An Integrated Assessment of Physical, Ecological, and Socio-economic Aspects of a Watershed System

Project Summary:
Host Institution: The University of Toledo
Disciplines: Environmental Science, Geology, Ecology, Geography, Planning, Law
Project Title: Integrated Assessment of Physical, Ecological, and Socio-economic Aspects of a Watershed System
Number of Students: 12
Number of Weeks of Summer Program: 10
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Website: http://remotesensing.utoledo.edu/education/reu.html

The University of Toledo's Lake Erie Center was awarded an NSF REU site (SES-9988038) with Dr. Kevin Czajkowski as the Principal Investigator and Dr. Alison Spongberg as Co-Investigator. Our REU project has been very successful over the last three years and we are proposing to continue the program for another three focusing on the physical, ecological, and socio-economic aspects of a watershed system. We will provide a summer research opportunity which will 1) educate students regarding the interconnected nature of hydrological processes, water quality, demographics/economics, land use practices, riparian ecosystem quality, sediment contamination, and the legal/policy implications of river ecosystem degradation, 2) mentor students in research projects focused on the Maumee River and Lake Erie health from environmental, biological, social and policy perspectives and 3) encourage students to pursue careers in science. Results from REU student research projects can be found at http://remotesensing.utoledo.edu/education/reu.html.

Due to the historic concern for the health of the Lake Erie watershed, the University of Toledo has been involved in and continues to develop multidisciplinary research initiatives focused on the Maumee watershed and Lake Erie. Significantly, among the Great Lakes, Lake Erie is unique in that its water quality problems are primarily related to the specific human phenomena of agricultural pollution and urbanization. We have chosen an interdisciplinary approach with emphasis on a watershed system for our contribution to the REU program because water quality issues transcend geographic setting. Nationally, government agencies, industry and the public are at odds over how to improve water quality in our nation's streams. One of the major problems facing local and regional communities is soil erosion, sediment transport and sediment deposition in the mouths of streams. In addition, contaminants such as heavy metals, pesticides and e-coli bacteria from landfills, brownfields and septic systems pose a threat to benthic communities as well as to drinking water and recreational uses.

Our funded REU site supported 10 undergraduate students each year. In addition, a NASA grant funded two students to participate in the program. Our ten-week summer program has involved the REU students in research efforts to address the environmental degradation of the Maumee watershed, the major environmental and social processes involved in defining the extent of the degradation problem and its associated remediation and the related policy/legal issues. The various projects group students with faculty and graduate students to study research projects that relate to the REU students' areas of interest. In our program, REU students gain a broad understanding of environmental issues through guest speakers from the local community who present the status of local, state and national efforts to remediate watersheds and career opportunities with their agency or in their field. In addition, the students learn techniques for collecting field observations through collecting environmental samples (soil, water, and biological), ground truth observations for remote sensing projects or GPS coordinates for Geographic Information System (GIS) projects.

Each year the program has attracted increased positive attention from faculty members who have seen the benefits to their individual research through the REU program. Therefore, we hope to expand it to 12 REU students for each of the next three years. Faculty involvement has increased especially from the Department of Earth, Ecological and Environmental Sciences (EEES) primarily due to the addition of four new faculty members with interest in environmental research.

Students will be recruited from all over the United States with particular attention paid to students from universities of underrepresented groups in science. Through recruiting efforts, nearly 60% of the REU students for our past three summers have been women, which is significant considering the traditional male dominance of Earth Science and Geography. Our recruitment of minority students has been less successful, with only two of 32 students being minorities. However, this is comparable with the percentage of those minorities majoring in these areas in the vicinity of our program. This is an area that we will address over the next three years.

F. Results from Prior NSF Funding

In the spring of 1999, Drs. Czajkowski and Spongberg were awarded an NSF REU site (SES-9988038). The focus of the study was to support interdisciplinary environmental research at the University of Toledo's Lake Erie Center. There were originally six investigators from the

Department of Geography and Planning, Department of Earth, Ecological and Environmental Sciences and the College of Law who worked on the project. We received funding for ten REU students and found that it was a great program for the students involved, the universities faculty and the Lake Erie Center. Over the last three years, a total of 32 students have participated in the program, two of which were funded from external grants other than the NSF REU site. Results from REU student research projects can be found at http://remotesensing.utoledo.edu/education/reu.html. The success of this program has prompted us to request 12 REU students under this proposal.

Our Program

We work hard to give the REU students an educational and enjoyable summer experience. To do this, we emphasize a broad background of environmental issues associated with the Maumee River and Lake Erie watershed.

Recruiting - Recruiting has been an important aspect of our REU program at the Lake Erie Center. Several faculty assisted with advertising on the Internet, on listservs and through flyers that were distributed to universities across the U.S. For the summer of 2000, 44 applicants from 16 states applied. In 2001, there were only 25 applicants and most were from Ohio or surrounding states primarily because advertising was not as widespread. In 2002 we had 27 applicants and again most were from Ohio and its surrounding states. Selection of participants was based on academic performance, research interests, out-of-class experiences, faculty recommendations and personal goals. Students were selected from a variety of personal, educational, and geographical backgrounds, contributing to the interdisciplinary nature of the program. We were able to attract students from across the country although excellent students from the University of Toledo were given the opportunity to participate in the program. Eight of the 32 students who have participated in the program were from the University of Toledo. Many of the students who were accepted came from undergraduate institutions such as Ohio Wesleyan University, Kenyon College, Shippensburg and SUNY Geneseo where research is not prevalent.

