American Ecological Engineering Society

Technical Notes

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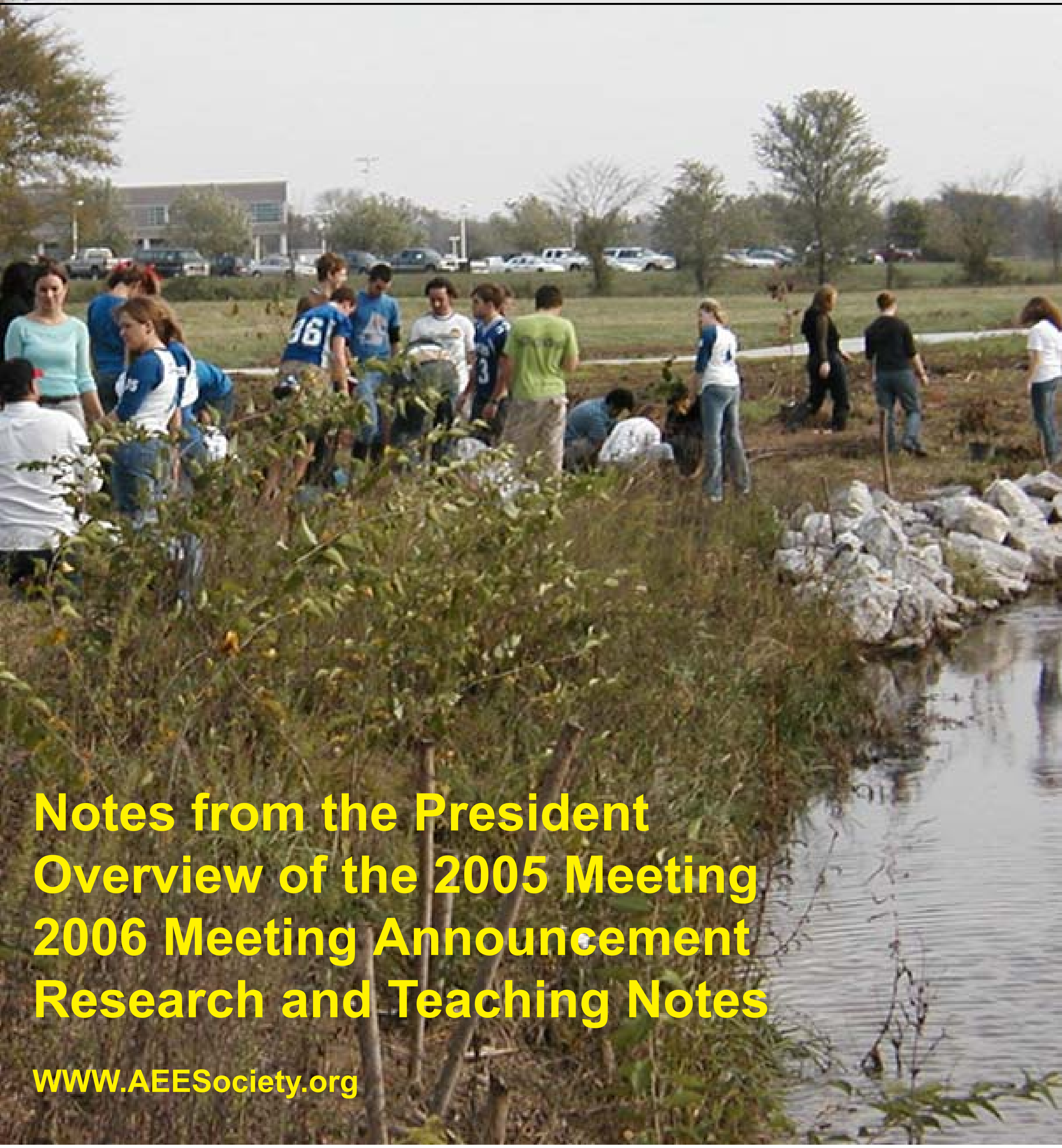

Notes from the President
Overview of the 2005 Meeting
2006 Meeting Announcement
Research and Teaching Notes

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American Ecological Engineering Society

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Volume 2, Issue 1 www.aeesociety.org Summer/Fall 2005

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AEES Technical Notes is a forum for exchange of technical information, knowledge, experience, and ideas related to the science and practice of ecological engineering. The articles are solicited and reviewed by the editorial board. Contact the Editor if you have an idea or article you would like to submit.

Cover Photo: Stream restoration riparian planting at Blossom Branch, Rogers, Arkansas, by Robert Morgan. Photo taken Fall 2004.

In This Issue…

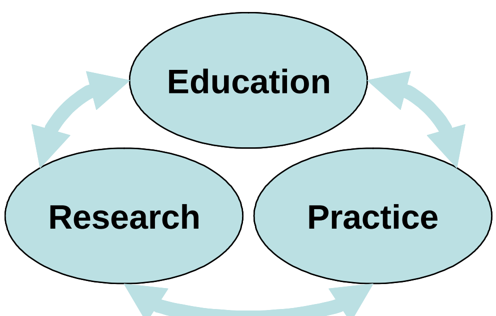
AEES TECHNICAL NOTES

Volume 2, Issue 1 www.aeesociety.org Summer/Fall 2005

Notes from The President

Looking Ahead for the American Ecological Engineering Society in 2005-2006

Since the 2000-2001 creation of the American Ecological Engineering Society (AEES) we have developed rigorous strengths in at least three areas—education, practice, and research. Developments in research over the past decade or two have been sufficient to develop the scientific discipline of ecological engineering and support the pioneering journal, *Ecological Engineering*. Development of outstanding ecological engineering curriculum at several universities was necessary to support the outstanding research.



More recently practitioners of ecological engineering have developed the confidence to take on a broad range of restoration projects. These range from the restoration of the Mississippi River delta to prevent future flooding of the U.S. Gulf Coast, restoration of the Delaware Estuary, to small scale wetland restorations. Our practice in ecological engineering of terrestrial ecosystems is not so advanced.

Having achieved some parity in practice, education, and research, ecological engineering seems to be ready for more rapid, synergistic growth as a scientific discipline and steady growth to a new engineering discipline. Based on these strengths, I propose the following goals for the society:

- Develop a more coherent body of knowledge—theory and science of ecological engineering
- Expand the practice of ecological engineering, especially for terrestrial systems and into design and not just restoration
- Continue development of curricula and outstanding educational programs
- Grow in numbers and influence with more local organization and service
- Recognize excellence in ecological engineering through a series of awards
- Function as an excellent volunteer professional organization in the organization of committees and service projects

Incoming President Steve McCutcheon congratulates Alex Horne, outgoing President, on a job well done.

The body of ecological engineering knowledge is vital to attain several Society objectives. This body of repeatable knowledge is the basis of the scientific discipline, and is largely captured by publication in *Ecological Engineering* and a few other journals. Since 1992, *Ecological Engineering* has experienced steady growth in number and quality of papers published and can now be considered the definitive journal of the field. How fast and with what synergy the diverse body of knowledge develops controls the extent of practice and how fast practice develops.

The growth of practice controls the development of a new engineering discipline unlike any others we have so far. For the first time it is feasible to forecast that future engineers can serve and protect both the ecosystem and humankind on equal terms. Perhaps for the first time in an engineering discipline, ecological engineering can establish a diverse science basis continuously using dynamic, holistic synthesis of the body of knowledge.

For now, we may concentrate on wetland ecosystem restoration and design but this must be done based on the general principles of science and not heuristically. As soon as the practice of terrestrial ecological engineering can be better formulated, we will need the general principles to extrapolate advances from one system to the other, and then synergistically with other ecosystems.

In the practice of ecological engineering, we are generally a group of self-taught maestros who mostly design heuristically. But we need optimized designs for aquatic and terrestrial problem solving. We especially need to fit ecological engineering into hazardous waste site management and soil and other terrestrial resource management. These fields have vital bodies of knowledge like environmental engineering and agro and forest ecology that should be integrated into the science basis for ecological engineering. This synthesis will strengthen ecological engineering as a discipline and allow us to take a leadership role in how to serve the ecosystem and human needs in a balanced fashion.

