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EDUCATION AND TRAINING OF FUTURE WETLAND SCIENTISTS AND MANAGERS

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Abstract: Wetland science emerged as a distinct discipline in the 1980s. In response, courses addressing various aspects of wetland science and management were developed by universities, government agencies, and private firms. Professional certification of wetland scientists began in the mid-1990s to provide confirmation of the quality of education and experience of persons involved in regulatory, management, restoration/construction, and research involving wetland resources. The education requirements for certification and the need for persons with specific wetland training to fill an increasing number of wetland-related positions identified a critical need to develop curriculum guidelines for an undergraduate wetland science and management major for potential accreditation by the Society of Wetland Scientists. That proposed major contains options directed toward either wetland science or management. Both options include required basic courses to meet the general education requirements of many universities, required upper-level specialized courses that address critical aspects of physical and biological sciences applicable to wetlands, and a minimum of four additional upper-level specialized courses that can be used to tailor a degree to students' interests. The program would be administered by an independent review board that would develop guidelines and evaluate university applications for accreditation. Students that complete the required coursework will fulfill the education requirements for professional wetland scientist certification and possess qualifications that make them attractive candidates for graduate school or entry-level positions in wetland science or management. Universities that offer this degree program could gain an advantage in recruiting highly qualified students with an interest in natural resources. Alternative means of educating established wetland scientists are likewise important, especially to provide specialized knowledge and experience or updates related to new management discoveries, policies, and regulations.

Key Words: accredited wetland science and management major, education, training

EVOLUTION OF WETLAND EDUCATION AND TRAINING

Wetland Science

Although research in fields of wetland science was evident in the first half of the twentieth century (Mitsch and Gosselink 2007:20), it did not become prominent until the last two decades of the century, when new environmental laws and recognition of the problems associated with loss of wetlands came to the forefront. Formation of the Society of Wetland Scientists (SWS) in 1980 promoted the evolution of ''wetland science'' as a distinct discipline. The aims of SWS include fostering conservation and understanding of wetlands; advancing public education and enlightenment concerning the World's wetland resources; providing a forum for interchange regarding wetlands; developing and encouraging wetland science as a distinct discipline by supporting student education, curriculum development, and research; encouraging and evaluating educational, scientific, and technological development and advancement of wetland science, and encouraging knowledgeable management of wetland resources. These aims suggest that education is a major driving force within the mission of SWS.

Wetland Education

An informal survey of past and present Associate Editors of *Wetlands* provided insights into wetland training at 25 academic institutions. The survey suggested that the roots of education and training in wetland science were found in wildlife biology

courses, especially those focusing on waterfowl management. However, those courses were typically directed at management of species and did not incorporate more complex topics such as interactions between biological and physical sciences. Courses with ''wetlands'' in the title began to appear in the late 1970s. By 1990, 12 such courses were being offered by those 25 universities. An additional 20 courses were first offered in the next decade, and six more courses were added through 2006. Several of those universities offer more than one wetlands course, and two schools subsequently dropped their course or folded it into a class with a broader focus. These figures are not intended to be comprehensive, but they provide insight into the evolution of academic training in wetland science. Most of the courses were described as popular, and although many universities still offer no specific wetland courses, the number of courses offered is increasing. Potential techniques for teaching wetland ecology in the classroom and field have also been described by practicing professors (e.g., O'Neal 1995, DeSteven 2000, Titus 2000, Baldwin 2001).

