Expanding GIS and GPS Applications in an Interdisciplinary Environmental Studies Program

Institute for Community and Environment
Colby-Sawyer College

PROJECT SUMMARY

The goal of this proposal is to expand opportunities for undergraduate student learning and research with GIS and GPS technologies. The project will primarily benefit students in the Community and Environmental Studies (CES) program at Colby-Sawyer College. The project will also benefit students that enroll in several science and environmental literacy courses that utilize GIS and GPS. The project will have local, regional and national impacts through numerous external collaborations involving students through class projects, internship experiences, training programs, and independent research projects. Project results will be of particular interest to those interested in interdisciplinary applications of GIS and GPS. The project will focus on the development of curricular initiatives for conventional GIS analyses in biology and environmental studies as well as problems in economics, political science, and sociology.

The project will take place in two stages. First, the project investigators will receive training that will allow them to specialize in appropriate areas of GIS technology and application. This stage of the project will also involve preliminary curriculum integration planning, developing an evaluation strategy and the purchase of a few select items that will augment existing GIS and GPS facilities. The second stage of the project will focus on developing a dedicated spatial ecology laboratory with computer hardware and peripheral equipment that will maximize student access to GIS technology. During this stage, project
investigators will focus on final plans for curriculum integration, project evaluation and the dissemination of project information.

Results From Prior NSF Support

The project investigators have not received any NSF support in the past five years.

PROJECT DESCRIPTION

Goals and Objectives

The quality of science education in the US has been widely discussed for the past few decades. Key studies done by the Boyer Commission (1998), the National Science Foundation (1996) and the National Research Council (1996) all emphasized the need for different forms of teaching and more dynamic learning environments such as group learning, problem-based learning and interdisciplinary education. The integration of computer-based information technologies into undergraduate educational experiences has also been encouraged (Boyer Commission, 1998).

The application and integration of GIS/GPS technology is a primary example of how computer-based information technologies can improve and advance science education. In many ways GIS has provided one of the best ways to promote environmental literacy, technology skills and field research (Lo, Affolter, & Reeves, 2002). In higher education, it has provided new approaches to multimedia instruction (Ramirez & Althouse, 1995; Deadman, Hall, Bain, Elliot & Dudycha, 2000; Wiegand, 2001; Zerger, Bishop, Escobar & Hunter, 2002), new understandings of environmental and social impacts (Sheifer, 1996; Antunes, Santos & Jordao, 2001; Bryant & Callewaert, 2002) and expanded opportunities collaborative efforts with community-based organizations (Benhart, 2000).
The goal of this project is to integrate and expand GIS and GPS applications within an environmental studies program that follows student-centered problem solving and locally-focused teaching. Comparable efforts have been successful at several other institutions including Wittenberg University (NSF-DUE 0087870), Gettysburg College (NSF-DUE 0088403) The Richard Stockton College of New Jersey (NSF-DUE 9455331), Alfred University (NSF-DUE 9952417) and The University of Maine Farmington (NSF-DUE9851507). For our project, we will adapt the initiatives at Wittenberg University and The University of Maine Farmington. These are the most appropriate models for our adaptation as The University of Maine Farmington promotes the problem-based learning approach we are seeking to expand and the project at Wittenberg University matches our institutional profile (liberal arts) and interdisciplinary focus. Key objectives of the project include:

- Faculty training and development in the use of GIS and GPS technologies,
- Refining and expanding curricular strategies for GIS and GPS instruction,
- Improving access to GIS and GPS technologies,
- Evaluating faculty teaching and student learning with the technologies, and
- Disseminating information on project outcomes.

**PROJECT PLAN**

**Present Situation**

Colby-Sawyer College, founded as a coeducational academy in 1837 and engaged in higher education since 1928, is an independent, coeducational, residential, undergraduate college that strives to lead in offering co-equal education to women and men. In recent years, Colby-Sawyer College has strengthened its position within the higher education community. Since 1996, there has been a 23% increase in student enrollment and a 34% increase in full and pro-
rata faculty – allowing the college to maintain a 12:1 student/faculty ratio. In 2002, Colby-Sawyer enrolled the largest student body in its history. Today more than 900 talented young women and men (approximately 65% women and 35% men) attend the college. Enrollment is expected to reach 1,000 within two to three years. The standard teaching load for faculty at Colby-Sawyer College is 12 credits of course content per semester.

Following three years of faculty planning and a substantial degree of student and community input, Colby-Sawyer College inaugurated the Community and Environmental Studies (CES) program (B.S.) in 1999. The CES program is developing into one of the flagship programs at Colby-Sawyer College and has quickly grown to include nearly 40 majors. Designed as an interdisciplinary initiative of the college, the CES program is administered by a faculty committee with representatives from the Natural Sciences, Social Sciences and Education, Nursing, Humanities and Business Administration departments.