Dr. Sam Attoh worked to recruit minority students while Dr. Spongberg worked to recruit women. Recruitment of minority applications has been difficult. We have accepted two students out of 32 in the program over the last three years, Matthew Do an Asian/Pacific Islander and Leslie Mendosa, Hispanic. In 2000 we offered a position to an African American woman however she had already accepted a position somewhere else. We have been much more successful in recruiting women into the program. Nineteen of our 32 students have been women (59%).

Weekly Field Excursions and Presentations - Weekly field trips and presentations are a weekly component of our REU experience. Many of the trips highlight the interdisciplinary nature of the program such as the tour of the Maumee River basin or the trip to Metzger's Marsh. Although students were not required to attend all of the events, the majority chose to do so. Students had the opportunity to visit the Toledo Zoo, a local wastewater treatment plant, a local landfill, and the Water Quality Lab at Heidelberg College in Tiffin, Ohio. Students also visited the local Manhattan Marsh, the Winous Point Marsh, and the Independence Dam (near Defiance, Ohio). In 2000, the students had the opportunity to attend the "Great Lakes 2000 Symposium" at the Seagate Center in Toledo, Ohio and Maumee Bay State Park in Oregon, Ohio. In addition, each year we have outside speakers from a variety of disciplines and environmental career paths. For instance, we had Steve Davis, a field scientist from the USDA Natural Resource Conservation District, talk about the impacts of conservation tillage on sediment loading to streams. We also had Kristina Patterson, watershed coordinator for the Duck and Otter Creek

watershed speak about what she does and how she is working with industry in her heavily industrialized watershed to help address environmental degradation.

Most students collect field data for their projects. Frequently, this involves collecting water samples, taking temperature readings, and gathering ground-truth data. Perhaps the most enjoyable data-gathering experience is the boat trips out onto Lake Erie. The boat trips are arranged in correlation with the Landsat 7 satellite overpass. The students collect water samples that are analyzed for turbidity, total solids and algae and take temperature readings to compare against the satellite imagery.

The Carp Round-up

Going out Sampling

Relaxing at Lunch

Social Activities - We sprinkle social activities throughout the summer experience to give the students an opportunity to get to know other faculty and graduate students working at the Lake Erie Center. An inter-departmental picnic is held each year at the home of Dr. Kevin Czajkowski. Other fun and social activities include a trip to Cedar Point Amusement Park, the Toledo Museum of Art, Put-in-Bay Islands, and many local restaurants, including the well-known Tony Packos. In 2001, some of the more adventurous students joined Dr. Bob Sinsabaugh for a kayaking excursion on Lake Erie. The students also assist with the annual "carp round-up" in the Lake Erie Center's man-made wetland. Picnic and BBQ's at the Lake Erie Center are also a frequent and favorite activity of the students and the Lake Erie Center offers a great setting for them. We believe that our social bonding activities have helped to create the "cohort" experience that the REU program wants. Many of the students made friends during our REU program and remain in contact with each other. For example, one of the students was married this summer and three of the REU students from the summer of 2000 came to her wedding from as far away as Texas.

Students and Research Projects

REU 2000		
Autumn Ash	*Policy issues with Manhattan Marsh nature preserve*	St. Mary-of-the-Woods
Sheryl Bell	*Comparison of microbial communities in an agriculturalimpacted marsh*	Morning Side College
Catherine Buchanan	*Feasibility of using Fostoria plants for phytoremediation—removal of heavy metals*	Humboldt State
Matt Cunningham	*Longevity of escherichia coli and heterotrophic bacteria in freshwater sediments*	Ohio Wesleyan University
Susan Dunham	*Crop identification using satellite imagery*	SUNY Geneseo
Natalie Gottschall	*Feasibility of using Fostoria plants for phytoremediation—removal of heavy metals*	Nipissing University
Jaclyn Hurley	*Communicating the goal: a united front against non-point source pollution*	Wheaton College
Laura Poulos	*Utilizing remote sensing and geographic information systems to locate and monitor riparian buffer zones*	University of Toledo

Bryan Sams	*Avoiding the pitfalls of voluntary environmental protection programs with agricultural zoning*	Ohio Wesleyan University
Katrina Schutte	*Assessment of the urban heat island effect in Lucas County with remote sensing technology*	San Diego State
Ariel Terranova-Webb	*The effects of spatial land-use change on the suspended sediment load of the Ottawa River and its tributaries; a study in non-point source pollution*	Ohio Wesleyan University

*Note: Natalie Gottschall from Canada was supported by a NASA grant to participate in the program.

REU 2001		
Matthew Do	*Application of Hyperspectral Remote Sensing to Crop Identification*	Penn State
Adam DeMars	*Application of Hyperspectral Remote Sensing to Crop Identification*	University of Toledo
Mike Edwards	*Application of Total Solids and Turbidity in the Ottawa River Watershed for Non-point source pollution detection*	University of Toledo
Andrew Hoskens	*Effects of stress on nematode life history characteristic*	University of Toledo
Sarah Fuller	*Prairie Wetlands: Application of Remote Sensing*	West Chester U.
Andrew Hudak	*Hydro-geologic Survey of the Lake Erie Center Property: Soil Analysis and Well Installation as Preliminary Steps for a Study of Ground Water/Lake Water Level Relationships*	Ohio Wesleyan University
Kelly Ketchum	*Correlation between biological crust composition and nitrogen fixation*	Bowling Green State
Stephen Meininger	*Effects of stress on nematode life history characteristic*	Ohio Northern U.
Katherine Rogers	*Crop Identification Using Multitemporal Satellite Imagery*	Indiana University
Justin Struble	*The Potential for the Use of Landsat in Time Series Analysis:Cloud Coverage in Northwest Ohio*	Kenyon College
Erin Weis	*Expand or Reroute: A Study of US Route 24*	Ohio Wesleyan U.