Regulatory and management concerns relating to wetlands also generated a need for specific training of environmental professionals. Agency-sponsored training courses appeared in the United States in the mid-1970s. The U.S. Army Corps of Engineers initiated training with the three-week, intensive ''Wetland Specialist'' course organized and taught by Richard Macomber, a key founder of the Society of Wetland Scientists (C. Newling, pers. comm.). Other courses were added in the early 1980s, including ''Wetland Science and Technology,'' ''Wetlands of the U.S.,'' ''Wetland Construction and Restoration,'' ''Wetland Executive,'' ''Wetland Soils and Hydrology,'' and ''Basic Wetland Delineation'' (Macomber 1981, C. Newling, pers. comm.). The U.S. Environmental Protection Agency also began to offer wetland training courses in the mid-1980s with assistance from the Corps of Engineers (C. Newling, pers. comm.). Federal agencies now collaborate to offer wetland training courses (e.g., http://www.pwrc.usgs.gov/wli/wettrain.htm, http://www.wli.nrcs.usda.gov/training/, http://el.erdcusace.army.mil/wetlands/wetlands.html), and some state agencies also offer training courses. Private wetland-training firms formed in response to the need for training and now also serve many agencies and individuals. Popular topics include wetland delineation, soils, hydrology, plant identification, construction, restoration, and regulatory policy (e.g., http://www.sws.org/training/, http://www.wetlandtraining.com/, http://www.wetland.org/educ_procourses.htm, http://www.richardchinn.com/).

Professional Certification

Several environmental professional organizations offer professional certification in their disciplines (e.g., Ecological Society of America, The Wildlife Society, Society of American Foresters) as a means of assuring prospective employers or contracting organizations that the certified scientists possess worthy credentials. Several states have wetland delineator certification programs (e.g., http://www.state.va.us/dpor/wet_reg.pdf, http://www.mnwetlands.umn.edu/cert, http://www.nhes.state.nh.us/elmi/licertoccs/wetlands.htm). However, a broader need for certification of wetland scientists was identified in the early 1990s.

The Society of Wetland Scientists Professional Certification Program (SWSPCP) was founded in 1994 and now serves as an independent, not-for-profit corporation that meets the needs of professional ecologists, hydrologists, soil scientists, educators, agency professionals, consultants, and other wetland scientists in demonstrating their qualifications to assess and manage wetland resources (http://www.wetlandcert.org). To receive Professional Wetland Scientist (PWS) certification, five years of professional experience specific to wetland science are required, and minimum academic standards at the collegiate level must be met. The required course work includes 15 semester hours each in appropriate biological and physical sciences, six semester hours in quantitative sciences, and 15 semester hours specific to wetlands, which may include equivalent short courses or continuing education credits based on semester credit equivalency (http://www.wetlandcert.org). Wetland Professional In Training (WPIT) designation is possible for scientists with at least a bachelors degree that meet most criteria for PWS but still require additional specific course work or professional experience.

AN ACCREDITED WETLAND SCIENCE AND MANAGEMENT MAJOR

The increasing need for well-trained professionals with strong credentials in wetland science and management suggests that there is also a critical need for an accredited major at the bachelors degree level to ensure that future students can receive the training needed for WPIT or PWS certification or to qualify for employment in government, academia, or the private sector. Other scientific organizations sponsor accreditation or approvals of majors in their specific disciplines (e.g., American Chemical Society, Society of Wood Science and Technology, Society of American Foresters). None, however, meet the needs of wetland science.

In February 2006, the Board of Directors of the Society of Wetland Scientists encouraged development of a draft curriculum that could serve as a foundation for an accredited undergraduate major in wetland science. The draft curriculum was based on the semester system widely used in the United States but with recognition that other equivalent systems could be adopted also. Several modifications were made to the original draft following input from numerous wetland scientists and students. Those modifications addressed issues such as 1) allowing sufficient credits to fulfill the general education requirements (e.g., history, arts, humanities, social science, language) of many universities; 2) changing some of the credit-hour requirements for basic required courses; 3) adding an independent study requirement; 4) adding more optional upper-level specialized courses; and 5) dividing the major into two options – wetland science and wetland management. Both options share many course requirements but diverge in some specialized courses. Both require a rounded education expected of most college graduates, a foundation in basic math and science, and a focus on communications. Other native languages could be substituted for ''English'' depending on the country in which the curriculum was offered, but technical writing would always be a requirement.

Wetland Science Option

This option (Table 1) is intended to produce graduates with a well-balanced understanding of wetland functional processes and underlying scientific principles. Students that complete this option should be well-prepared to undertake graduate education in many specialized fields of wetland science or to fill technical positions in research, government agencies, non-government organizations (NGOs), or consulting firms. Coupled with basic required courses, the specialized required courses move beyond the typical wildlife biology curriculum to ensure an understanding of both the physical and biological drivers of wetlands. The optional upper-level specialized courses allow students to focus on their personal area of interest. A key element in the curriculum is the required four-credit Wetland Independent Study, which should include in-field, problem-solving experiences. An example of a four-year course schedule that might be selected is shown in Table 2.