A primary emphasis of the CES program is that students are provided with ample experiential learning opportunities that involve real-world problem solving (Dewey, 1938; Nagel, 1996; Shaping the Future, 1996). The program also focuses on active and group learning projects (Livingstone & Lynch, 2000). Specific examples of this pedagogy include a yearlong community-based research course, a required internship experience and a senior research project. In the past two years we have already collaborated with the Ausbon Sargent Land Preservation Trust, the Friends of the John Hay National Wildlife Refuge, the Lake Sunapee Protective Association, the New London Conservation Commission, the Society for the Protection of New Hampshire Forests and the Vermont Institute of Natural Science.

In 2000, Colby-Sawyer College received a $1 million dollar Congressional Grant administered by the Fund for the Improvement of Postsecondary for Technology to upgrade
faculty, staff and student computer technology. Each academic program received a portion of the grant and the CES program dedicated its share ($7500) to purchasing equipment and software for Geographic Information Systems (GIS) and Global Positioning Systems (GPS) work. In the following two years additional purchases have expanded our work in this area (see Major Equipment List on the Facilities, Equipment, & Other Resources form). Initially, our work with GIS was concentrated in one course – CES 202: Earth. This course examines land-based ecosystems and in the first year several GIS tutorials were developed to assist students in developing natural resource maps for local communities.

Because of the GIS technology we had purchased, we were approached by the Vermont Institute of Natural Science (VINS) to host their Community Mapping Program in the summer of 2001. This program teaches mapping and GIS skills to middle and high school science teachers. We used this opportunity to also provide basic instruction in GIS and GPS to five of our CES faculty. Also during the summer of 2001, John Callewaert (PI) was selected to attend a NSF-supported workshop on problem-based instruction at the University of Maine Farmington. A key component of this workshop included discussing ideas and strategies for integrating GIS and GPS into environmental studies program. Two of the workshop presenters, Michelle Hluchy and Daniel Buckley, were recipients of CCLI funding for GIS/GPS projects (NSF-DUE 9952417 and NSF-DUE 9851507).

Following our initial successes with GIS, we repeated our work in CES 202 the following year and made some advances with introducing GIS into other courses – CES/BIO 107 (ecology), CES 301/302 (community-based research seminar) and CES 486 (senior research seminar). We also hosted the Community Mapping program of VINS for a second summer in 2002. During this academic year we have expanded the applications of GIS and GPS in CES
301/302 to include developing a Natural Resources Inventory for a local national wildlife refuge and several students are expected to integrate GIS/GPS into their senior research projects next semester.

Despite our successes with GIS, what has become increasingly apparent is that we need a dedicated GIS lab. Because of limited computer classroom space, our current GIS resources must be relocated to a different classroom each semester. Some classrooms have worked better than others and we have received tremendous technical support from our Information Resources department. However, we have also run into numerous software problems attempting to run GIS software (Arcview) in low-security, high-use computer labs. In addition, many of the monitors in our current computer labs are not adequate (due to size and resolution) for effectively analyzing GIS work.

The college has an exceptional opportunity to address this problem with a new 30,000 square foot science building. Construction on the Curtis L. Ivey Science Center will begin in February 2003 and it will be ready for use in the fall of 2004. The Ivey Science Center will house all Natural Science programs (biology, chemistry, math and general science), the Community and Environmental Studies program, and a Social Science lab. This new building will place Colby-Sawyer College in an exceptional position for high quality science education over the coming decades. The building will also enable the college to dedicate one room as a spatial ecology lab with computer hardware and peripheral equipment that will maximize student access to GIS technology.

The lab will allow us to provide GIS/GPS instruction to a much wider group of students. For example, through our new liberal education program we have developed an exploration category call environmental literacy. This was developed in response to our own reflection on
the need for this type of study and the increasing attention over the past decade to the importance of environmental literacy (Orr, 1990) and place-based education (Elder, 1998; Leslie, Tallmadge, Wessels & Zwinger, 1999). CES 202 is one of the course options in this new category. This curricular development will provide us with an opportunity to offer GIS and GPS technologies instruction to students beyond the CES program and help generate interest in the study of other applications of the technologies.

**Key Elements of the Project**

**Stage I**

The first stage of the project will involve training for the 4 project investigators that will augment their current expertise with GPS/GIS/image analysis technology. Each of the project investigators has basic familiarity with GIS and GPS. Additional training will allow us to instruct students in the most valuable aspect of integrating GIS into community-based education; conducting their own analyses from data they generate and collect from various sources.