The advancement of practice necessarily requires forecasting tools, including some models are necessary to minimally design performance consistent with reasonable expectations of self-design by ecosystems. Understanding self-design is the key to some forms of sustainable development. To magnify our practical efforts and make a coherent curriculum possible, we need to think in terms of design guidance to magnify our efforts domestically and internationally. We further must begin to think of the business of ecological engineering to ensure jobs for the great students we train. Because business relies on intellectual expertise and properties of different kinds, this Society must ensure professional registrations and certifications to allow practice to develop. At first, registration and certification by other organizations are necessary, but within the decade AEES must think about state registrations as ecological engineers, and before those registrations begin, certifications of different types of ecological engineers. Throughout this process, dynamic feedback to curricula development is vital for the growth of our discipline.

Education is no less or no more important than research and practice, but shares a vital role in modern societies across the globe. Whether driven by the desire to provide a basis for practice, scientific curiosity, or a desire to establish a body of knowledge to be taught, the research scientists need a dynamic dialog with educators and practitioners. To exist in a more dynamic discipline that strives to better integrate science and practice than any other engineering discipline, curricula must not only provide liberal breadth but also design concentration. These powerful tensions between breath and concentration will necessitate a number of healthy educational debates that must be open to all. For example, will a four or five-year entrance degree be necessary to practice? Above all, we must introduce to all students the need for rigor in research, education, and practice and the need for ethics in practice, education, and research.

To build on these strengths as a Society, we must not forget a few organizational fundamentals. We started with over 200 Charter members but had fallen to less than 100 members last year. To be sustainable we probably need to double or triple membership in 2005-2006 or the near future. Key to this is insuring our great students remain involved in the Society! We could use local chapters and follow up contacts as our students enter practice or research. With many students going to work for the Army Corps of Engineers, these are ideal concentrations for local chapters. Taiwan is an ideal area for international growth as are other countries. Local chapters could also focus on developing a coherent practice and feedback to academic and research programs.

We need awards to recognize excellence in practice, research, and teaching to be fully sustainable and then to grow to influence societies worldwide. At the same time, naming of awards recognizes our roots and history of excellence. But any awards need to be carefully set up with permanent endowments. We could co-sponsor some awards to get started and have been offered this opportunity.

To grow we must have operational AEES committees and an active Board. Committee efforts are vital for sustaining inclusiveness and growth and committees are a vital means of communication and developing a profession. The best approach is that each member must empower themselves to pursue objectives for AEES and guide the Board.

Steven C. McCutcheon, Ph.D., P.E., D.WRE
President of the American Ecological Engineering Society
Faculty of Engineering
Driftmier Engineering Center
University of Georgia
Athens, Georgia 30602
Tele (706) 542-1455
Fax (706) 542-8806
StevenMc@uga.edu

Overview of 2005 Meeting at The Ohio State University, Columbus, Ohio

The Fifth Annual American Ecological Engineering Society (AEES) Conference was held at the Ohio State University in Columbus, Ohio from May 18-20, 2005. The theme of the AEES Conference was "Restoration and Design of Ecosystems." There was an enthusiastic turnout for the conference, with over 100 attendees, encompassing a mixture of educators, students and practicing ecological engineers.

The Olentangy River Wetland Research Park at The Ohio State University.

The conference began with a moving Plenary by Dr. William J. Mitsch, entitled "Applying Science to Conservation and Restoration of the World's Wetlands." During the two-day conference, over 40 oral presentations and 35 poster presentations were given in ten technical sessions. For the first time at an AEES conference, there was a panel discussion entitled 'Practicing Ecological Engineers.' During this session, five practicing Ecological Engineers shared their experiences and insight with students and educators about the 'real world' of Ecological Engineering.

There were also many light-hearted moments at the conference, including the much anticipated wetland song "Fixing the Planet on a Budget" by the AEES President, Alex Horne. There was a social at the Olentangy River Wetland Research Park with a welcome by Dr. Karen Holbrook, President of the Ohio State University. There were also field trips, which gave the attendees insight into the Ecological Engineering research being pursued on the Ohio State University campus. These field trips

Field trip to a dairy waste treatment system using ecological engineering principles.

included a canoe trip down the Olentangy River, a tour of the Olentangy River Wetland Research Park, and a trip to an ecological treatment system for agricultural wastewater.

This year's conference wrapped up with a half-day seminar, entitled "Advancing the Field of Ecological Engineering." This round-table discussion engaged professors, practicing engineers, and students in forward-thinking discussions. This year's conference was a success due to the hard work and dedication of the planning committee. There were many first-time attendees at the conference, and the planning committee developed a schedule with a variety of venues and activities, which worked to promote unique exchanges between the conference attendees.

Workshop participants debate how to advance the field of Ecological Engineering.

The planning committee included the incredibly helpful student-run Ohio State Ecological Engineering Society and professors from the Ohio State University, Dr. Jay Martin, Dr. Tim Granata, Dr. William Mitsch, and Dr. Li Zhang. The 6th Annual American Ecological Engineering Society Conference is planned for Berkley, California. We hope to see you all there!

Stephanie Lansing
President, Ohio State Ecological Engineering Society - lansing.10@osu.edu

Hobnobbing at the AEES 2005 mixer in Columbus, OH.

Former President and Journal Editor Bill Mitsch and Christina Toms debate wetland design.

"Now, that there is wet, and it's land, so I think it's a wetland!"

Being ecological engineers makes us happy!

A gaggle of Ecological Engineers out standing in their field.

2005 American Ecological Engineering Society Meeting
The Ohio State University, Columbus, Ohio

Past President's Reflections

The society was definitely fired up at the last meeting, I felt an energy in both the audience and the incoming president at Ohio. Possibly it was the synergy of the campus home to Bill Mitch and his impressive colleagues but also the feeling that we are onto something with Ecological Engineering. Even my campus here at Berkeley is feeling the energy and this summer the Department of Civil & Environmental Engineering at the University of California will advertise for a replacement for my position. The ad will be for either an Ecological Engineer or a Water Resources Engineer so it is not a slam dunk for the ecological position. Please apply if you like the West Coast. Also it looks like we will be having our next annual meeting at Berkeley, as requested by the society last time. Berkeley is a great school but not the ideal site for a conference in term time so be prepared for some walking around in the April sun!

I was thinking about how the synergies of Ecological Engineering are not yet fully focused. Our Friday meeting last year at the end of the conference articulated some of these concerns in that crowded room close to the famous kidney wetlands of The Ohio University. One reason may be that we do not have a hit TV sitcom based on our field. You know a kind of "Friends" or "Dallas" where the leading male and female are in rival Ecological Engineering firms where one emphasizes solar-powered desalination for the water problems on the Florida and Californian coasts and the other firm pushes constructed wetlands to provide water via reuse. If you remember Dallas, the oil business seemed mostly about jealousy and questionably legal deals so I don't think our Hollywood or New York script writers would need much more Ecological Engineering that to add "sustainable" to the deals.

Ebro River Reflections. Talking about synergies, I have just completed a manuscript on the Ebro River water diversion scheme on the Spanish Mediterranean Coast. Just like Florida and California, this region has become the "Sun Belt" for Europe similar to the US version and for the same reasons of low cost and nice winter weather. The Spanish Government originally tried to move a bit less than a million acre feet (~ 1×10^9 m^3) annually from the relatively wet north to the arid south. Just like we do in California! However, hundreds of thousands of protestors on the streets gave the government pause. They asked me to put together a team of 6 engineers and scientists to review the approximately €3 billion (~ $4 billion) Ebro section of the Spanish Hydrological Plan. This I did and found the usual hydrologic plan of moving a fixed amount of water from site to site in the most economic fashion and avoiding natural resources damage. We looked at the 910 km long pipeline route, the Ebro River, its delta, and the southwestern coast of Spain that was the destination of most of the water. There were the usual hydrological arguments about how much water was in the river, was it going down with climate change, objections to more dams on the river and so on. On the ecological side, the Ebro River is not in good shape. Its beautiful sturgeon that grew up to 16 feet long and weighed half a ton was extinct, the many reservoirs had cut off the sediment supply needed to maintain the delta, and both nutrients and toxic pollution were present pretty much everywhere from farms, sewage treatment plants, and industry. That is the usual sad story in countries coming out from authoritarian regimes and with limited economic resources.

