

Changing academic culture: interdisciplinary, science-based graduate programmes to meet environmental challenges in freshwater ecosystems

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Listening in on the easy private banter of scientists, one hears deprecation of the politicians who run this world and wishful claims for the rationality of science. If only the scientific approach were applied to the way countries are governed, it is supposed, the world's problems would vanish. . . . Confused, even hurt, by the complexity of the world they live in, scientists reach naively for the dream that the wild universe of emotions and collective actions is governed by some rational principles, still to be discovered (Hoffman, 1990).

INTRODUCTION

Traditional graduate programmes in the life sciences are challenged by the accelerating pace of environmental degradation, the expanding role of information technology, and the increasing complexity of society. This scenario requires that we produce young ecologists who are not only technically proficient, but also adaptable to these increasing rates of change (Greene *et al.*, 1995; National Academy of Sciences, 1995; National Research Council, 1996). Accordingly, there is a need to provide ecologists with interdisciplinary skills, not only in the science of ecology but also in areas such as management, policy and environmental outreach—at the very least to provide training in how to create and work within interdisciplinary partnerships.

Twenty senior ecologists recently described ecology as a discipline with a time limit, because much of what we study (and upon which society is dependent) is fast disappearing (Bazzaz *et al.*, 1998). These authors contend that ecologists have a responsibility to humanity, one that we are not adequately meeting. They urge senior scientists to take the lead in pressing for transformation and they pledge themselves to that task. Likewise, Lubchenco (1998) proposed a new 'social contract for science' which calls for a commitment on the part of all scientists to devote their energies and talents to the most pressing problems of the day, in proportion to their importance, in exchange for public funding. This paper focuses on how changes in academic culture and graduate training in the environmental sciences can help us fulfil the goals of this new social contract for science.

In this era of global environmental change and deterioration, there are many challenges and opportunities for scientists to provide useful science (National Research Council, 1996; Lubchenco, 1998), and educational programmes/tools that can be used to guide citizens, managers and policy-makers in the

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decision-making process (Pringle *et al.*, 1993a, 1999; Bjorkland *et al.*, 1997, 1998; Firth, 1998; Natural Resources Conservation Service, 1999). There is also a critical need to communicate better the scientific information that is already in hand, given that many current environmental policies are based on the science of past decades not the 1990s (Lubchenco, 1998). It might be argued that someone approaching the field of environmental outreach might be best served through a degree in education. However, my premise here is that graduate students with strong scientific backgrounds can play a unique and effective role in communicating complex scientific issues (see Case Studies I and II below). While environmental outreach and education has been traditionally characterized as 'soft' by the scientific community, our global future depends on effective communication of multiple and complex environmental issues. The two case studies presented here describe initiatives that have been developed through the University of Georgia Institute of Ecology's graduate masters programme in Conservation and Sustainable Development: (1) the Upper Etowah Basin Initiative, which involves partnerships for science-based riverine protection policies in the Georgia Piedmont, USA; and (2) *Water-for-Life*, a community-based environmental outreach programme in Sarapiquí, Costa Rica.

CASE STUDY I: THE UPPER ETOWAH BASIN INITIATIVE, GEORGIA, USA

A partnership between stakeholders in the Upper Etowah River Basin and the graduate conservation programme at the University of Georgia's Institute of Ecology has facilitated the adoption of a variety of innovative stream protection policies based on ecological research. This initiative focuses on the upper Etowah River in northern Georgia because it is a hotspot of biodiversity which is imperiled by the rapid growth of metropolitan Atlanta. The river historically contained at least 82 native species of fish and as many as 50 species of mussels. The present fish fauna includes three federally protected species, two of which are endemic to the Etowah and which were listed under the Endangered Species Act in the last 5 years. The five counties that lie within the catchment were historically rural with many small communities and few large cities. Over the past decade, however, population growth rate per annum in these counties has ranged between 24 and 27%. This rapid growth has increased societal concern for water quality and biotic integrity. County and municipal government officials are struggling to balance the demands of urbanization with environmentally sustainable approaches and with the preservation of the natural character that makes the area a desirable place to live.