Wetland Management Option

This option (Table 3) is also intended to produce graduates with a balanced understanding of wetland

Table 1. Proposed curriculum requirements for the Wetland Science option of an accredited major in Wetland Science and Management.

Credits/Topic
A. The Basics (all required)
6 English (including technical writing)
3 Public Speaking
3 Environmental Policy/Management
9 Mathematics (entry + differential and integral calculus)
6 Statistics (intro. and applied biometrics)
12 Chemistry (general and one semester of organic)
4 Physics
4 Geology
11 Biology (general biology or botany/zoology;general ecology)
1 Senior Wetland Seminar
20–22 Electives to meet requirements in history, arts, humanities, social science, language
79–82 total
B. Upper Level Specialized Courses (all required)
3 Wetland Ecology
3 Aquatic Plants
3 Wildlife Ecology
3 Aquatic Invertebrates
3 Fisheries Biology or Ichthyology
3 Hydrology
3 Soils
3 Wetland Policy and Management
4 Wetland Independent Study
29–30 total (allowing for some lab credits)
C. Optional Upper Level Specialized Courses (4 required)*
3 Population Ecology
3 Community Ecology
3 Conservation Biology
3 Ornithology
3 Mammalogy
3 Herpetology
3 Algal Biology
3 Limnology
3 Freshwater Ecology
3 Marine Ecology
3 Restoration Ecology
3 Landscape Ecology
3 GIS/Remote Sensing
3 Biogeochemistry
3 Genetics
3 Specialized wetland courses (e.g., pocosins, peatlands, BLH, mangroves, salt marshes)
12 total
120–124 CURRICULUM TOTAL

*Additional courses could also be considered within the optional category.

Table 2. Example four-year course schedule for Wetland Science Option, with courses likely to cover university minimum general education requirements denoted by *.

Semester 1 (17 credit hours)	
3	English (basic technical writing)*
3	entry math*
4	General Chemistry I*
4	General Biology I
3	American History*
Semester 2 (17 credit hours)	
3	Differential Calculus
4	General Chemistry II
4	General Biology II
3	Western Civilization*
3	social science elective*
Semester 3 (17 credit hours)	
3	Integral Calculus
4	Organic Chemistry I
4	Physics
3	World Civilizations course*
3	arts elective*
Semester 4 (16 credit hours)	
4	Geology
3	General Ecology
3	Env. Policy and Management
3	humanities elective*
3	elective of choice
Semester 5 (16 credit hours)	
3	Statistics
3	Soils
3	Aquatic Plants
3	Wetland Policy and Management
4	Upper Level Optional Course
Semester 6 (16 credit hours)	
3	Biometrics
4	Wildlife Ecology
3	Hydrology
3	Upper Level Optional Course
3	elective of choice
Semester 7 (16 credit hours)	
3	English (advanced technical writing)
3	Wetland Ecology
3	Fisheries Biology
4	Upper Level Optional Course
3	elective of choice
Semester 8 (15 credit hours)	
3	Public Speaking
3	Aquatic Invertebrates
4	Upper Level Optional Course
4	Wetland Independent Study
1	Senior Wetland Seminar

Table 3. Proposed curriculum requirements for the Wetland Management option of an accredited major in Wetland Science and Management.