REU 2002		
Erica Bishop	*An Accuracy Comparison of an ASTER Derived DEM to existing USGS 30 meter DEM*	Oklahoma State University
Amy Campbell	*Ecological study of a northern forest ecosystem*	University of Idaho
Adam Dellinger	*Watershed Planning in Northwest Ohio: A Small-Scale GIS Application*	Shippensburg University
Adam DeMars	*Landsat 7 vs. EO1 Hyperion for the Classification of Corn and Soy*	University of Toledo
Deanna Haluska	*Phytoremediation of Fostoria Sludge Farm*	Keystone College
Kate Lanza	*Phytoremediation of Fostoria Sludge Farm*	University of Toledo
Leslie Mendoza	*Doehler-Jarvis: A Toledo Brownfield Site*	University of Toledo
Shawn Spears	*Habitat Preference of Painted Turtles (Chrysemys picta) in the Ottawa National Wildlife Refuge*	University of Toledo
Justin Struble	Monitoring Turbidity in Lake Erie using Landsat 7/ETM+	Kenyon College
David Tessier	*Habitat Preference of Painted Turtles (Chrysemys picta) in the Ottawa National Wildlife Refuge*	Ohio Weslyan U.

Results from many of these projects are onlined on the University of Toledo's REU web site. Students received a short-course on webpage development. The goal was to have a tangible product from the experience that the students could point to and say "I did this" to a potential employer.

Faculty Involvement as Mentors

Originally we had six faculty members associated with the REU program at the Lake Erie Center. We have had a total of eleven faculty members from across campus have been mentors for students (see list below). This past year, there were even more faculty than those listed interested in mentoring a student however there were not enough students to go around.

Kevin Czajkowski – Geography and Planning (GEPL) – Remote Sensing and Watershed Modeling
Sam Attoh – GEPL – Urban Geography
Patrick Lawrence – GEPL – Environmental Geography
Karl Schneider – GEPL – Remote Sensing and GIS
Alison Spongberg – Earth, Ecological and Environmental Sciences (EEES) – Soil Science
Deb Neher – EEES – Microinvertibrates
Jamie Martin-Heyden – EEES – Groundwater Hydrology
Donald Stierman – EEES – Geology, Stratigraphy
Daryl Moorhead – EEES – Biogeochemical Cycles
Daryl Dwyer – EEES – Phytoremediation
Jiquan Chen – Ecological Modeling
Sandra Zellmer – Environmental Law

Presentations

Students in the REU program perform research with faculty members that the students can present at professional conferences. An important evaluation component of our program is the number of papers presented at professional conferences. We strongly encourage the students to present at professional conferences and the REU grant pays part of their travel. From the first two years of the program, seven student presentations have been given at conferences such as the East Lakes Division of the Association of American Geographers, the Ohio Academy of Sciences and the National Conference for Undergraduate Research.

Lawrence, P., S. Fuller, and K. P. Czajkowski, The Application of Remote Sensing Technology for Wetland Classification and Implications for Environmental Planning within the Maumee River Watershed, NW Ohio, East Lakes Division of the Association of American Geographers (ELDAAG) conference, Cincinnati, OH, Oct. 27, 2001.

Weis, E. and K. P. Czajkowski, Expand or Reroute: a Study of US Route 24, East Lakes Division of the Association of American Geographers (ELDAAG) conference, Cincinnati, OH, Oct. 27, 2001.

Edwards, M., K. P. Czajkowski, K. P. and P. Lawrence, Application of Total Solids and Turbidity Readings in the Ottawa River Water shed for Non-point Source Pollution Detection, East Lakes Division of the Association of American Geographers (ELDAAG) conference, Cincinnati, OH, Oct. 27, 2001.

Andrew J. Hosken and Deborah A. Neher Effect Of Environmental Stress On Soil Nematode Life History Characteristics, Ohio Academy of Science, April 2002.

Roberta M. Veluci, Kelly Ketcham, Deborah A. Neher, Microbiotic Crust Communities Fix Nitrogen In A Temperate Oak Savanna. Ohio Academy of Science, April 2001.

Kelly D. Ketcham, Microbiotic Crust Communities Fix Nitrogen In A Temperate Oak Savanna. (Deborah A. Neher), National Conference for Undergraduate Research (NCUR), UWisconsin-Whitewater, WI, April 2002.

Andrew J. Hosken and Deborah A. Neher, Effect Of Environmental Stress On Soil Nematode Life History Characteristics, National Conference for Undergraduate Research (NCUR), UWisconsin-Whitewater, WI, April 2002.

Several students from the summer 2002 REU program have expressed interest in presenting at professional conferences.

Drs. Czajkowski and Spongberg presented results from the REU program at the American Geophysical Union's (AGU) fall meeting in San Francisco. We shared recruiting and

training experiences with other researchers from a wide range of disciplines interested in undergraduate mentoring.

2001 Czajkowski, K. P. and A. Spongberg, Research Experience for Undergraduates (REU) at the University of Toledo's Lake Erie Center: Environmental Studies of the Lake Erie Watershed, American Geophysical Union Fall Meeting, San Francisco, CA. Dec. 10-14, 2001, p. 230.

Where They Are Now

One of the goals of the REU program is to encourage students to pursue careers in science and possibly go to graduate school. Many of the students that we had in our program the first two years have either taken up a profession related to their REU experience or have gone on to graduate school.