But … Ecological Engineering to the rescue! We decided to accept the kinds of environmental criticism and more than compensate for them by producing a new plan entitled "A Restoration and Enhancement Plan for the Sustainable Ecology and Agriculture for the Spanish Mediterranean". It elevated ecology to at least a co-equal with water need. We decided to make the re-introduction of the Ebro sturgeon the flagship for the restoration that would be paid for by a 10% tax on the diverted water. To get the sturgeon back would require a cleanup of the river, modification or elimination of dams with no new ones needed. We also proposed to restore the wetlands all along the Mediterranean Coast where anoxic pools caused by eutrophication from nitrate draining from rice farms were threatening large bird migrations. In order to make financial sense, the cleanup we proposed made extensive use of wetlands to polish domestic and industrial waste and to remove nitrate from the rice and other farmlands that dominate much of the valley. Our plan proposed to modify the existing dams to get sediment back to the delta. We also planned to expand the wetlands in the delta on a 20 year rotating basis to build up peat that could then be farmed and used up again.

Well, it sounded good but it was a case of too much too late. After some hesitation the revised plan was accepted by both the EU and the Spanish Government. Unfortunately, our revised plan was less acceptable to the opponents of the original plan. In a 12-city TV hookup and an Iberian Peninsula conference in Berkeley we received grudging acknowledgement from biologists that at least we tried to improve the river. However, we made no converts from the opposition in terms of going ahead with the revised Plan. Both the local government in a main area to receive the diverted water and the central Spanish government of President Aznar at the time had made the Ebro Plan a main plank in their agenda and election campaigns. Their opponents opposed the Ebro Plan. Both incumbent parties lost elections in 2003-4 and their winning opponents of President Zapatero cancelled the Ebro plan, revised or not in June 2004. However, little of no money was saved since the new plan which relies on costly and power-demanding desalination is estimated at €3.7 million for many small local schemes. Ironically, there are now protests by environmental groups focusing on preventing the huge electric pylons that will be required to bring electric power for desalination from France along the same path as was proposed for the Ebro water diversion. This summer (2005) there have been huge droughts in the region and the solution is as far away as ever. Meanwhile the magnificent Ebro sturgeon remains extinct!

Much of this work was covered in principle by others at last April's AEES meeting only the Mississippi was then the focus. If only that work had been a done a decade ago we would not have the same flood problems in New Orleans and would have an example to show other countries. Anyone for writing or starring in the new Ecological Engineering TV series, "Pollution Busters" or the "The Sustainable Ones?" Also apply for the new Ecological Engineering faculty position at Berkeley in case you fail the casting.

Finally, I have visited China four times this year spreading the word of Ecological Engineering – in this case via "Wetlands Parks" that are in vogue there. These wetlands are viewed as aesthetic and beautiful only. That's not a bad idea but in several lectures in Shanghai, Beijing and Yangzhou I tried to indicate that these wetlands could treat waste and harbor lots of wildlife as well as look gorgeous. The first wetland we have designed in China is for an industrial wetland where the conventional plant effluent has high refractory COD and ammonia. With my UCB collegue Professor Slav Slav Hermanowicz we envisage using a biotower (up to date trickling filter for us old folks) to nitrify and the wetland for the rest of the cleanup. We think we might need a novel shallow open water area where the high DO, high UV and warm water should break some of the refractory bonds on the COD components. I have been very impressed by the common sense in conventional sanitary engineering in China and also by the speed they accept new ideas such as Ecological Engineering and then apply them rapidly. Now I know what it must have been like in Civil Engineering in Victorian England or 19th Century America. There are lots of openings in China for new outside engineers.

Alex Horne, Past President 2004-05, AEES
Ecological Engineering Group (Retired),
Dept. Civil & Environmental Engineering
University of California, Berkeley CA

Ecological Engineering Program Started at Virginia Polytechnic Institute

The Department of Biological Systems Engineering at Virginia Polytechnic Institute and State University is developing a graduate program in Ecological Engineering. Dr. Cully Hession recently joined their faculty from the University of Vermont, joining fellow ecological engineering faculty Tess Wynn, Mary Leigh Wolfe, and Theo Dillaha III. Their web page is found at: http://www.bse.vt.edu/BSE_Dept/index.php.

A Student Design Competition is in the Works!

Planning is underway to develop a student design competition in ecological engineering. Preliminary discussions took place at the 2005 ASAE meetings in Tampa with participation by Cady Engler, David Gattie, Stacy Hutchinson, Pat Kangas, Jay Martin, Scott Osborn and David Tilley. The initial thinking is to pattern the AEES competition after existing models (such as the ASAE tractor design and fountain wars events, the solar car competition, etc.), but with modifications related to the field of ecological engineering. If successful, the design competition will encourage student involvement and contribute towards professional development in ecological engineering. The proposal will be reviewed by the AEES Executive Committee and, hopefully, a trial can be held at the 2006 annual meetings in California.

2006 AEES Meeting: Efficient Sustainability in a Dry Land

The Program Chair for the 6th Annual Meeting of the American Ecological Engineering Society is Dr. Alex Horne, Past-President of AEES. Members Christina Toms and Nicole West will coordinate meeting details.

The 2006 annual meeting of the AEES will be held on the University of California Berkeley Campus on 13-14th April 2006 (Thursday-Friday). If there is sufficient interest, pre and post conference trips to sites of Ecological Engineering interest are planned for the 12th & 15-16th among the winery wetlands of Northern California including Napa Valley (14th) and the wetlands and lakes of the high Sierra Nevada around Lake Tahoe (15-16th) where skiing and its effects can be sampled. Full registration details will soon be available on the AEES web site (AEES.org).

We in California are proud to host the first AEES meeting in the West and so would like to give it a western flavor. We do have floods but out here in the semi-desert we usually have water shortages. That occasional westerner, Mark Twain said "Whisky is for drinking; water's for fighting" or something like that. As the population expands we need more efficient use of the water we have.

This is especially true for constructed treatment wetlands. While in this dry land any wetlands are valuable because they are rare, we do not have the luxury of creating them at will. Attendees to the 6th annual meeting are invited to present papers in this general area as well as any other in the field of Ecological Engineering. Some suggestions are:

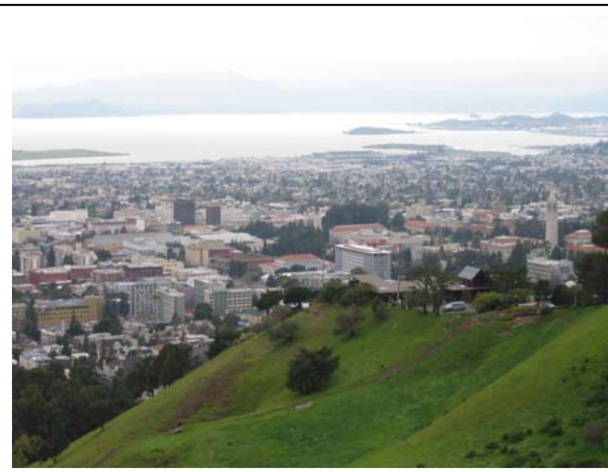
1. Ecological Engineering in dry climates
2. Modeling sustainable pollution control
3. The Mississippi Mess - progress since the last conference
4. Sustainable nitrogen & phosphorus removal
5. Wildlife and Aesthetics in wetlands design
6. River Restoration Projects
7. Other topics of interest to our members

Contact Christina Toms with proposed sessions at christina@swampthing.org.