The Etowah Initiative was prompted by two factors: (1) an increase in sedimentation and erosion in the basin; and (2) multiple requests from government agencies and conservation organizations who approached the University of Georgia in 1997 for assistance in developing scientifically and legally defensible environmental controls. The Institute of Ecology and the School of Law quickly mobilized to provide an interdisciplinary forum, called the Etowah Initiative, for graduate students and faculty to apply skills learned in the classroom to challenges identified by citizens and/or stakeholders in the Etowah Basin. Objectives of the Etowah Initiative are to: (1) provide an educational environment where students can apply skills learned in the classroom to community problems; (2) provide an opportunity for students and faculty to work with other disciplines in integrated environmental decision-making and problem-solving; and (3) increase awareness of the importance of addressing environmental issues proactively within the University and broader community.

The foundation of the Etowah Initiative is a graduate course that is cross-listed between the Institute of Ecology and the School of Law. This course admits up to 10 law and 10 graduate ecology and environmental design students each semester. An environmental attorney (L. Fowler) coordinates the course and brings in lecturers from a variety of different disciplines, as well as environmental professionals, to address issues relating to that semester's topics. Graduate students in ecology who are involved in drafting science-based guidelines for aquatic systems protection take rigorous science courses

(e.g. limnology, hydrology, fluvial geomorphology, aquatic entomology) and are advised by interdisciplinary committees.

The students work in groups to address various projects identified by stakeholders in the basin. For example, two law students and an ecology student drafted a conservation subdivision ordinance for Cherokee County, Georgia, which allows cluster development of residences in order to protect critical natural areas in perpetuity (Bergstedt *et al.*, 1999). This ordinance was adopted unanimously and is already protecting many kilometres of riverfront property. Graduate students also made recommendations for establishing a system of Transferable Development Rights (TDRs) to preserve critical environmental areas, including riparian buffers and wetlands (Bledsoe *et al.*, 1998). Legislation based on these recommendations was passed by the Georgia legislature in 1998. Another project, which involved two ecology students and a law student, focused on drafting science-based guidelines for a new wetland mitigation programme in Georgia, the Georgia Wetlands Trust. Graduate students helped develop a legally sound mechanism for transferring wetland property or development rights to land trusts or other partners (Cox *et al.*, 1998) and the programme's first mitigation project is taking place in the Etowah Basin. In some instances, graduate students develop their masters thesis projects based on work inspired by the Etowah Initiative, such as the development of science-based riparian buffer protection policies (Wenger, 1999). Students are also involved in the development of outreach tools to help stakeholders understand the biology of riverine ecosystems and the role of riparian zones in the ecology of both aquatic and terrestrial systems. This unique partnership between graduate students (in both law and science) and stakeholders has enabled local governments to take bold steps to protect the Etowah River. Other sustainable development and ecosystem protection projects include development of guidelines for establishment of a Greenway for Cherokee County, an Aquatic Safe Harbor Program, water efficiency programmes, and environmental planning criteria compliance. Pollution prevention projects include drafting guidelines for poultry waste management, septic system impacts and management, stormwater management, and total maximum daily load recommendations. All of these graduate student-stakeholder projects are available on the internet at <http://www.ecology.uga.edu/outreach/home.htm>. Each class has culminated in a presentation of findings to stakeholders. Following such presentations, stakeholders have offered a new round of needs which have, in turn, provided the foundation for the next cycle of student projects.

CASE STUDY II: COMMUNITY-BASED ENVIRONMENTAL OUTREACH *WATER-FOR-LIFE* PROGRAMME IN PUERTO VIEJO DE SARAPIQUI, COSTA RICA

Graduate students at the University of Georgia's Institute of Ecology have been working with the Organization for Tropical Studies (OTS) and high-school teachers to develop an environmental outreach programme, *Water-for-Life*, which focuses on water quality and quantity issues faced by communities of the Caribbean lowlands of Costa Rica. OTS is a nonprofit consortium of ~56 universities and other academic institutions in the USA and the Commonwealth of Puerto Rico (of which the University of Georgia is a member) whose goal is to promote tropical education and research. The consortium has three main field stations in Costa Rica and the environmental outreach programme on which this case study focuses was initiated at La Selva Biological Station in the Caribbean lowlands.