Summer 2000 Students	**Where They Are**
Susan Dunham	Graduate student at SouthWest Texas State
Laura Poulos	Works for an Environmental Engineering Firm
Katrina Schutte	Works for the city of Los Angeles in planning.
Ariel Terranova- Webb	Graduate student at the University of Kentucky
Summer 2001 Students	
Kelly Ketchum	Graduate student at Ohio State University
Andrew Hoskens	Graduate student at the University of Toledo

Many of the students from the summer of 2001 and all of the students from this past summer 2002 have not graduated yet. During our REU program we mentor the students about careers in environmental science and the benefits of attending graduate school. Many students say that they want to try to work for one year before setting out for graduate school.

Lessons Learned

- Advertising early is critical to get a good group of students. – although we had the most applicants the first year, delays in awarding the positions caused many of the best students to accept summer jobs or positions with other REU programs. We resolved this issue in 2001 and 2002 by offering positions early. It paid off because only 1 student each year turned us down.
- Apartments are much better for the students to live in than dormitory rooms (primarily because of access to a kitchen).
- It is best to have students working on projects that feed off one another rather than totally separate projects even if those separate projects in the same area.
- Bonding is enhanced by students living in close proximity.
- Some students require strict guidelines about what is appropriate behavior in apartments (i.e. cleanliness, rowdiness).
- Start application process early so best students are not lost to other jobs/programs.
- Give students more information before arriving on campus. – We have worked to do this.
- Some students may get lost in the shuffle. They need to be identified and worked with early in the program to resolve the issue.

A. Overview

At the University of Toledo, faculty have been involved in and continue to develop multidisciplinary research initiatives focused on the Maumee watershed and Lake Erie. Among the Great Lakes, Lake Erie is unique in that its water quality problems are primarily related to the specific human phenomena of agricultural pollution and urbanization. We have chosen an interdisciplinary approach with emphasis on a watershed system for our contribution to the REU program because water quality issues transcend geographic setting. Nationally, government agencies, industry and the public are at odds over how to improve water quality in our nation's streams. One of the major problems facing local and regional communities is soil erosion, sediment transport and sediment deposition in the mouths of streams. In addition, contaminants such as heavy metals, pesticides and e-coli bacteria associated with sediments pose a threat to benthic communities as well as to drinking water and recreational uses. This is an especially acute problem when sediments are dredged from shipping channels and the contaminated sediments require special handling. The Maumee River Watershed in Northwest Ohio is an example of a watershed that has a severe siltation and contamination problem.

This REU opportunity will give students the opportunity to collaborate with faculty on an environmental problem of global significance by using the Maumee River watershed as a test case. We will use a ten week summer program to expose students to the environmental degradation of the Maumee watershed, the major environmental and social processes involved in that degradation and the related policy/legal issues. Students will be drawn from all over the United States with particular attention paid to students from universities of underrepresented groups in science. Students will then be teamed with a faculty mentor to conduct a research project which will evaluate a specific aspect of environmental degradation/land use change, demographic/social factors or the policy implications of a particular problem. We will use the final week of the research experience for a student project symposium where students will present their research results and discuss the overarching processes that unify their research efforts. Guest professionals will attend these meetings and will also provide an overview of the significance of environmental/policy research training for real-world careers. In addition, these community partners will evaluate individual projects as well as the overall program.

Project Objectives

Research and teaching need to be integrated as we educate our students. Promoting active engagement of students in discovering concepts in science requires their direct involvement in the excitement of the process that produced such concepts. Such an approach helps interested and qualified students develop an ability to critically think about the complexity of living systems and the role of science in uncovering this complexity. It trains these students in making critical observations, developing testable hypotheses, designing experiments, collecting data, and presenting the results in oral and written format. It also prepares them for a career in the sciences.

Specific objectives of this project include:

1. bringing students together from diverse backgrounds, providing them training in the use of interdisciplinary approaches to understand and address environmental and socially relevant issues.

2. giving students a solid education in research methodology which will provide them with the skills necessary to be active contributors to the research/professional community.

3. providing opportunities for students to work with community organizations that collect data relevant in monitoring our changing environmental and social landscape, enabling students to see how our communities evaluate environmental problems and make plans for the future.

4. learning about the nationally important issue of water resource quality, using the Maumee watershed/Lake Erie basin as a case study.

The depth in which students perform interdisciplinary versus disciplinary research will be closely monitored. The group as a whole will, through their interaction, understand the interdisciplinary nature of water resources issues. They will however gain experience in a particular discipline by working closely with a faculty mentor.

Targeted Student Participants

Students between their Junior and Senior years of college will be targeted, however, outstanding students between their Sophomore and Junior years will be considered. As we have in the previous three years, we will target students from primarily undergraduate institutions where research experiences may be limited. In particular, we will continue to seek well qualified women and minorities.

Organizational Structure

As a center promoting interdisciplinary projects, the Lake Erie Center is a closely linked group of environmental faculty interested in water quality issues. The director of the REU program is the director of the GIS and remote sensing laboratory at the Lake Erie Center. He with the help of the Co-Investigator, Dr. Spongberg, take responsibility for organizing the REU program. All faculty will be responsible for recruiting qualified students and mentoring students. In the past, groups of faculty members have worked with groups of REU students on collaborative projects. This mode of organization will be further promoted under this proposed grant.

Timetable

Year 1, January 2003 to December 2003

Nov.-Dec.	Update REU web pages.
Jan.	Advertise for REU students in trade journals (Association of American Geographers Newsletter, Bulletin of the Ecological Society of America, and Eos).
Mar.	Submit Final Report for REU grant SES-9988038 Student applications due.
April	Award of REU positions.
June – Aug.	REU program at Lake Erie Research Center
Aug.	Evaluation of program including exit interviews with students.

Year 2, repeat year 1 but making improvements learned from the first year.
Year 3, repeat year 1 but making improvements learned from the first and second years.

