hydraulics, sediment transport, and fluvial geomorphology to select an appropriate design approach. Understand the basics of standards, specifications, design notes, and drawings of design features
Uncertainty and risk	X	X	X				Understand design types and modes of failure, probability of failures, expected failure costs, and uncertainty types. Apply methods to reduce uncertainty
Project development	X	X	X				Apply project and goals management principles to build multi-agency and interdisciplinary teams, set up administrative systems, and create internal and public communication plans
Restoration policy (codes and regulations)	X	X	X				Understand major laws relevant to stream restoration projects, including federal, state, and county laws, and recognize variable regulatory timeframes and show effects on project implementation
Communication and information management	X	X	X				Prepare and apply a plan that incorporates information distribution, performance reporting and administrative closure and defines how effective communication of information with all involved parties will be accomplished at key stages in the process. Manage and facilitate a process to ensure timely and appropriate generation, collection, dissemination, storage and disposition of information
Construction inspection	X	X	X				Apply quality assurance testing and engineering surveys and document construction activities to assure that goals of the planned project are realized during construction. Coordinate with the contractor's quality control personnel and maintain the as-built plans
Professional and ethical responsibility	X	X	X	X	X	X	Critically evaluate ethical issues that arise in stream restoration, including relationships between ethics and professional life and the particular consequences of ethical considerations within the practitioner's own profession and the professions of others involved with the project

Note: A general practitioner requires fulfilling 21 outcomes to the appropriate minimum level of learning to have breadth and depth of knowledge to work as part of a restoration team. Minimum levels of learning (as indicated by the grey cells): L1—Knowledge, L2—Comprehension, L3—Application, L4—Analysis, L5—Synthesis, L6—Evaluation).

for an engineer who designs the project and creates the plans and specifications.

2. All 22 outcomes are fulfilled through the application level to ensure a knowledge level to effectively complete responsibilities and to communicate across disciplines.
3. Four outcomes (3, 13, 20, 21) require an analysis level of achievement given their close relationship to engineering and an understanding sufficient for design and communication across disciplines.
4. Five outcomes are listed that require a synthesis level of achievement given their importance in the design and project management process (10, 14, 16, 17, 18, and 19).
5. Six outcomes require an evaluative level of achievement given their direct application in the engineering discipline and their importance to design (1, 2, 4, 9, 15, and 22).
6. Six outcomes are listed that are often not covered in standard engineering training: stream ecology, habitat structure and function, fish biology, riparian dynamics, geomorphic and habitat assessment, and biomonitoring/bioassessment. The engineer is expected to seek out professional development courses to fulfill these portions of the SRE-BOK to at least the application level of achievement.

The establishment of a SRE-BOK clearly defines the knowledge and skills required of an engineer to practice in the area of stream restoration but does not specify how an engineer fulfills these requirements. Fulfilling these requirements is accomplished through a combination of undergraduate education, graduate education, professional development courses, on-the-job training, and experience. Professional development is obtained through continuing education university courses or short courses delivered through independently evaluated, high quality, standards-based educational programs (Task 1). Currently, no specific validation process exists for professional development courses; thus, evaluation is in the hands of the practitioner (and required by professional ethics) to ensure successful completion of courses that offer the appropriate level of learning for each outcome, as indicated by course description, goals, and objectives. Experience should be on the basis of broad technical and professional practice guidelines that provide flexibility for a wide range of roles in stream restoration practice. Because restoration is a profession of practice, many of the outcomes in the SRE-BOK are expected to be met as part of on-the-job experience; however, a critical need exists to ensure that a more experienced mentor supervises the on-the-job experience. A strong mentor provides valuable guidance and direction and, as a result, improves the quality of learning and the experience gained by a practicing professional. Thus, mentorship is essential to the practice and to the verification that outcomes have been achieved.

Foundation for a National Stream Restoration Certification

The delineation of a standard SR-BOK provides a foundation for the certification process, and its importance in establishing the

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Table 9. Stream Restoration Engineer Body of Knowledge (SRE-BOK)