Water-for-Life was developed specifically in response to water resource problems faced by the local community of Puerto Viejo de Sarapaqui (population 10000) which is located just 5 km from OTS's La Selva Biological Station at the juncture of the Sarapiqui and Puerto Viejo Rivers. The town has experienced explosive population growth over the last decade as a result of the development of extensive banana plantations (Pringle and Scatena, 1999). This growth has placed extreme demands on the municipality, and water quality and supply issues promise to become even more significant in the coming

years. Local surface waters and groundwaters have become contaminated by faecal coliforms (introduced by livestock and domestic sewage), pesticides, and herbicides from the banana plantations (Vargas, 1995; Laidlaw, 1996; Pringle, 1997; Pringle and Scatena, 1999). While the region receives ~ 4 m of rainfall per year, aquifers are surficial and therefore vulnerable to contamination by agricultural and urban activities.

The sheer magnitude of deterioration of water resources in the Puerto Viejo-La Selva region led to the initiation of environmental outreach activities on water quality and water protection in the early 1990s by faculty and graduate students from the University of Georgia's Institute of Ecology (working at La Selva Biological Station) and local educators and leaders in Puerto Viejo. The programme grew out of a science-based research programme at La Selva Biological Station (funded by the National Science Foundation) on ecological processes and how they are affected by physical and chemical properties of streams (e.g. Pringle and Triska, 1991; Pringle *et al.*, 1993b). The involvement of Costa Rican nationals (two which were involved as graduate students from the University of Georgia) has been the key to the success of the programme to date. An ongoing challenge to the continuity of the programme has been the relatively high turnover of local educators in Puerto Viejo, OTS community outreach staff at La Selva, and graduate students.

To date, three masters students from the University of Georgia have completed theses associated with *Water-for-Life* (Vargas, 1995; Laidlaw, 1996; Pohlman, 1998) and two more theses are in progress. OTS has begun to provide much needed infrastructural support for the programme and now offers fellowship opportunities in environmental outreach for graduate students from OTS member institutions in both Costa Rica and the USA (<http://www.ots.duke.edu>). Environmental outreach tools/products resulting from the programme include:

1. slide show presentations, designed for high-school students and adults (Vargas, 1995), that describe the history of municipal water resources in Sarapiquí Province and threats to water resources;
2. development (and dissemination to local communities) of three outreach posters designed to show the importance of intact riparian zones, the dependence of local communities on forested watersheds in the highlands for potable water supplies, and the importance of river corridors for migrating biota, respectively (Vargas, 1995; Pohlman, 1998; <http://www.arches.uga.edu/~cpringle/wflproducts.html>);
3. development and implementation of a volunteer stream monitoring programme (Adopt-a-Stream) in a local high school accompanied by the development of a manual in Spanish and English which provides details on how to initiate volunteer stream monitoring programmes, the sampling methodology to follow, and data interpretation (Laidlaw, 1996; Pringle, 1997);
4. development of teaching materials (study guide) for local high-school teachers on stream protection and water quality (Pohlman, 1998).

Projects underway include: the development of an environmental outreach website on water quality and quantity issues for local high schools in Costa Rica; an investigation of the location and cumulative effects of 19 hydroprojects (planned and existing) in the Sarapiquí region; and expansion of *Water-for-Life* to communities adjacent to other OTS field stations. This partnership between graduate students in ecology, OTS, and local communities has been successful in promoting public awareness about aquatic resources and providing ecology graduate students with skills in environmental outreach and in initiating and maintaining effective partnerships.

CONCLUDING REMARKS

As we enter the next millennium, it is clear that water for ecosystem preservation will become an increasingly important socio-political issue (e.g. Biswas, 1998; Gleick, 1998; Pringle, in press). Humans have already appropriated half of the accessible global freshwater run-off and conservative estimates

indicate that this appropriation could climb to 70% by the year 2025 (Postel *et al.*, 1996), with consequently less water available for the maintenance of ecological values and ecosystem services. Global water requirements have increased by almost 10-fold during the 20th century (Biswas, 1998) and this high growth rate in water use cannot be maintained throughout the 21st century. The two case studies presented in this paper illustrate how graduate programmes can train students to address effectively these environmental challenges in freshwater ecosystems. Both case studies involve graduate programme initiatives that include: buy-in from local leadership; public involvement; and 'free' research and outreach products that are focused on key issues of socio-economic importance. While these programmes have been successful in the short time frames of their existence, their long-term success is dependent on maintaining effective partnerships (in this case the continuity of academic and stakeholder involvement).

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