Examples of possible training opportunities include the Community Mapping Course (3 weeks) and the Faculty Mapping Access Project (2 weeks) through the University of New Hampshire Cooperative Extension. Efforts will be made to ensure that the project investigators develop skills in both the natural resource applications of the technology as well as social applications including census data. Following the training opportunities, investigators will develop curricular plans (lab experiences, course projects, case studies, etc.) for expanding the application of GPS/GIS in several courses and determine the evaluation plan for the project. At this stage of the project we plan to purchase a Trimble XR-Pro GPS unit and a digitizer. Also, the project consultant and assessment coordinator at Colby-Sawyer College will work closely with the project investigators at this time. Courses that will benefit from these efforts include the following:
1. **CES 101: Air** (4 credits)

This is the introductory course for the CES program and an environmental literacy exploration course option. Students encounter the concepts of systems and sustainability and work to understand the necessity of a multidisciplinary approach. Students see how science, ethics, economics and business, environmental health, public policy, and the study of communities and human population growth can all affect environmental problems and solutions. Currently in this course students are given an introduction to GIS and GPS and also develop basic skills in map and compass reading. We anticipate that the faculty training opportunities and preparation will generate additional lab experiences and activities that prepare students for more advanced work in subsequent courses.

2. **CES 202: Earth** (4 credits)

This is an intermediate course for CES students and another environmental literacy exploration course option. In this course students examine the development of the earth and the processes that continue to change its structure. Soil pollution and topsoil erosion and their effects on human and non-human communities are addressed, as are terrestrial ecosystems and flora. Students are provided an extended opportunity to work with GIS in this course. Working with tutorials that have been specifically developed for this course, students develop natural resource maps for local communities. We would like to continue revising the tutorials for this course so that students can examine additional information such as social variables (population density, income, etc.) and can build oral and written presentation skills as well as experience in using a plotter.

3. **CES 301 & 302: Advanced Community and Env. Studies I & II** (18 credits)
The third year is the defining characteristic of the Community and Environmental Studies program. Rather than choosing from a series of 300-level course options, all students are immersed in an in-depth, yearlong analysis of a local environmental problem or issue with detailed fieldwork and extended site visits. This structure allows students to work at length on a complex problem while developing important skills in group-oriented tasks to a degree that is not obtainable in traditional courses. A new project is developed each year that focuses on an important environmental issue or problem in the local community. Students must enroll in both CES 301 (fall – 12 credits) and CES 302 (spring – 6 credits). Given its structure, this course provides the primary opportunity for students to significantly advance their GIS/GPS skills beyond simple projects and applications. They are provided with dynamic, real-world problems that require the collection and analysis of data. We would like to strengthen our GIS/GPS work in this course by developing an array of GIS/GPS techniques that students could use with future projects. Examples include tracking, examining demographic information, and integrating GIS/GPS into environmental impact assessment.

4. CES 486: Senior Research Seminar (3 credits)

As a final component of the CES program, an independent research project must be completed by students in some area relevant to the study of community and environment. In consultation with the faculty member directing the seminar, students identify a topic of interest, complete a literature review, determine appropriate research or analytical methodologies, prepare a project proposal, conduct the research and analysis, and present the findings to the appropriate audiences. These efforts culminate in a final written report and oral presentation. In addition, each student identifies and works with a faculty mentor throughout the semester to gain or develop specific project-related expertise. Class sessions
provide opportunities to discuss project progress and problems, issues related to analysis and writing, and preparation for the final presentation. This course also addresses the professional development of students as they prepare to seek employment or pursue graduate studies.

Working with GIS/GPS is becoming a popular choice for students who take this course. With the loan of a Trimble XR-Pro GPS unit from University of New Hampshire Cooperative Extension, one student designed an interpretative trail for a local land trust. Other students are already preparing for projects that will examine winter habitat for white-tailed deer on state land in Vermont and wildlife corridors at a national wildlife refuge in New Hampshire.

As each student must work with a faculty member, the training that the investigators will receive through this project will allow us to support a broader range of student research projects.