PROVISIONAL PROGRAM

Time	**Event**
Wednesday 12 April	**Field trips**
8:00 – 5:00	Lodi & Napa Valley Winery Treatment Wetlands & local wineries
7-10 pm	Pre-meeting Social
Thursday 13 April	
8:15-5:00	Welcome, Plenary & contributed sessions
5:00-5:45	AEES Business Meeting
5:45-7:00	Social hour
Evening	TBA
Friday 14 April	
8:30-3:45	Invited & contributed sessions
Saturday-Sun 15-16 April	**Field trips**
Post conference trip	Treatment wetlands. Davis ww & Lake Tahoe protection wetlands, S. Shore & Incline Village + Skiing

Travel. The closest airports are Oakland (~ 10 miles from campus) and San Francisco (~ 20 miles). Both have BART (subway) access and a BART station is at the foot of the campus. Auto parking will be possible near the campus but in this urban area during the spring semester it will not be simple. It is possible to drive to some BART stations and park and commute in and also the City of Berkeley has a pay lot close to campus.



Accommodations. There are several hotels around the campus but not one big or close enough for us. We are still negotiating for rates with local hotels within walking distance. Announcements will follow.

2006 AEES Meeting
Call for Sessions and Papers

The 6th Annual AEES meeting will be held at Berkeley California on 13-14th April 2006. Abstracts should be emailed to the AEES Conference Committee Program Chair Nicole West (nwest@pirnie.com). Abstracts should be limited to 250 words in the following format (Times New Roman, regular font 12 point, single spaced).

EXAMPLE ABSTRACT

Uses of wetlands to treat rude people.
Jones, Peter .J. & Ronald. N. Encounter. Dept. Environmental Engineering, University of California Davis 95616 (jpeters@ee.uc.ca.edu 760-557-5555 & Brownfields Consulting, Davis California 95616 (brownfields@comcast.com 760-456-1234).
Wetlands are widely used to polish wastewater and provide wildlife habitat. Over 1,000 wetlands have been constructed in the US in the last decade. People also appreciate the aesthetic value of wetlands. In China, "wetlands parks" add a visual advantage requested by the Central Government. We have extended the use of wetlands to determine their ability to reduce bad temper and rudeness in humans. Potentially rude persons were collected from freeways and lines for ski lifts. They were exposed to various kinds of wetlands (constructed gravel bed & free surface as well as natural bogs, marshes & swamps) and then re-tested for rudeness using the finger scale and voice stress techniques. It was found that natural marshes and constructed free-surface wetlands significantly reduced rudeness, especially in males. However, bogs, swamps and gravel bed wetlands significantly increased rudeness for older people (> 30 y) while having little effect on younger ones (< 20 y). ANOVA showed that the sight of ducks, sunlit open water, and darkness caused by plant shading explained 76% of the findings. Planting of wetlands along freeways is thus an appropriate management technique to reduce rudeness and accidents but in ski lift lines wetlands may not be as successful.

ABSTRACT DUE DATE: February 1, 2006

For more information, or questions about sessions, organizing sessions, chairing sessions, etc., please contact the Conference Committee Program Chair, Nicole West, at nwest@pirnie.com.

University of Florida Receives IGERT Award, seeks PhD Candidates

Adaptive Management refers to the process for continually improving management policies and practices by learning from the outcomes of operational programs. The University of Florida Integrative Graduate Education and Research traineeship (IGERT) program in Adaptive Management focuses on research and training experiences for doctoral students that integrate the physical, biological, chemical, and social sciences to address the chosen research theme, *Wise Use of Water, Wetlands, and Watersheds.*

The goal for this IGERT Program is to provide scientists with greater understanding of the complex issues of coupled human and natural systems and a framework for interfacing policy and science to manage them. While building from a firm disciplinary base (each fellow's major), the program will overlay coursework in complementary disciplines and incorporate interdisciplinary training and research experiences. The program links four colleges, fifteen departments, and three research centers at the University of Florida with international wetlands research centers in Africa, Mexico, South America, Australia, and south Florida.

We are working with four international research partners in strategic wetland/watershed systems with whom we have had past research involvement. The doctoral research of each student in our program will evolve from and be shaped by specific problems and research questions identified with our research partners. However, research in three fundamental areas has been identified for the focus of this program:

1. Comparative studies of watersheds and wetlands to advance our understanding and prediction of the fluxes of biotic and abiotic components (organisms, invasive species, sediments, organic matter, and nutrients) leading to better understanding and scientifically driven policy and resource management alternatives.

2. Measuring, modeling, and tracking interaction of socioeconomic, political, legal, cultural and ecological variables that affect the sustainability of watersheds and wetlands,

3. Developing novel engineering methods, natural resource management techniques, and policy frameworks for protecting water resources, managing their use, and evaluating and rehabilitating damaged or degraded watersheds and wetlands.

A core set of interdisciplinary team taught courses are a key part of the educational experience of our fellows. In addition, fellows will spend each summer at one of the international research centers researching and exploring, first hand, Adaptive Management and the science, engineering, and policy frameworks that are necessary to drive the integration of research, policy, and management.

IGERT is an NSF-wide program intended to meet the challenges of educating U.S. Ph.D. scientists and engineers with the interdisciplinary background, deep knowledge in a chosen discipline, and the technical, professional, and personal skills needed for the career demands of the future. The program is intended to catalyze a cultural change in graduate education by establishing innovative new models for graduate education and training in a fertile environment for collaborative research that transcends traditional disciplinary boundaries.

Additional information and application guidelines are on-line at: http://AMw3igert.ufl.edu

For more information

Contact Dr. Mark T. Brown, Director, Center for Environmental Policy ~ PO Box 116350
University of Florida
Gainesville, FL 32611.
Email: mtb@ufl.edu Phone: (352) 392-2426

IGERT Integrative Graduate Education and Research Traineeship

UNIVERSITY OF FLORIDA

ECOLOGICAL ENGINEERING: Review of Ecological Responses in Recent River Restoration Processes

Cailin Huyck Orr, Ph.D.
Carolina Environmental Program
University of North Carolina -Chapel Hill
100 Miller Hall CB #1105
Chapel Hill, NC 27599-1105
chorr@unc.edu

ABSTRACT

Fragmentation, geomorphic simplification and regulation of river systems have caused significant and widespread changes in flow regimes and ecological properties. Managers are increasingly looking to restoration techniques as means to re-establish the physical, biological and chemical processes of riverine ecosystems. Current stream ecology research suggests that improving flow dynamics may be the cornerstone to rehabilitating ecological components of degraded systems such as fish habitat, macroinvertebrate diversity, nutrient dynamics and productivity. Here I review the application of the concept of flow as a master variable to physical alterations of rivers. Existing literature suggests that physical alterations have achieved restoration goals in many settings, but individual site characteristics make overarching application for these ideas difficult. In only 61% of cases authors reported a positive response to restoration. Short monitoring time frames also made it difficult to determine if rehabilitated conditions persist. In 26% of cases the change was demonstrated to be self-sustaining and in only 3% of cases were the new conditions maintained for more than 10 years after restoration. Future restoration projects of this type should be used as experiments to test the applicability of specific physical alterations to particular restoration goals.

INTRODUCTION

River ecosystems across North America have been vastly disturbed and altered. Fragmentation, straightening and regulation have caused significant and widespread changes in flow regimes (ie. hydrograph dampening, lowered discharges) and ecological properties (ie. habitat availability, productivity) (Dynesius and Nilsson 1994, Nilsson and Berggren 2000). A new awareness of the damage caused by river regulation has recently spurred interest in rehabilitating the ecological goods and services that rivers provide. Restoration has become a major tool of river management, used to re-establish the physical, biological and chemical processes of lotic ecosystems. Despite the significant effort and resources put into restoration, there is only sparse evidence that we can restore basic functions to river systems, in part because river restoration projects are rarely evaluated after completion (Kondolf and Micheli 1995). This lack of evaluation is hindering innovation in restoration techniques.