Foundational outcomes	Minimum level of learning						Outcome
Number and title	L1	L2	L3	L4	L5	L6	Definition
Hydrology	X	X	X	X	X	X	Solve physics problems related to hydrologic processes and apply this knowledge to evaluate runoff generation, plant-soil water relations, and coevolution of fluvial geomorphology and hydrologic response
Hydraulics	X	X	X	X	X	X	Solve natural channel flow problems using mass, momentum, and energy; analyze uniform, gradually and rapidly varied flow, flow resistance, and flood routing; and apply this knowledge to evaluate natural channels
Fluvial geomorphology	X	X	X	X			Analyze fluvial processes and morphological responses in different environments and types of dynamic rivers including channel response to change and channel patterns. Understand and apply geomorphological approach to river channel management and restoration
Sediment transport	X	X	X	X	X	X	Understand sediment transport principles and apply strategies to estimate transport in rivers, including incipient motion, mixed size sediments, and alluvial transport. Design steps to incorporate sediment transport in channel design and evaluate when transport rates are not important
Stream ecology	X	X	X				Understand basic concepts of river ecology to determine structure and function of freshwater lotic ecosystems and solve problems in stream/habitat/hyporheic restoration of resources to maintain environmental flows
Habitat structure and function	X	X	X				Apply methods to assess stream habitat characteristics (e.g., mesohabitat types, velocity, depth, substrate type, riparian vegetation) as they apply to in-stream flow, monitoring, habitat quality, and fish-habitat studies
Fish biology	X	X	X				Understand the comparative biology of fishes, species traits, and habitat preferences; identify common/economically important species and apply knowledge to examine the effect of restoration actions on concerned species (i.e., increased in-stream flows, dam removal, and in-channel restoration)
Plant ecology and riparian dynamics	X	X	X				Understand plant community dynamics and apply ecological techniques to examine different restoration scenarios, predict riparian vegetation recruitment, and develop effective revegetation designs
Surveying/hydrometry	X	X	X	X	X	X	Understand river field measurement techniques. Apply techniques to survey stream morphology and evaluate stream dynamics. Evaluate water quality, water quantity, and sediment transport data collected in the field
Watershed analysis	X	X	X	X	X		Characterize connections between landscape properties, human activities, and ecosystem services related to sediment, water resources, and aquatic ecosystems, and design procedures to analyze the main processes that control water quantity, quality, sediment transport, and aquatic habitat
Geomorphic and habitat assessment	X	X	X				Apply rapid geomorphic assessment and rapid habitat assessment to assess stream condition using multiple data types across scales. Use the results to identify how channel, floodplain, and watershed stressors effect hydrological processes and alter the physical and ecological structure and habitat
Biomonitoring/bioassessment	X	X	X				Understand rationale for biomonitoring and the use of benthic invertebrates as indicators of water quality and overall stream health. Apply bioassessment methods to identify benthic invertebrates using the visual description of diagnostic characters for sensitive groups (i.e., EPT index)
Alternatives analysis	X	X	X	X			Analyze scientific information to place restoration alternatives in the context of fluvial geomorphology, hydrology, and sediment transport in light of stream processes overlain with biologic goals and human values

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Table 9. (*Continued.*)

Foundational outcomes	Minimum level of learning						Outcome
Number and title	L1	L2	L3	L4	L5	L6	Definition
Analytical techniques	X	X	X	X	X		Synthesize modeling results to characterize flood discharge and stage, sediment transport conditions, bank mechanics and erosion, and fish habitat and passage (e.g., HEC-HMS, HEC-RAS, BSTEM, BAGGS, River2D, FishXing)
Restoration design	X	X	X	X	X	X	Evaluate multiple design approaches for restoration projects and select one to design a stream project that integrates landscape scale considerations of geology, soils, and hydrology with stream processes of hydraulics, sediment transport, and fluvial geomorphology. Produce standards, specifications, drawings, and design notes to implement design features
Uncertainty and risk	X	X	X	X	X		Design a stream channel restoration project that minimizes risk and uncertainty
Project development	X	X	X	X	X		Apply project and goal management principles to construct a plan that includes building multi-agency and interdisciplinary teams, set up administrative systems, and create internal and public communication plans
Restoration policy (codes and regulations)	X	X	X	X	X		Integrate the major laws relevant to stream restoration projects into design, including federal laws, state laws, and county ordinances
Communication and information management	X	X	X	X	X		Develop and apply a communications plan that incorporates information distribution, performance reporting, and administrative closure, and define how effective communication of information with all involved parties will be accomplished at key stages in the process. Understand how to manage and facilitate a process to ensure timely and appropriate generation, collection, dissemination, storage, and disposition of project information
Construction inspection	X	X	X	X			Apply quality assurance testing and engineering surveys and document construction activities to assure that the goals of the planned project are realized through the construction and implementation of the project's design elements. Supervise the contractor's quality control personnel and maintain as-built plans
Construction management	X	X	X	X			Apply the basic principles of stream restoration project construction management. Define and control project scope with respect to estimating, scheduling, budgeting, purchasing, design, safety, insurance, construction techniques, labor, and public relations
Professional and ethical responsibility	X	X	X	X	X	X	Critically evaluate ethical issues that arise in stream restoration, including relationships between ethics and professional life and the particular consequences of ethical considerations within the practitioner's own profession and the professions of others involved with the project

Note: A practicing engineer requires fulfilling 22 outcomes to the appropriate level of learning to have sufficient breadth and depth of knowledge to complete project management and design responsibilities. Dark grey cells indicate an appropriate level of learning for engineers (SRE-BOK) beyond that of general practitioners (SR-BOK—Table 9).