We anticipate that more than 75 students per year will benefit from these curricular integration plans. This will include first year students and sophomores from the entire student population and juniors and seniors in the CES program. As the majority of Colby-Sawyer College students are women (65%) this project will also expand science education opportunities for women. In addition, we expect that students enrolled in the following courses will also benefit from this project as these courses are regularly taught by the project investigators and cover topics associated with the GIS/GPS applications:

- CES/BIO 107: Interactions in Biology (4 credits)
- CES/BUS 116: Introductions to Organizations (3 credits)
- CES/BIO 407: Conservation Biology (3 credits)
- CES 350: Field Studies
- CES 485: Community and Environmental Studies Internship (0-6 credits)
- SCI 120: Environmental Issues (4 credits)
**Stage II**

Following the initial work on curriculum integration, project personnel will work to revise curricular plans based on preliminary project evaluation information. The project investigators will then split into two teams. One team will work on dissemination plans for the project and the other team will develop a new interdisciplinary GIS/GPS course (CES 3XX or 4XX) that will provide students with opportunities to conduct conventional GIS analyses such as spatial data and problems in field-oriented disciplines such as biology and environmental studies as well as problems in economics, political science, and sociology.

At this time, the new science building will be ready and we will work on the second phase of equipment purchase - the development of a dedicated spatial ecology laboratory with computer hardware and peripheral equipment that will maximize student access to GIS technology. Once this is done we will start a second iteration of the curriculum integration and project evaluation work before sharing project outcomes according to our dissemination plans.

**Timetable**

The timetable for this project is 36 months. Faculty training and materials development will occur prior to curriculum implementation. The College will continue to support the project after the fiscal timetable has expired through ongoing course instruction and standard funding for faculty development opportunities. The complete project (fiscal and curriculum integration) is scheduled to begin June 1, 2003 and end May 31, 2006. The timeline is as follows:

**Summer 2003**
- Investigator training, preliminary curriculum planning, evaluation planning
- Purchase Trimble XR-Pro GPS unit and digitizer

**Fall 2003 – Spring 2004**
- Preliminary curriculum implementation and evaluation
Summer 2004
➢ Purchase computer hardware, develop instructional materials, plan new interdisciplinary GIS course (CES 3XX or 4XX), develop final stage of evaluation plan, determine dissemination activities

Fall 2004 – Spring 2005
➢ Secondary curriculum implementation and evaluation

Summer 2005-Spring 2006
➢ Dissemination

Experience and Capability of the Principal Investigators

**Dr. John Callewaert (PI):** Dr. Callewaert is director of the Institute for Community and Environment and an Assistant Professor in the department of Social Sciences and Education. He has used a variety of GIS techniques to demonstrate the disproportionate impact of environmental problems on communities of color and low-income. Dr. Callewaert promotes community-based research and service learning activities in his courses. These activities are enriched by his numerous community collaborations including the Community Mapping Program of the Vermont Institute of Science, board memberships with the Lake Sunapee Protective Association and the Friends of the John Hay National Wildlife Refuge, participation in the New Hampshire GIS Higher Education Consortium and funded projects of the Wellborn Ecology Fund of the New Hampshire Charitable Foundation. He is a co-instructor with the land-based environmental core course (CES 202), lead instructor with the third year community-based research course (CES 301/302), and directs the senior research seminar (CES 486).

**Dr. Ben Steele (Co-PI):** Dr. Steele is a Professor of Biology in the Natural Sciences department. He was instrumental in the design of the CES program and developed the introductory course for the program (CES 101). During the summer of 2001 he participated in the Community Mapping Program hosted at Colby-Sawyer College by the Vermont Institute of
Natural Science. Over the past two years Dr. Steele has developed several lab sessions for CES 101 that provide a basic introduction to GIS as well as training in map reading, compass work and the use of GPS units. The course also includes units on the local zoning ordinance and students attend planning board meetings. Dr. Steele teaches several other courses related to the CES program that have GIS applications. These include ecology (BIO/CES 107) and conservation biology (BIO/CES 407). For most of 2003 Dr. Steele will be on sabbatical studying population changes of Sea Ducks in Finland, specifically how nutritional condition at the beginning of the breeding season affects breeding behavior and reproductive success. His work with the New England Institute of Landscape Ecology includes studies of the effects of habitat fragmentation on bird populations, specifically how low-density housing and openings in forests affect populations, nest predation, and predator behavior.