We envision three distinct units in our undergraduate experience program which will take place over a ten week period at the University of Toledo's Lake Erie Center:

1) Week one will be intensive course work for all program participants, taught by all of the faculty participating in the program. It will provide the study area setting, the broad research context, and an introduction to the critical geographical, ecological, geological and legal issues which relate to the problem of water quality in the Maumee watershed.

2) Weeks two through nine will be devoted to student research projects which will be under the direct supervision of faculty mentors. During this time the students will experience the full range of activities involved in conducting research, from observing and conceptualizing a problem, to developing research objectives and hypotheses, to acquiring and analyzing data, to summarizing these data to writing up their research results.

3) Week ten will be devoted to student presentations of their research projects. We will invite guests from the professional community who will attend the student research symposium, evaluating the student work. During this final week their will also be a "careers in research" presentation by the REU faculty mentors. Students will also develop web pages for their projects as many have done in the past.

Institutional Commitment

The REU program is an important component of the research mission of the Lake Erie Center. The University of Toledo completely supports the program and is encouraging its expansion as evidenced by our request for 12 students. Facilities such as the Lake Erie Center's boat, computer equipment, wet lab and canoes are made readily available to the REU students. The REU program is often cited when the Lake Erie Center is promoted within the community. The program gives researchers the opportunity to expand the research projects they have funded, develop seed projects to look for funding or conduct collaborative research with community partners. Finally, when Senator DeWine and Congresswoman Kaptur of Ohio visited the Lake Erie Center, the REU program was highlighted and the REU students talked with each politician at length. One student (Adam Dellinger) was pictured in a Newspaper article with Senator DeWine after his visit.

B. **Nature of Student Activities**

Students in the REU program will work closely with faculty mentors from Geography and Planning, Earth, Ecological and Environmental Sciences and Law. Mentors will include:

Mentor	Department	Field of Specialization
Dr.Czajkowski	Geography and Planning	Hydrometeorology/Land Use from Remote Sensing
Dr. Spongberg	EEES	Contaminants in sediments
Dr. Attoh	Geography and Planning	Demographics, Public Perception
Dr. Lawrence	Geography and Planning	Land Use and Water Quality from Remote Sensing, Erosion Monitoring
Dr. Moorhead	EEES	Biogeochemical Cycles within the watershed
Dr. Neher	EEES	Riparian Habitat/Mammalian diversity/ Bird migration patterns
Dr. Daryl Dwyer	EEES	Phytoremediation
Dr. Zellmer	Legal Institute of the Great Lakes (School of Law)	Public Policy/Environmental Policy

Dr. Jiquan Chen	EEES	Ecosystem Modeling
Dr. Donald Stierman	EEES	Geology, Stratigraphy

*please note that Drs. Chen and Stierman were out of the country (China and Costa Rica respectively) at the time of the writing of this proposal and were not able to submit biosketches and current and pending support for this proposal.

Specific Projects

a) Hydrometeorology/Remote Sensing in the Maumee Watershed

One common question regarding the hydrology of the Maumee watershed is, how does water quality vary related to rain events in the watershed? Our study area contains a significant component of industrial/developed land and that it remains unclear as to how suburban landscapes impact the watershed's sediment problem. A pervasive question for those exploring the sediment problem in the Maumee is, what role do agricultural practices have on watershed sediment pollution? While approximately 78% of the Maumee watershed's land area is devoted to agriculture, the management of those practices are generally summarized and aggregated for counties in a non-spatially distributed manner. We currently lack detailed maps of farm practices which might provide insight into source areas of sediment pollution along the watershed. Satellite remotely sensed data hold potential for providing a means to map contrasting tillage practices for the watershed because of documented differences in signals of exposed soils, crop residue-coated soils, and different crop types. We will work with two undergraduate students to select a number of watersheds in Northwest Ohio with sub-basins where farm land management consists of conservation tillage vs. conventional tillage. Past REU students have concentrate on crop identification from satellite imagery for use in hydrological models, wetland identification and turbidity modeling/budgeting in Lake Erie. This work has led to funding from the U.S. Army Corps of Engineers to study the Upper Auglaize watershed (a tributary to the Maumee River) and turbidity from Landsat imagery. This is a focal area of much of the research at the Lake Erie Center and if this project is funded, REU students will continue to play a significant role in solving the areas problems.

b) Wetland Habitat Ecology, Environmental Degradation, And Impacts On Fauna

The focus of this project will be the importance of ecological functions of wetlands in the landscape. Wetlands generally exhibit high productivity and diversity, change the quality of water that flows through them, and moderate the effects of floods. In addition, they serve as important refuge, feeding, and spawning areas for many fish and shellfish, birds, reptiles, amphibians, and mammals.

In the summer of 2002, two students participated in a turtle habitat analysis project. Students went into the field each day to Metger's Marsh and the Ottawa Wildlife Refuge to count and weigh the turtles captured in traps that the students made. This was one of the most interesting and fun projects of the summer. The local newspaper did a story on the project. We plan to continue the turtle project for a number of years and add aviary populations and habitat analysis in the future.