Within the river restoration community, it has been suggested that hydrologic regimes should be the focus of restoration activities (Gilvear 1999, Strange et al. 1999, Galat and Lipkin 2000,) as flow timing and quantity control many ecological variables in rivers (Poff et al. 1997).

A number of recent publications describe how hydrologic manipulations can be applied to promote river restoration (Stanford et al. 1996, Gilvear 1999, Strange et al. 1999, Galat and Lipkin 2000, Ward and Tockner 2001, Nilsson and Svedmark 2002, Bunn and Arthington 2002). These suggest that if flow dynamics of degraded systems are restored, other ecosystem components will recover in the new hydrologic setting. Restoration of hydrologic and geomorphic setting may promote a favorable response in ecological and biogeochemical parameters. If and when hydrologic alterations promote a switch in biologic function, hydrologic controls can be thought of as the primary driver of ecological changes in rivers. These situations should provide particularly good opportunities for river restoration.

I explored conditions under which physical alterations promote river restoration through shifting rivers from degraded to rehabilitated conditions. The goals of this paper were to 1) review arguments promoting a hydrologic master variable in rivers, 2) review published literature on river restorations where physical manipulations have been done, and 3) discuss usefulness and future direction of using physical alterations to restore rivers.

The argument for physical restoration

Flow regime is a fundamental aspect of fluvial systems and has broad impacts on lotic communities (Poff et al. 1997). Flow is known to be a key driver of ecological processes in rivers such as maintenance of biologic diversity and primary productivity. (Puckridge et al. 1998). Because hydrologic conditions create the context for ecological processes, it is easy to recognize significant relationships between physical and ecological components of rivers (Strange et al. 1999), although quantifying the strength of these relationships remains difficult (Bunn and Arthington 2002). It is easier to quantify degradation due to anthropogenic alteration of flow regime, and it is clear that flow regulation has degraded natural processes, such as maintenance of habitat structure and population viability of river species, and has deleterious impacts on aquatic ecosystems (Sparks 1995, Bunn and Arthington 2002).

One set of restoration strategies has been built on this understanding of the importance of flow to maintaining ecologic properties of rivers. The argument follows that if hydrologic parameters of rivers that control biological processes are restored, then biological components should adjust to match the new flow regime. Therefore restoration of hydrology is presumed to result in rehabilitation of biological components in streams. In this context, I am defining ecosystem functions or attributes broadly to encompass any ecological process that the manipulation is intended to restore. This theory is sometimes called passive habitat restoration (Scott et al. 2001), biohydrology (Strange et al. 1999) or an eco-hydromorphic approach (Clarke et al. 2003). Collectively these approaches employ flow manipulations to increase biodiversity and ecosystem services in degraded watersheds (Strange et al. 1999).

Physical manipulations intended to restore flow attributes will influence water timing and flow, and benthic substrate, either directly or through geomorphic manipulation. They include additions such as wood or root installation (Larson et al. 2001, Shields et al. 2004), artificial riffles or deflectors, and artificial structures placed to provide bank stability and structural heterogeneity to the river bed or fish habitat (Hunt 1993, Moerke et al. 2003). Structure removal can be restorations, such as dam removal and levee breaching to promote more natural flow timing and interaction between channel and floodplains. Channel changes can also include reshaping to add meanders or structural heterogeneity to a previously straightened river (Rinaldi and Johnson 1997).

Responses of rivers to physical manipulation

We can evaluate if and when physical manipulations promote intended ecological responses in rivers and ask the question: If restoration projects create the physical template for a riverine ecosystem, do ecosystem functions and attributes recover as a response to the physical changes? To evaluate current knowledge of the ability of hydrologic alterations to promote biological change, I surveyed existing literature on rivers restorations involving these types of manipulations. I drew from refereed articles published 1995 – 2005. I included projects if the major manipulation was a physical alteration to a river, the restoration goals were clearly stated and included promoting a biological or biogeochemical response, and if an evaluation of the project achievements was clearly included in the text. Restoration success was defined in each paper by individual authors and their determination was used here. I evaluated whether or not the post-restoration conditions were shown to cause an intended change to a biotic or ecologic attribute, and if they were likely to perpetuate that response past the duration of the study.

Searches were conducted in the Web of Science, Cambridge Scientific Abstracts and Aquatic Sciences and Fisheries Abstracts databases using a list of relevant search terms (Table 1). Additional targeted searches were done in Environmental Management, Restoration Ecology and Regulated Rivers – Research and Management as these three journals had produced the most relevant articles in the abstract searches.

Table 1. Search terms used in river restoration database search.

artificial riffles	meander addition
bank stability	rehabilitation
channel adjustment	restoration
channelization	river management
dam removal	river restoration
flow deflectors	stream management
flow enhancement	stream restoration
habitat enhancement	structure addition
habitat restoration	wood addition

Thirty one papers that met these criteria were included from projects in North America, Australia and Europe (Table 2). Of these, in 19 (61%) cases authors reported a positive response to restoration. In 26% of cases the change was demonstrated to be self-sustaining and in only 3% of cases were the new conditions maintained for more than 10 years after restoration. In 29% of cases the

Table 2. Results of literature review of physical restorations in streams.

Ecosystem	Manipulation	Response variable	Time of sampling	Restored	Persistent	Citation
7 rivers	structure addition	fish richness	3 years	yes	yes	Jungwirth et al. 1995
river	structure addition	fish and bird habitat	1 year	yes	no	Habersack and Nachtnebel 1995
stream	structure addition	fish abundance	1 year	yes	no	Shields et al. 1995b
stream	structure addition	fish abundance	2 years	yes	?	De Jong et al. 1997
stream	structure addition	salmon habitat use	1 year	yes	?	Mitchell et al. 1998
stream	structure addition	fish habitat use	36 years	yes	no	Champoux et al. 2003
stream	structure addition	fish abundance	1 year	no	no	Jones and Tonn 2004
stream	structure addition	fish community	1 year	yes	no	Bond and Lake 2005
stream	channel adjustment	invertebrate abundance	1 year	yes	?	Korsu 2004
river	meander construction	invertebrate richness	6 years	no	no	Friberg et al. 1998
stream	meander construction wood addition	invertebrate abundance, detritus accumulation	1-16 years	yes	?	Laasonen et al. 1998
stream	wood and structure addition	fish community and abundance	5 years	yes	yes	Shields et al. 1998
stream	wood addition	fish abundance	1 year	yes	yes	Zika and Peter 2002
stream	wood addition	fish habitat use	1 year	no	?	Roni and Quinn 2001
6 streams	wood addition	invertebrate community	2 – 10 years	no	no	Larson et al. 2001
2 streams	wood addition	invertebrate abundance and community	1 year	no	?	Hilderbrand et al. 1997

- Table 2 is continued on the next page

Table 2 (continued). Results of literature review of physical restorations in streams.

Ecosystem	Manipulation	Response variable	Time of sampling	Restored	Persistent	Citation
stream	gravel addition	invertebrate abundance	1 year	yes	?	Mertz and Chan 2005
stream	dam removal flow enhancement	fish abundance	6 years	yes	yes	Scruton et al. 1998
stream	dam removal	invertebrate richness	1 year	yes	yes	Stanley et al. 2002
stream	dam removal	fish and invertebrate richness	1 year	yes	yes	Bushaw- Newton et al. 2002
stream	dam removal	nutrient retention	1 year	no	yes	Stanley and Doyle 2002
stream	dam removal	invertebrate community	1 year	in part	?	Pollard and Reed 2004
stream	dam removal	invertebrate richness	1 year	no	?	Thomson et al. 2005
stream	weir addition	fish community	1 year	in part	?	Shields et al. 1995a
3 rivers	channel widening	riparian vegetation diversity	4-12 years	yes	?	Rohde et al. 2004
stream	flow enhancement channel shaping	invertebrate richness	1 year	in part	?	Purcell et al. 2002
stream	riffle addition	invertebrate community	1 year	yes	?	Gore et al. 1998
13 rivers	riffles and flow deflectors	invertebrate abundance	1 year	no	no	Pretty et al. 2003
lowland river	riffle and deflector addition	invertebrate richness	1 year	no	no	Harrison et al. 2004
river wetland	flood control structure	fish richness	3 years	yes	?	Theiling et al. 1999
floodplain	flow restoration	riparian tree abundance and richness	10 + years	yes	yes	Rood et al. 2003

authors determined the restorations did not meet project goals, and in 10% of cases restoration criteria were only partially met. The most common indices of restoration were measures of benthic macroinvertebrate and fish diversity and abundance.