**Dr. Leon-C. Malan (Co-PI):** Dr. Malan is an Associate Professor of Business Administration. He was actively involved in the development of the CES program. He has designed a special section of an introductory business course (BUS 116) to specifically meet the needs of CES students. He has team-taught CES 101 with Dr. Steele and CES 302 with Dr. Callewaert. For the current academic year, Dr. Malan is on sabbatical. His sabbatical work involves the completion of a Ph.D. in environmental studies at the Antioch New England Graduate School. His research is focused on the study of the establishment of protected areas in post-colonial African countries and the development of policies to accommodate communities in and around national parks. More specifically, he is examining the application of GIS and GPS technologies for collecting data for social impact assessment surveys in Angola. Dr. Malan is also a member of the Sutton Conservation Commission.
Ms. Laura Alexander (Co-PI): Ms. Alexander is a doctoral student in the environmental studies program of Antioch New England Graduate School. Her doctoral work is centered around issues of community change and place attachment. During the summer of 2001 she participated in the Community Mapping Program hosted at Colby-Sawyer College by the Vermont Institute of Natural Science. For the past three years she has been an adjunct instructor with the CES program and before that served on several curriculum design committees for the CES program. She is a co-instructor with Dr. Callewaert for the land-based environmental core course (CES 202), a co-instructor with Dr. Callewaert and others on the third year community-based research course (CES 301/302), and has served as a faculty advisor for a senior research project. Alexander developed a set of 9 GIS tutorials that guide students in CES 202 in the development of natural resource maps for local communities. (One of the tutorials is included as a supplemental document with this proposal.) She has also developed a virtual herbarium of locally significant plant species (http://www.colby-sawyer.edu/academic/ces/herbarium/index.html). Ms. Alexander is a member of the New London Conservation Commission and the New Hampshire GIS Higher Education Consortium.

Other Project Personnel

**Students:** Two CES students will be identified to provide input on the curriculum integration plans and in evaluating the project. Other opportunities for students on this project include serving as teaching assistants for 100 or 200 level courses that integrate GIS and GPS.

**Consultant:** Nancy Lambert, Natural Resources Specialist with University of New Hampshire Cooperative Extension has agreed to serve as the project consultant. She has expertise in the development of geospatial technology training programs for educators,
community decision makers and natural resources professionals. She also has experience as a professional evaluator in developing evaluation instruments.

**Assessment Coordinator:** Deborah Taylor is the Academic Dean at Colby-Sawyer College. She is currently heading a coordinated assessment effort at the college and has agreed to work with the evaluation efforts for this project.

**Evaluation Plan**

For project evaluation we will follow several assessment techniques developed by the Field-Tested Learning Assessment Guide (http://www.flaguide.org). These are assessment techniques specifically developed for science, math, engineering and technology instructors. An initial list of assessment goals and techniques for this project are identified below:

<table>
<thead>
<tr>
<th><strong>Goals</strong></th>
<th><strong>Techniques</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Students</strong></td>
<td>▪ Attitude Inventory</td>
</tr>
<tr>
<td>▪ Develops skill in using materials, tools, and technology central to subject</td>
<td>▪ Concept Mapping</td>
</tr>
<tr>
<td>▪ Recognizes interrelationships among problems and issues</td>
<td>▪ Concept Tests</td>
</tr>
<tr>
<td>▪ Communicates in writing and speaking effectively</td>
<td>▪ Conceptual Diagnostic Tests</td>
</tr>
<tr>
<td>▪ Uses computer-based resources effectively</td>
<td>▪ Interviews</td>
</tr>
<tr>
<td>▪ Indicates understanding of interdisciplinary perceptions</td>
<td>▪ Performance Assessments</td>
</tr>
<tr>
<td><strong>Instructors</strong></td>
<td>▪ Portfolios</td>
</tr>
<tr>
<td>▪ Instructors develop and refine instruction based on feedback</td>
<td>▪ Weekly Reports</td>
</tr>
</tbody>
</table>

The project’s impact on the curriculum and college learning outcomes will also be evaluated using the college’s established assessment techniques including formative and summative approaches. We will use all of these techniques to examine the specific course outcomes and the overall success of expanding GIS/GPS application in our curriculum.
Dissemination of Results

The project investigators, representing diverse fields, will have access to a wide variety of forums for disseminating project results. Funds requested in the project budget will be used for project personnel to attend professional conferences where environmental education and problem-based learning are emphasized – including the North American Environmental Education Association, the Northeast Environmental Studies Programs Association, the National Conference on Undergraduate Research and/or written up for journal publication by students and faculty. Edited reports of student projects will also be shared with collaborating organizations and will be featured in poster format as part of our annual CES Expo that draws more than 150 students, faculty and local residents. In addition, we will make the results of this initiative and student project available on the CES program homepage (http://www.colby-sawyer.edu/academics/ces). We also anticipate sharing the results of our work with colleagues at Colby-Sawyer College. This includes the other 6 faculty members of our CES faculty committee and other faculty colleagues who are interested in GIS/GPS applications in their disciplines.


National Science Foundation. 1996. Shaping the future: new expectations for undergraduate education in science, mathematics, engineering and technology. National Science Foundation, Washington, DC.


Shaping the Future. 1996. New Experiences for undergraduate education in science, mathematics, engineering, and technology: a report on its review of undergraduate education. The Advisory Committee to the National Science Foundation.