Related research conducted by several REU students focuses on the use of soil invertebrates as bioindicators to measure the health or quality of soil in terrestrial and wetland soils. This project will also be continued under a renewed REU grant. A student in the program would be either involved in controlled experiments designed to evaluate candidate genera or field experiments that employ community indices that indicate the current status or remediation progress of polluted soils. Photos of previous REU students on my lab web page, http://research.eeescience.utoledo.edu/sobo/

c) Socio-economic Impacts and Environmental Change

To understand changes in runoff and sedimentation rates in the Maumee River watershed, the human activities that impact the river system need to be examined. One might ask, what are the socio-economic drivers of urban landscape change in the Maumee watershed, and, how do prevailing attitudes and planning philosophies potentially influence river water quality? While satellite data can provide an overview of the spatial extent of development over time, an evaluation of the social processes driving development of our suburban landscapes requires exploration to understand the philosophical realities of environmental planning and their potential impacts on environmental quality. A suite of demographic data, from new housing starts to census data to local plans (such as the 20/20 Comprehensive Plan and an Updated Landuse and Policy Plan for Lucas County) will be used to explore the socio-economic factors which have driven changes in population distribution and development. As well, the local plans will be used to explore the framework for future directions in environmental planning. The residential and economic growth for selected municipalities will be explored relative to nearby river water quality over the last 10 years. In addition, river stakeholders, as represented by city and town officials, residents and nearby industries, will be interviewed to gain perspective on their uses of the river, how they value the river, and their roles in the future of the river.

Under the previous grant, REU students have studied collected information and studied such issues as construction of a new highway, U.S. 24 through environmentally sensitive areas and redevelopment potential of a brownfield in Toledo.

d) Sediment Contamination Originating From Selected Sites

Both soils and water provide substrates in which a range of pollutants, such as pesticides, heavy metals and nutrients may accumulate. At Toledo's harbor, more than half of the sediment dredged annually has to be contained due to its hazardous contents. A variety of techniques are available to explore sediment records of contamination, from grab samples of water (which contain suspended sediment) to sediment cores. Solid phase extraction techniques coupled with gas chromatrogaphy have been used to specifically explore sediments for pesticide contamination (e.g., atrazine and metalochlor). The presence of heavy metals which emanate from urban/industrial sources can be deciphered by exploring acid digestion of sediments and plasma spectrometry. Molecularly complex hydrocarbons which emanate from industrial/urban sites can be identified using organic solvent extraction and gas chromatography approaches.

While biogeochemical analysis of pollutant species is complex, there are test kits available which can provide students with the means of identifying specific contaminants. These test kits, and perhaps a limited number of sediment cores, will be used to identify specific anthropogenic contaminants originating from a spatially limited source region. Dr. Spongberg has experience training undergraduate students to identify pesticides or other contaminants which originated from source areas along the Maumee watershed.

e) Environmental Regulations And Implications For Future Watershed Management

Professor Zellmer plans to lead students in an exploration of laws and policies governing water pollution and water rights (the use and allocation of water resources). They will examine the effects and regulation of industrial and non-point sources of pollutants (e.g., agriculture and urbanization), invasive species, and human alteration of flow through wetland modification, dams, impoundments and diversions. Students will also analyze the current legal framework governing the rights to use water for municipal and industrial purposes, flood control, navigation, irrigation and recreation. They will then be required to design solutions to “fill in the gaps” left by current law to better address pollution control and to preserve and protect the Maumee.

Course materials will include legal resources, as well as interdisciplinary materials, such as scientific articles on hydrology and riparian ecology.

C. Research Environment

The Faculty

The faculty assembled for this undergaduate research experience program represent a breadth of background in the social and physical sciences. The range of expertise encompasses disciplinary areas related to hydrometeorology, urban planning and human dimensions of environmental change, land cover/land use changes, wetland ecology, paleolimnology, non-point source pollution, biogeochemistry, law, and remote sensing. Several of the faculty mentors already have received funding for research efforts that are particularly germaine to the topics to be addressed in this program. Dr. Czajkowski, along with scientists from the OhioView Consortium, has received a research grant from the USGS to develop a land use monitoring system using Landsat imagery. Dr. Gottgens has studied the transport of organic matter into Lake Erie through a grant from the USDA and he has studied the longterm effects of non-point pollution on Lake Erie marshes through a grant funded by the Lake Erie Protection Fund. Dr. Attoh has studied the socio-economic changes of Northwest Ohio through a grant on Global Changes in Local Places from NASA. Dr. Spongberg has been funded since 1995 under the U.S. Department of Agriculture's Special Grants Program. Her collaborative research with colleagues at the University of Toledo has focused on fate and transport of a range of agricultural pollutants in local watersheds and wetlands. In the legal profession Dr. Zellmer has expertise in natural resources law, water law and policy. Her expertise is manifest in her representation of various federal agencies (such as U.S. Forest Service, Park Service, Fish and Wildlife Service and the Environmental Protection Agency) in cases involving public lands and resource management when she was a trial attorney for the U.S. Department of Justice Environment and Natural Resource Division. In private practice she has represented a variety of clients on environmental issues such as solid and hazardous waste management and water quality standards.

Faculty Undergraduate Training Records:

The University of Toledo has a strong commitment to undergraduate education and research. The atmosphere of the university is faculty are encouraged to both research and teach. The university supports undergraduate research through the long-standing REU site in the Department of Physics and Astronomy that has been ongoing for 10 years. The university also has a summer research program supported by the Ohio Board of Regents that is highly regarded in Toledo. The Lake Erie Center REU site under this proposal is the newest of the undergraduate research activities at the University of Toledo and it has also received strong support from the university administration at all levels up to the president’s office as well from the community.