In this body of literature, there were instances of restoration which met and did not meet goals for each type of ecological response. For example, adding wood to stream channels increased fish abundance in two projects (Shields et al. 1998, Zika and Peter 2002), but not in a third (Roni and Quinn 2001). Riffle additions increased benthic invertebrate abundance or richness in two streams (Gore et al. 1998, Theiling et al. 1999). However, in two other riffle addition projects invertebrates were similar in control and restored reaches (Pretty et al. 2003, Harrison et al. 2004). Details of individual study sites were critical to determining the restoration outcome and were difficult to compare across study sites. For example, available colonist pool, water quality, and degree of degradation prior to the restoration all influenced final results. Unfortunately, parameters such as the degree of degradation in a Finnish lowland stream versus a Pacific Northwest salmon stream are not comparable from descriptions given in these publications.

Likewise, in many studies it was difficult to determine if rehabilitated conditions were likely to persist. This is due to the short timeframe of monitoring, which in most cases was 1 – 2 years post-manipulation. From the information provided by authors, it is unclear if the responses measured just following restoration were maintained. Restoration sites certainly change and develop for long time-periods following a restoration activity, both as a response to the manipulation and due to natural variability, and some researchers suggest that a decade or more of monitoring is necessary to determine the outcome of a restoration project (Kondolf and Micheli 1995). However, because monitoring takes resources, it may not be done for the length of time needed to fully understand the outcome of a particular manipulation (Kondolf 1998, Bash and Ryan 2002). The goals of individual projects that initially appear unsuccessful may be met in a longer time frame, or conversely, initially positive responses may not persist.

DISCUSSION

This survey highlights evidence in the published literature that physical alterations can restore at least some river ecosystem attributes. For example, in a case study of a dam removal in Pennsylvania (Bushaw-Newton et al. 2002) the fish community shifted from a characteristically lentic to lotic composition in response to increased flows post-removal. This is a condition that is likely to be sustained into the future because the dam will not be rebuilt. In contrast, reevaluation of structure additions added to a small Wisconsin stream 23 years after they were put in place (Champoux et al. 2003) showed that while the structures had initially improved fish habitat, they had later become silted and their benefit was reduced with time. Projects where physical alterations have led to the intended ecosystem response give hope that this approach can be used and expanded to other sites and parameters. The situations where the intended results were not produced demonstrate that caution must be used when applying those methods across systems and goals.

While conceptually it is reasonable to hypothesize that intentional physical or hydrologic alterations to rivers may rehabilitate biological parameters, there is not yet good evidence that current river restoration techniques can consistently produce this response. In fact, despite the fact that $1 billion is spent annually on restoration in the US, monitoring data are only collected for less than 10% of projects, making it impossible to evaluate the outcome of the remaining 90% (Bernhardt et al. 2005). It is useful to consider river restorations as ecosystem experiments and design them with testable hypotheses involving both the goals of the restoration and the persistence of ecosystem responses. While it is not practical to evaluate every ecological response to every restoration project, it may be useful to group types of restoration projects based on the type of response they are most likely to show. There is ongoing interest in the creation of additional studies that use restoration as experiments for determining when hydrology and physical structure is the dominant control of ecosystem attributes (Arthington and Pusey 2003). There are also significant obstacles to the addition of scientific study in the design of restoration projects and a shift in the way managers view project goals may be necessary before experimental restorations are fully implemented in the field (Walters and Green 1997).

Discriminating between persistent and transient outcomes of restoration has implications for the prioritization and allocation of resources for river management. If reconstructing natural hydrologic regimes sufficiently improves riverine ecological functions, managers could focus time and resources on physical alterations. However, if we find that physical changes are not promoting the desired ecological responses, further attention and resources will need to be allocated to achieving restoration goals.

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Ecosystem Survivor: An Experiential Exercise that Reinforces Ecosystem Principles for Restoration Ecology Students

David R. Tilley
Department of Biological Resources Engineering,
Natural Resources Management Program,
University of Maryland, College Park, MD
Email: dtilley@umd.edu

Abstract

I describe a unique experiential-game called 'Ecosystem Survivor' used in a 'Restoration Ecology' undergraduate course whereby students compete in small teams to build, manage, measure and simulate an ecological microcosm for maximum 'greenness'. Below I explain the motivations, objectives, materials and methods, and achievements of the game.

Introduction

Among the many aspects that restoration-minded students need to learn about ecosystems is their ability to self-organize as they develop over time and respond to management and disturbance. As the professional practice of ecosystem restoration matures and learns to more fully appreciate the dynamics of ecosystem development, young practitioners should be prepared with skills that allow them to assess, monitor and predict the trajectory of ecosystem change. Class field trips to natural, disturbed and restored ecosystems gives students a chance to see what real ecosystems look like, but offers them little opportunity to observe temporal dynamics. Ecological microcosms placed in greenhouses offer students the opportunity to experience temporal dynamics in a semester length course of 15 weeks. Integrating the exercise of creating and observing an ecological microcosm into a competitive, team-oriented game can accentuate the academic experience by drawing on students' desire to interact informally and compete with one another, and learn to work together as a team.

To couple the hands-on experience of watching an ecosystem self-organize with the enjoyment of a game, I developed 'Ecosystem Survivor' as a semester-length pedagogical exercise. The objectives of Ecosystem Survivor are for students to:

1. Contemplate the ingredients needed for creating an ecosystem,
2. Explore campus ecosystems for microcosm ingredients,
3. Think about what helps an ecosystem resist disturbance and recover afterwards,
4. Learn team work,
5. Take responsibility for caring for a living system,
6. observe vegetation change,
7. Measure diversity,
8. Learn about how hyperspectral reflectance of live plants, dead plants and soil can be used to estimate leaf area index,
9. Develop simple computer simulation models of vegetative growth, and
10. Observe how ecosystems respond to various types of disturbance (i.e., fire, wind storm, flooding, wild pigs).

Materials and Methods

Students are assembled into teams of four. Teams decide what they want to put into their microcosm. At least one class period prior to building the microcosms, the instructor takes the students on a tour of campus ecosystems (forest, stormwater wetlands, rain gardens) to discuss some strategies of ecosystem development, which also makes them aware of what and where they can collect their ingredients. One of the main constraints for assembling the ecological microcosms is that no plants taller than 2 cm are allowed. This disallows lumping in a sod of lawn and allows students to witness more stark change during the experience. Teams are taken to the forest, given a shovel, bucket and microcosm container, and allowed to collect for 45 minutes (Figure 1). During the three semesters that I have used Ecosystem Survivor, students have collected gravel, sand, forest soil, wetland soil, leaf litter, woody debris, rocks, tree seedlings, herbaceous plants, seeds, spiders, worms, insects and other material. Some added ash by burning paper.

Figure 1. Students collect plant, soil and microbial material from a campus forest for their team's ecological microcosm.

Once teams have collected their desired materials, they head to the greenhouse to assemble their masterpiece (Figure 2). Some teams are extremely methodical and aim for extraordinary diversity, while others are more haphazard and strive for production. Generally, teams have made terrestrial microcosms, but a few have experimented with aquatic/terrestrial combinations. A time limit on assembly is required. I give them an hour.

Figure 2. Students assemble their collected materials to build ecological microcosm.

After the microcosms are assembled and placed in the greenhouse, the students are allowed only to add water during the semester. Adding plants, pulling out unwanted species, or other manipulation is not allowed, except when a reward is won (discussed below). The idea is to minimize management. Teams keep a journal to record watering dates, plant emergence, species counts, and other commentary.