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jurisdiction of the stream restoration practice should not be underestimated (Morris et al. 2006). Certification provides a means to verify and validate the completion of the SR-BOK. Currently, no way exists to validate that a practitioner has achieved the SR-BOK outcomes to the appropriate levels. The fact that courses often do not attempt to assess learning is a major deficiency in stream restoration professional development. Thus, the committee recommends the next logical step: implement this proposed SR-BOK as the foundation for establishing a national stream restoration certification.

Although a national certification is warranted (Morris et al. 2006; Kite 2009; Marr 2009; Fischenich 2009), implementing a structure for certification and assuring consistent preparation faces significant challenges given the diverse background, training, and expectation of professional competence of those currently practicing stream restoration. To earn a certification, a candidate must meet a set of requirements that identify whether he/she has met the minimum level of competence for practice. Respondents to our practitioner survey were asked to rate potential criteria for assessing the credentials of restoration certification candidates. Not surprisingly, respondents already in practice showed a preference for professional experience and a portfolio of completed projects over the administration of a national exam (Table 10). These results provide preliminary insights into developing an implementation plan for national certification.

On the basis of the results of the NCED working group, the practitioner survey results, the SR-BOK, and the important need to learn assessments and outcome validation in short courses, we suggest a steering committee is needed to initiate the creation of a certificate in stream restoration. The committee should consist of carefully selected experts from relevant fields of the stream restoration profession, including representatives from national professional societies such as the ASCE, American Ecological Engineering Society (AEES), American Society of Landscape Architects (ASLA), American Fisheries Society (AFS), and the Society for Ecological Restoration (SER), and academics and regulatory representatives. The initial charge of this committee is to draw on models from other fields that recently implemented their own certification, such as the American Society of Floodplain Managers (ASFM) and the Association of State Wetland Managers (ASWM), and formulate a preliminary certification implementation plan.

Contributions to the Stream Restoration Profession

The outcomes (Table 8) collectively describe the SR-BOK and the necessary depth and breadth of knowledge and skills required of a general practitioner aspiring to practice in the field of stream restoration. After fulfilling the SR-BOK, general practitioners will be able to (1) analyze physical and ecological processes that are fundamental to understanding river form, process, and function, (2) apply this knowledge to determine an appropriate defective design solutions, (3) maintain technical breadth in their chosen discipline, (4) acquire broader technical exposure to disciplines outside their area of expertise to support effective project implementation and communication, and (5) achieve greater technical depth or specialization in their chosen discipline.

This work also provides a foundation for the creation of national certification. We believe that certification is necessary to demonstrate a minimum acceptable level of competence in a diverse, multidisciplinary profession practiced by those with a wide range of training. Certification is meant to recognize that a practitioner has mastered the knowledge and practice requirements of the profession and will reliably act within the structures of the profession and apply good professional judgment in the interests of the client (Morris et al. 2006). Certification will not guarantee performance; rather, it shows that the practitioner acts within the parameters of accepted best practice and applies discretion reasonably (Morris et al. 2006). With the establishment of a national certification program, regulatory agencies and potential clients may start to recognize its value and begin to require certification for stream restoration activities. The result is expect to be greater consistency in the practice of stream restoration, which can lead to improved project outcomes and healthier streams.

Table 10. Average Rating of Potential Certificate Requirements

Certificate requirement	Average rating
Professional experience	4.14
Portfolio of projects completed	3.99
Established curriculum	3.69
Continuing education credits	3.52
Endorsements	3.26
National exam	2.83

Note: scale: 5 = one of the best; 1 = one of the worst.

Concluding Discussion

Professions are defined largely around their area of distinctive competence and the SR-BOK presented is an attempt to map out the elements of this competence. Developing a SR-BOK is important to both practitioners and academics and to advance the stream restoration profession. Practitioners have a strong interest in a BOK because it has a direct effect on industry views regarding competence, best practice, training, and development. Academics have a strong interest in a BOK because it guides the development of curricula and challenges careful thought about the scope and foundation of a subject (Morris et al. 2006).

Distinctively identifying an appropriate knowledge base remains a challenge because of a lack of effectiveness in monitoring and researching what makes a stream restoration project successful (Bernhardt et al. 2005). The SR-BOK presented was developed by expert professionals selected from a variety of sectors and stream restoration disciplines. We acknowledge that the legitimacy of the SR-BOK is derived primarily from current practice and this group's endorsement, and it whether it will be widely accepted and adopted remains to be seen. We hope that this work stimulates critical discussion that leads to improvements and revisions to the SR-BOK on the basis of continued interaction between the practice and research communities. The result is expected to be a better understanding of the nature and limitation of the knowledge element in stream restoration professional competence; more informed content; and a better understanding of professional development and the value of certification (Morris et al. 2006).

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