Dr. Czajkowski has been the director of the Lake Erie Center REU program since its inception and has directed 2-3 students per year. His experience working with undergraduate students began while he was a graduate student at the University of Michigan, extended through his research scientist position at the University of Maryland and is an important part of his work as an Assistant Professor at The University of Toledo. Dr. Czajkowski was in the Atmospheric, Oceanic and Space Sciences Department at the University of Michigan. He supervised undergraduate students on several field projects including at the Southern Oxidants Study held in Atlanta, Georgia, on the solar car team and on various occasions, forecasting the weather for balloon races and boat races. As a research scientist in the Department of Geography at the University of Maryland, Dr. Czajkowski supervised three undergraduates, Denny Mathews, David Shirey, and Anita Walz working on research projects funded by NASA. Each student contributed greatly to the project and Mr. Shirey and Ms. Walz are a co-authors two papers that

Dr. Czajkowski has published on remote sensing. In addition, Dr. Czajkowski has supervised many undergraduate projects who studied student understanding of Global Warming. They published their results on the Internet on a web site that they developed. Currently, as an Assistant Professor at the University of Toledo, Dr. Czajkowski is directing the undergraduate honors project of Lara Trame. She is investigating the relationship of storm events in Northwest Ohio to runoff and sediment transfer in the Maumee River.

Dr. Spongberg has been the Co-director of the Lake Erie Center REU program since its inception. She is a biogeochemist who had twelve years of professional experience as a research scientist prior to her joining the faculty of the University of Toledo in 1994. Her research funding at the University has focussed on studies of pathogens, pesticides and non-point pollution sources within local watersheds and wetlands. She has taught students at all levels in their academic experience and has had undergraduate student research interns. She has been the research advisor for three undergraduate Honor's Program Students at the University of Toledo. The honors program involves students choosing a department on campus where they would like to pursue a one year long research project. All of Dr. Spongberg's undergraduate Honors students have completed studies involving pesticide or contaminant research . One student conducted a study involving a transect along the Ottawa River to identify PCBs and hydrocarbons (S. Fuggett, 1996). Another student pursued pesticide analyses at the Blue Creek Wetland to determine degradation rates (Hugg, 1995). The other student explored pesticide transport within and off a Northwestern Ohio golf course (Niekamp, 1999).

Dr. Attoh is the Chairperson of the Department of Geography and Planning at the University of Toledo. For the last two years he has been on the Executive Committee of the Ohio Geographic Alliance, working with K-12 teachers and students on in-service training programs and workshops related to the human dimensions of environmental change. He has supervised two undergraduate honors theses and he has mentored more than 40 undergraduate students through independent studies in topic areas such as environmental planning, growth management planning and planning for an urban corridor. He has also led the development of a model Geography laboratory which integrates social and environmental Geography issues for a local high school.

Professor Zellmer has been an Assistant Professor of Law at the University of Toledo's College of Law since 1998, where she teaches and writes in the areas of environmental law, water law, natural resources law and policy, and property. Prior to that, Professor Zellmer was a visiting professor at Drake University Law School in Des Moines, Iowa (1997-1998) where she taught courses in property, natural resources and American Indian Law. Professor Zellmer has advised law students at all levels of their academic experience on environmental research and scholarship. She has also guest lectured to various undergraduate courses and symposia on environmental topics, and for the U.S. Department of Agriculture's Natural Resources Management Certificate Program, working with students at all levels of post-secondary education. Professor Zellmer is a committee member of the Legal Institute of the Great Lakes and has recently given a presentation to the International Joint Commission (IJC) on the United States law and policy governing the use and diversion of water resources. She will present a paper on controlling exotic species at the IJC biennial meeting in September, 1999.

The University of Toledo's Lake Erie Center

The REU program in this proposal will be conducted at the University of Toledo's Lake Erie Research Center. The Lake Erie Center is a newly constructed 30,000 ft^2 laboratory, classroom and conference facility located on the shore of Maumee Bay within Maumee Bay State Park. The Lake Erie Center was opened in September, 1998 to promote interdisciplinary research on Lake Erie and the watersheds that drain into it. The Lake Erie Center is a joint venture between the Department of Agriculture and the University of Toledo. Faculty from

Geography and Planning, the Department of Earth, Ecological and Environmental Sciences, and the School of Law are working together on several interdisciplinary projects. The Lake Erie Center is a member of the organization of Biological Field Stations. The Lake Erie Center has three large classrooms, office space and research labs for Geography, Biology and Geology. The REU students will work in the GIS/Remote Sensing laboratory and two wet laboratories for chemical analysis and 24 foot boat (and staff captian) for water sampling. The GIS/Remote Sensing (GISRS) Laboratory at the University of Toledo's Lake Erie Center supports interdisciplinary research on Lake Erie and the watersheds that drain into it including research on watershed modeling and water quality monitoring. The Lake Erie Center has 8 high-end PC's devoted to remote sensing and GIS research. The GISRS has over a Terabyte of storage space accessible within its intranet of two servers, attached RAIDs and suite of recently-purchased PC computers and appropriate backup devices for all data. Other equipment at the Lake Erie Center include a large number of water sampling and water quality monitoring equipment, an HP Large Format Printer, zoomable digital camera. All data from REU projects are entered and maintained in the Lake Erie Environmental Database (LEED), an Oracle 7.1 relational database written in SQL-Plus.and supported by a database manager at the Lake Erie Center.

In addition to the Lake Erie Center resources, the resources available from the Department of Geography and Planning's Geographic Information System Applied Geography Laboratory (GISAG) with 4 Terabyte data server and high-end computing power and GER 3700 spectrometer and the Department of Earth, Ecological and Environmental Sciences has laboratory facilities.