Credits/Topic	
A. The Basics (all required)	
6	English (including technical writing)
3	Public Speaking
3	Environmental Policy/Management
3	Economics
6	Mathematics (entry + intro. to calculus)
3	Statistics
8	Chemistry
4	Physics
4	Geology
11	Biology (general biology or botany/zoology; general ecology)
1	Senior Wetland Seminar
20–22	Electives to meet requirements in history, arts, humanities, social science, language
72–74 total	
B. Upper Level Specialized Courses (all required)	
3	Wetland Ecology
3	Aquatic Plants
3	Wildlife Ecology
3	Aquatic Invertebrates
3	Fisheries Biology or Ichthyology
3	Hydrology
3	Soils
3	Environmental Economics
3	Natural Resource Policy
3	Natural Resource Management
3	Wetland Policy and Management
4	Wetland Independent Study
37–38 total (allowing for some lab credits)	
C. Optional Upper Level Specialized Courses (4 required)*	
3	Population Ecology
3	Community Ecology
3	Conservation Biology
3	Freshwater Ecology
3	Marine Ecology
3	Restoration Ecology
3	Landscape Ecology
3	Wildlife Management
3	Fisheries Management
3	Water Resources Management
3	Invasive Species Management
3	Natural Resources Law
3	GIS/Remote Sensing
3	Natural Resources Sociology
3	Outdoor Recreation
12 total	
121–124 CURRICULUM TOTAL	

processes because effective managers must know how wetlands function. However, students that complete this option would take more course work in policy and management to prepare them for entry or mid-level operational positions in government, NGOs, or private firms. As with the Wetland Science Option, key components include blending of physical and biological sciences and the required four-credit Wetland Independent Study focusing on in-field problem solving. This option could be attractive to students with skills that extend beyond science and could serve as a strong preparation for developing wetland managers. Again, the optional upper-level specialized courses allow students to focus on their area of interest. An example of a four-year course schedule for this option is shown in Table 4.

Table 4. Example four-year course schedule for Wetland Management Option, with courses likely to cover university minimum general education requirements denoted by *.

Semester 1 (17 credit hours)	
3	English (basic technical writing)*
3	entry math*
4	General Chemistry I*
4	General Biology I
3	American History*
Semester 2 (17 credit hours)	
3	Intro. To Calculus
4	General Chemistry II
4	General Biology II
3	Western Civilization*
3	social science elective*
Semester 3 (16 credit hours)	
3	Economics
3	Env. Policy and Management
4	Physics
3	World Civilizations course*
3	arts elective*
Semester 4 (16 credit hours)	
3	Environmental Economics
4	Geology
3	General Ecology
3	humanities elective*
3	elective of choice
Semester 5 (16 credit hours)	
3	Natural Resource Management
3	Natural Resource Policy
3	Aquatic Plants
3	Soils
4	Upper Level Optional Course
Semester 6 (16 credit hours)	
3	Wetland Policy and Management
3	Statistics
3	Hydrology
4	Wildlife Ecology
3	Upper Level Optional Course
Semester 7 (16 credit hours)	
3	English (advanced technical writing)
3	Wetland Ecology
3	Fisheries Biology
4	Upper Level Optional Course
3	elective of choice
Semester 8 (15 credit hours)	
3	Public Speaking
3	Aquatic Invertebrates
4	Upper Level Optional Course
4	Wetland Independent Study
1	Senior Wetland Seminar

Recognition and Incentives

One ultimate goal of either option would be recognition by SWSPCP for PWS or WPIT certification. Completion of the required courses in either option should meet the certification requirements (H. Jones, pers. comm.). A second goal would be for local, state, provincial, or federal agencies to recognize that persons with an accredited wetland science and management degree meet their requirements for specific positions that are offered (both wetland and general natural resource positions). A tangential result could be that components of these curricula, especially the inclusion of physical sciences, may also become requirements in traditional wildlife biology and other natural resource majors. Finally, in the tight market in which universities are competing for the best-qualified applicants, a wetland major that spells out the specific course load could catch the interest of high school students with a strong interest in natural resources and thus help meet enrollment goals. As witnessed by the SWS jobs web site (http://www.sws.org/jobs/), there is a constant demand for persons to enter the wetland field. University administrators that recognize this opportunity and take advantage of it in advertising campaigns might attract highly motivated students with an inherent interest in natural resource sciences.

Implementation

Many universities will be unable to offer either the wetland science or wetland management option because their science majors are enveloped in liberal arts programs that require much broader generalized course work and do not allow enough credits to meet the requirements of this or any other accredited science major. I recognized this fact before beginning development of the curriculum. However, many specialized colleges and universities already have similar specialized majors. During the process of seeking input to modify requirements for the major, many participants commented that their university already

offered nearly every course required. Even if only a few colleges or universities in a geographic region chose to adopt this program, the goal of producing new, well-qualified wetland scientists and managers could be met. In addition, those schools could become regional magnets for the best-qualified applicants.