The game part of Ecosystem Survivor enters the exercise as 'Ecosystem Challenges', whereby class time is used for teams to compete in a quiz-show format. The instructor asks a topical question of a team. If that team answers correctly they receive a point, but if they answer incorrectly then the next team gets an opportunity to answer. A maximum of two teams get a try at any one question. Subject material for questions is derived from course lectures, general ecology, current events, and historical facts. An almanac can be gracious for questioning material. The Challenge lasts about 20 to 25 minutes.

The team with the most points gets a 'management credit', which is the right to perform some type of management to their microcosm. I have given teams seeds and fertilizer as reward. The team with the fewest points during a Challenge gets an 'ecological disturbance'. The disturbance is randomly selected from a list that includes fire (Figure 3), windstorm, flood, simulated insect infestation and simulated wild pig escape. There are three Challenges during the semester.

Figure 3. One of the disturbances was 'FIRE', which was simulated with a blow torch.

Two weeks before the end of the semester each team's microcosm is brought into the classroom to determine the winner. There could obviously be multiple ways to decide a winner. The criteria should be stipulated at the beginning of the semester. We have convenient access to a spectroradiometer so we measure reflectance in the red and near-infrared wavebands to calculate a reflectance index (i.e., normalized difference vegetation index) that is correlated to leaf area index. Thus, the team with the highest NDVI has the highest LAI and is determined the winner. When there has been a tie, we count vegetation species to declare the winner the team with more species. Harvesting, drying and weighing the aboveground biomass is a cheaper and easier alternative to reflectance.

Results and Discussion

Figure 4 contrasts a productive winning microcosm with a barren losing one. The winning microcosm, 'Terp' (Figure 4a), exhibited a typical pattern of reflectance with a peak in the green waveband and high reflectance in the near-infrared (700-1075 nanometers; Figure 4c). In contrast the reflectance of 'Btu' (Figure 4b) looked more like soil (Figure 4c).

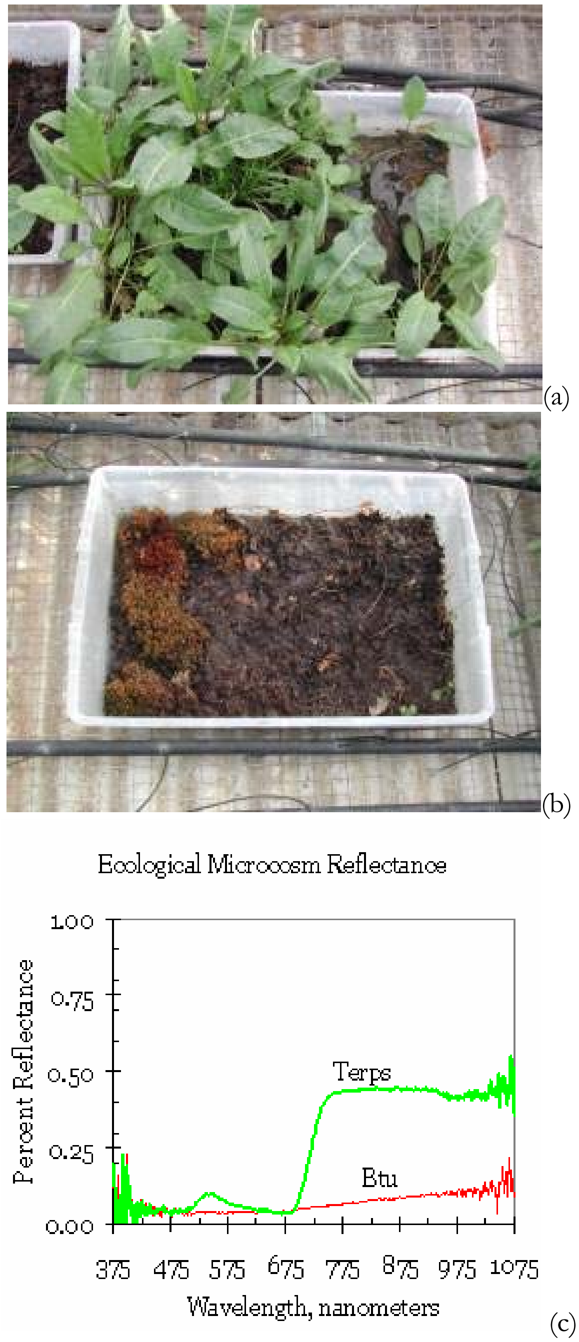

Figure 4. The microcosm of the winning team, 'Terps' (a) was far more 'green' and productive than the least successful entry by team 'Btu' (b), which was confirmed from their hyperspectral reflectance (c).

Two microcosms with different dominant vegetation but seemingly similar leaf area indices (Figure 5) had similar patterns of hyperspectral reflectance (Figure 5c), which would have made declaration of a winner difficult. Fortunately, these two teams were from different sections of the course.

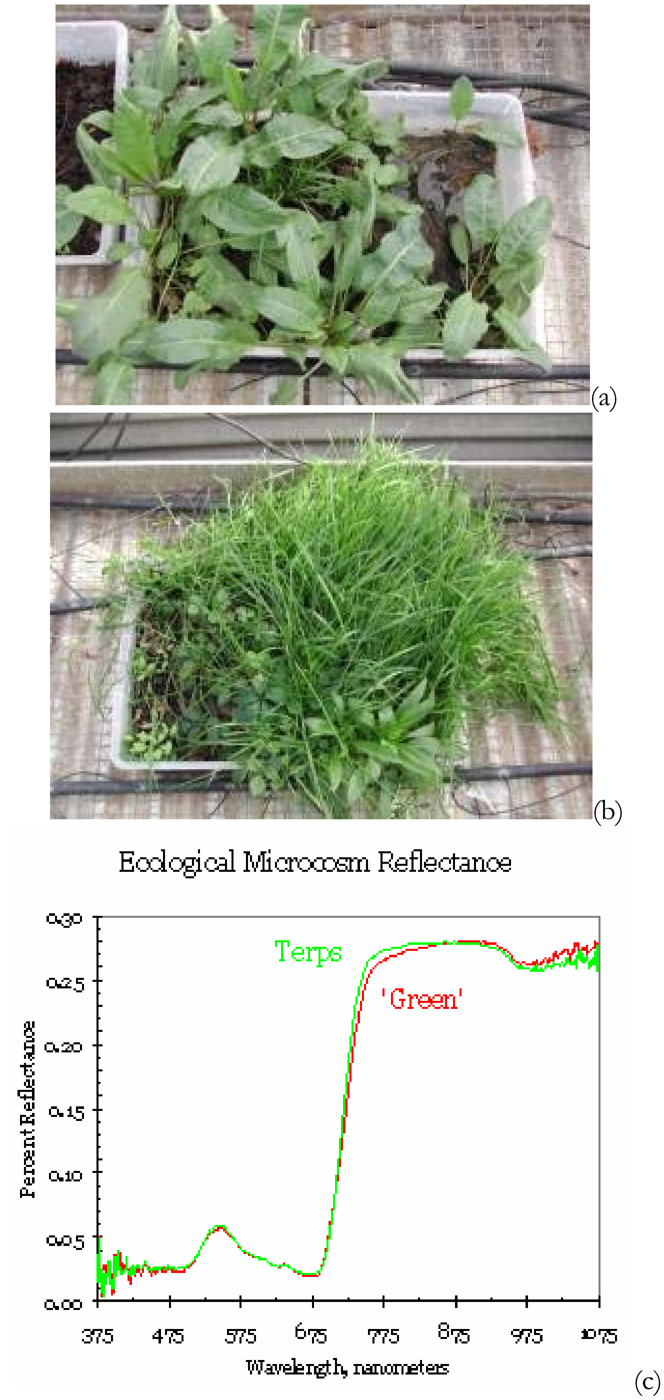

Figure 5. Two microcosms with similar amounts of plant cover but different species (a & b) and comparison of their reflectance (c).

Conclusions.