OhioView: Spatial Data Resources

Dr. Czajkowski is the University of Toledo's coordinator for the OhioView Remote Sensing Consortium. OhioView is a consortium of ten Ohio universities that was established to reduce the financial and technological barriers to the application and use of remotely sensed satellite data in research, education, and public and private decision making. OhioView was established through United States Congressional support and has established data links between the U.S. Geological Survey's Eros Data Center in Sioux Falls, South Dakota and the NASA Glenn facility (formerly NASA Lewis) in Cleveland, Ohio. The OhioView data link was activated in July of 1999. Satellite imagery from the new Landsat-7 satellite, that was launched on April 15, 1999, will be acquired by Eros Data Center, sent to NASA Glenn and then passed onto the universities in Ohio, including the University of Toledo, within two hours after the satellite passes overhead. Currently, the Lake Erie Center has access to over 300 satellite images for the state of Ohio and Lake Erie and will continue to have up-to-date images available throughout the course of the proposed activity. This availability of imagery has allowed REU students to do remote sensing application research using multiple imagery that has not been done often due to the cost of the imagery.

Community Relationships:

Cooperation between the investigators of this proposal and community partners (local government agencies, non-profit organizations and educational institutions) to address the issues associated with sedimentation within the Maumee River basin is an important aspect of faculty research initiatives in Maumee watershed. Several of the REU students will work closely with several of these partners utilizing their expertise and available data sets.

Table 1 below lists active partners with the Lake Erie Center. These agencies and organizations offer a wealth of knowledge which will enhance students' experiences in the REU program. This link to the local community will give students experience on how university research fits with and can help address the local concerns of citizens. An example of a specific

link is the students working on land use change and farmland management issues can work very closely with the USDA's Natural Resource Conservation Service (NRCS), Lucas County Auditor's Office, the county Soil and Water Conservation Districts and Allen County/Lima Regional Planning Commission. These organizations have in situ observations and aerial photographs that will aid in the validation of land cover mapping of the satellite imagery.

Table 1: Lake Erie Center Partners and Their Areas of Concern

Organization	Concerns
Henry County Soil and Water Conservation District	A rural county: Promote no-till and conservation tillage.
Lucas County Soil and Water Conservation District	An urban/rural county: Promote no-till and conservation tillage.
Wood County Soil and Water Conservation District	An urban/rural county: Promote no-till and conservation tillage.
Lucas County's Auditor's Office	Toledo development.
Allen County/Lima Regional Planning Commission	Urban Sprawl/Farmland Loss
TMACOG (Toledo Metropolitan Area Council of Governments)	Lead organization of the Maumee River RAP (Remedial Action Plan) and the Maumee River Student Summit.
City of Defiance	Develop in environmental friendly way.
USDA Natural Resource Conservation Service (Lima and Marysville offices)	Reduce soil erosion from farmland and sediment in the Maumee River.

D. Student Recruitment and Selection

An important aspect of this entire REU project is to attract good students from across the United States who will benefit from our program and go on to become leaders in watershed management research and policy. As stated in our Results from Prior NSF Funding, we have been very successful at recruiting well-qualified women to our program. Students will be recruited through distribution of a program flyer, postings on the world wide web, and mailings to Geography, Biology and Geology department and pre-Law program heads around the country. As stated in our Prior Results, we believe we need to do a better job recruiting minorities to the program. To date, we have had two minorities out of thirty-two students offered a position that accepted. To improve our minority recruitment we will Minority institutions will be particularly targeted. Dr. Attoh to coordinate minority recruitment by contacting departments from traditionally minority institutions including but not limited to those with membership in the United Negro College Fund, the American Indian College Fund, the Andrew W. Mellon Minority Undergraduate Program, the Female Interest Group (FIG) of the Association of Collegiate Schools of Planning (ACSP) and other minority-oriented societies such as the Latin American Educational Fund and American Women in Science. Since many of these colleges and universities do not have Geography Departments or pre-Law programs, we will contact Sociology, Political Science and Anthropology Departments at these schools.

To apply to the program, students will be asked to submit an application package that will include a 3 page narrative on their background, research interests and career goals. In addition, they will submit two letters of recommendation from faculty at their home institution and course transcripts. The REU faculty mentors will review the applications and, as a group, determine the most qualified students to admit into the program. It is critical that we receive good applications for each discipline area in our interdisciplinary project, however, we will not set any quotas as to

how many students of a particular background will be allowed into the program. To avoid having a group of students concentrated in one discipline, we will concentrate on attracting a well qualified and diverse applicant pool through our advertising techniques.

E. Project Evaluation and Reporting

The evaluation of the REU students in the past has helped us improve our program. The success of the project and identification of improvement for the project will be addressed in the following ways:

Formative Evaluation

1) We will carry out Formative Evaluation throughout the program through weekly meetings between the REU students and the director of the program, Dr. Czajkowski. Through this approach, a student in 2001 expressed issues with his current research project. He was switched to a different mentor and finished a research project that better fit his interests.
2) We have found that the undergraduate students are more likely to open up to a graduate student than to a faculty member. We have assigned a graduate student "mom"/"dad" to keep an eye out for problems that start so that they may be fixed before the problems get too big. Many of the issues flagged in the past in this way had to do with living arrangements.

Summative Evaluation

1) Students will be given a pre and post survey of their perceptions of science developed by P. Burnley at Georgia State University. This test has been shown to reveal systemic changes in students feelings of careers in science.
2) Each student will be given an exit interview by several of the faculty mentors and a survey to evaluate the student's individual progress and to determine ways to improve the program in subsequent years.
3) Efforts will be made to turn student reports into peer-reviewed journal articles or presentations at professional meetings.
4) Attempts will be made to track the progress of the students that attend the REU program to see if they pursue careers in science.

Each of these considerations will help the REU program faculty gauge the success of the summer program and to determine if the goals for each student are being met. Ultimately, giving students exposure to doing research with an environmentally and socially relevant research focus will help them see that doing research can be a challenging but worthwhile way to contribute to society.