Implementation would require approval by SWS and establishment of an accreditation review board that operates as an independent organization to develop guidelines for the program and administer university applications for accreditation. The board would evaluate courses intended to fulfill requirements and use discretionary authority to make allowances for differences in approaches to teaching specific courses. Although universities may already offer many of the required courses, examination of the topics covered in sometimes broad-focused courses such as hydrology would ensure that students are exposed to the elements of the science most critical to wetlands. The board would also administer post-implementation surveys of students, faculty, universities, agencies, and various other employers that could be used to make modifications to the program as needed. As universities acquire the ability to provide the major, the option of seeking representation and support from the Association of Specialized and Professional Accreditors could be explored, and formal recognition of the accreditation program by the Council for Higher Education Accreditation could be pursued, although this is not a common practice among professional scientific societies (C. Davenport, Association of Specialized and Professional Accreditors, pers. comm.; J. Watkins, Council for Higher Education Accreditation, pers. comm.; Terry Clark, Society of American Foresters, pers. comm.).

ALTERNATIVE EDUCATION OPPORTUNITIES

Classroom education cannot address all components required to produce the scientists that will carry wetland science into the future or the managers to whom we will entrust the resources of the future. Instinct developed by being in the field as a child, teenager, college student, or graduate can play a role in understanding or managing the resource. Therefore, alternative opportunities should also be encouraged. Formal mentoring from well-qualified wetland scientists and managers or formal internship programs could provide recent graduates with practical experience. Agencies that incorporated internships into their programs (with funding) could reap the benefits of both the accredited wetland science and management major and the personal knowledge handed down to future employees by their mentors. Such internships might also be sponsored by granting organizations, such as the National Science Foundation.

If an accredited wetland science and management major becomes a reality and is implemented by enough universities to provide an adequate supply of well-trained candidates for scientific and management positions, the process will likely take at least a decade to meet those needs. Many currently practicing wetland managers lack the rigorous formal training in wetland science that is proposed here, especially process-based physical science, and some have had few opportunities to collaborate with scientists regarding management decisions. Innate capabilities and experiences in the field may have served them well in decision-making (L. Fredrickson, pers. comm.); however, examples abound in which management decisions created environmental problems that might have been avoided with appropriate scientific input (see examples in Smith et al. 2008). A strategy is needed to improve contacts and collaborations among existing wetland managers and wetland scientists and to bridge the gap in time until new managers with a stronger wetland science background become available.

Individual wetland scientists and managers may take personal initiatives to create collaborations, as in the past, but more organized efforts would likely achieve better results. An open invitation to scientists to use managed wetlands as study sites for research that is not specifically related to management could result in interactions that ultimately focus on management questions also. Alternatively, inquiries made by scientists could also identify important management challenges that require research attention. Current managers typically receive training in workshops that address many topics, including supervision and specific management practices. In the U.S., the National Conservation Training Center in Sheperdstown, West Virginia operates to present this specific type of training. Training could be supplemented with a series of agency-sponsored workshops in which wetland scientists provide managers with abbreviated training in relevant aspects of the course work proposed in the wetland science option or on scientific approaches to specific management problems. Efforts could also be made to attract wetland managers to meetings of scientific societies, such as SWS. A regular series of workshops or invited symposia at annual meetings, with a focus on science in managed wetlands, could attract managers from

at least the regions in which the meetings are held. Buy-in and encouragement from agency administrators would enhance this opportunity. Wetland scientists could also make greater efforts to attend meetings that are typically attended by managers.

Finally, because scientific knowledge changes with each new discovery and regulatory policies change, continuing education in the form of refresher courses, specialized training, and workshops or specialized symposia at scientific meetings should be on everyone's agenda, including those who complete an accredited major. Continuation of these efforts (including monetary support) and participation in them by new and old wetland practitioners is a necessity to meet the goal of having educated wetland scientists studying and managing the resources and, ultimately, having a positive influence on the quality, functions, and values of the wetlands.

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