Ecosystem Survivor was used as an experiential game in a restoration ecology course to give students a hands-on experience with ecological self-organization. Periodic team challenges were used to allocate management credits and disturbance events to team microcosms. End of semester student commentary on the game, given on course evaluations, indicated that the majority appreciated the experience. The few graduate students with some experience in controlled experimental design seemed to have a difficult time seeing much utility in the game. Students that attempted to have ultra-highly diverse microcosms quickly realized how difficult that was. Most students were amazed at how many species volunteered from the seed bank, and how quickly those plants grew. Like any exercise improvements are needed. Replication of each team's microcosm could provide some interesting insight on effects of initial conditions on ecosystem trajectories.

Acknowledgements
Over three consecutive Autumn semesters I had four classes with a total of about 60 students participate in Ecosystem Survivor. Thanks to all them for indulging my pedagogical experiment.
To learn more about 'Ecosystem Survivor' go to:
http://www.nrm.umd.edu/tilley/honors/index.html.

Announcements from other Professional Societies

Note: To post a meeting call for papers or job announcement in this section please send the announcement to the editor at: mmatlock@uark.edu

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AWRA 2006 Annual Conference
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Baltimore, MD
November 6-9, 2006
http://www.awra.org/meetings/Baltimore2006/

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http://www.asabe.org/meetings/Forest2006/index.htm

World Environmental & Water Resources Congress
May 21-25, 2006
Omaha, Nebraska
http://www.asce.org/conferences/ewri2006/

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DOCTORAL FELLOWSHIPS AVAILABLE
University of Florida's
IGERT Program in Adaptive Management:
Wise Use of Water, Wetlands and Watersheds

Our IGERT program in Adaptive Management focuses on research and training experiences for doctoral students that integrate the physical, biological, chemical, and social sciences to address the chosen research theme, *Wise Use of Water, Wetlands, and Watersheds.*

For more information
Contact Dr. Mark T. Brown, Director, Center for Environmental Policy ~ PO Box 116350 ~ University of Florida ~ Gainesville, FL 32611. Email: mtb@ufl.edu
Phone: (352) 392-2426

Hydrologist/Stormwater Engineer
Belle W. Baruch Institute of Coastal Ecology & Forest Science, Georgetown, SC.
Agricultural & Biological Engineering
Clemson University, Clemson, SC
This position is a 12-month, tenure-track faculty appointment with Clemson University as a member of a team of water resources expertise at the Baruch Institute. A PhD is required in engineering with strong training and background in hydrology, natural resources, geosciences, bioscience, hydraulics, soil physics, and related disciplines. The individual will study hydrological dynamics via modern process studies and/or modeling approaches in order to describe and predict effects of stormwater runoff from a coastal ecosystem beginning pre-development, during development and continuing through post-development. An emerging research program of national prominence involving hydrologic modeling of watersheds to determine runoff, storage, detention, and discharge with emphasis on developing areas is expected.

The successful applicant will address quantity characteristics of small watershed hydrologic and hydraulic design to convey and/or contain the flows resulting from extreme events and function as a stormwater hydrologist with interests in watershed hydrology at the local and regional scale. Research may include consideration of surface dynamics, surface water – groundwater interactions, and/or land surface – atmosphere interactions, and water quality implications. Emphasis will be placed on improving currently used technologies as well as developing innovative methods such as low impact development (LID) methods. Since design of stormwater structures requires considerable knowledge of federal, state and local requirements, this individual will be expected to have experience with relevant regulations including NPDES requirements, coastal zone limits, Corps of Engineers regulations, and the S.C. Stormwater and Sediment Control Act. The person in this position should understand the uniqueness of South Carolina coastal areas, their sensitivity, wetland issues, coastal hazards, terrestrial and aquatic ecological systems, and possess a working knowledge of the ecology of southeastern coastal areas.

This candidate will be expected to:

- meet scholarly standards by developing a high-quality research program that meets the standards of periodic peer review, including regularly publishing research results in peer-reviewed literature,
- develop a strong extramural funded research program,
- expect affiliation and cooperation with the South Carolina Water Resources Center of the Strom Thurmond Institute on the Clemson University campus,
- collaborate with on-campus, Extension, and stakeholder teams in order to develop outreach programs to disseminate new knowledge as quickly as possible, and
- direct and advise graduate students with an eventual opportunity to teach at the graduate level.

RANK: Assistant Professor preferred. A senior appointment at the Associate Professor level may be considered depending on qualifications.

APPOINTMENT: 75% Research and 25% Extension/Outreach

Clemson University is committed to affirmative action, equal opportunity, and the diversity of its workforce. "Clemson University does not discriminate against any person or group on the basis of age, color, disability, gender, national origin, race, religion, sexual orientation, or veteran's status." An offer of employment is contingent upon establishment of identity and verification of employment eligibility as required by the Immigration Reform and Control Act of 1986.

TO APPLY : Send a letter of application, transcript, current vita, and the names and addresses of at least three professional references to Dr. John C. Hayes, Search Committee Chair, 226 McAdams Hall, Clemson University, Clemson, SC 29634-0312. Screening will begin after November 15, 2005 and will continue until the position is filled. Applications received by November 30, 2005 will be assured consideration.

Ecological and Environmental Engineering Job Links

Environmental Career Opportunities - www.ecojobs.com/engineeringjobs.htm

Order your AEES T-Shirt today! Indicate color (Ocean surf tie-die or sunrise tie-die) and size(s) – Kids, S, M, L, XL. $15.00 each. Contact Marty Matlock (mmatlock@uark.edu) with your order today.

American Ecological Engineering Society

American Ecological Engineering Society Theme Song

Fixing the Planet on a Budget

by Alex Horne, PhD

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- played to the tune of "Big Rock Candy Mountain"

If you're fixing the planet and don't have much cash
You'll need to be ingenious and even to be rash
Then learn some solutions as I sing this song
And you'll soon save the planet and never go wrong

Now the first thing we need is to protect our lakes
Our rivers and oceans and make no mistakes
They're full of pollutants, nutrients and oils
And we have to fix them, before the world spoils

From farms all around us, nutrients flow
Down the Mississippi to the Gulf of Mexico
The big muddy river drains half the USA
And pours out pollutants every single day

Now out in the Gulf there is the dead zone
It's origin's farm runoff, that it is known
Nitrates grow algae, that die and then sink
They use up oxygen making quite a stink

From the shores of the Great Lakes to San Francisco Bay
You see posted warnings, eat no fish today
PCBs, PAHs, and good old DDT
Its quite a sharp warning for you and for me

You can't eat the fish in Lake Onondaga
Mercury pollution, New York's saga
For over 100 years from the factories around
Mercury and salt to the lake they were bound

Out West in the Golden State we mined streams for gold
The Hearsts made super profits from all the gold they sold
Extracting shiny gold requires mercury
And they left it to poison good old you and me

Two-thirds of the planet is covered by sea
But it's mostly unknown to you or to me
If we're going to survive for another million years
It's protect our oceans or end up in tears.

Even in Antarctica, pesticides are found
In penguins and fishes, even whales as they sound
DDT it is volatile, mercury too
So they cover the globe with a mild toxic stew

So how do we fix all of this mess?
It is not very easy, that I'll confess
Especially on a budget, where money is tight
But if we just think about it we'll do alright

I'll tell about wetlands and how they can work
To clean up pollution, a job they don't shirk
They are living factories, systems we can use
But we must get on with it and no longer snooze

In the mud of a wetland, bacteria live
They destroy pollutants, a service they give
They fix heavy metals, nitrates they destroy
And all we have to do is encourage their joy

Now to do all this good stuff and clean up the world
We must build new wetlands where pollution's been hurled
Designed to clean up water and look mighty fine
Wetlands give wildlife a pretty good time

Now how do new wetlands clean up the world so cheap?
They need no fossil fuels for benefits to reap
Sustainable power, it comes from the sun
And via photosynthesis the project we run

Let's build more new wetlands all over the planet
To clean up pollution, maybe even ban it.
Natural Treatment Systems is where they are from
You can see an example at IRWD.com

