a. Project Overview

The Environmental Studies (ENS) curriculum at Alfred University offers a rich variety of natural and social science courses in which students take a hands-on approach to learning. Recently we began to offer geography courses, including GIS, and were supported in this endeavor by a modest University investment in software and hardware (App. A). However, our strengths in teaching geographical analytical skills are limited by our inability to place much of our work in our own local spatial context. We want students to be able to collect and analyze their own geographic information and relate their results to characteristics of the local landscape.

This proposal requests funds to obtain equipment that allows students to collect and input spatial data into existing computer systems, to interpret those data with GIS, and then to create visual output of the data or resulting analyses for classes and public presentations. We will adapt and implement educational materials and evaluation methods as we integrate a spatial perspective into our curriculum.

b. Goals and Objectives

We will revise our curriculum to:

• provide students at all levels with a geographic perspective of place and scale;

• create opportunities for comprehensive field-based inquiries at local sites;

• enhance the available geological, hydrological and biological data sets with relevant and precise spatial information;

• introduce science and non-science majors to GIS technology and its analytical capabilities;

• take advantage of the multidisciplinary nature of geographic inquiries to strengthen the bridges between the natural and social sciences.

In the past two decades, new approaches to teaching science have been widely discussed (cf. Johnston and Aldridge 1984; AAAS 1990; Emiliani 1991; Johnson et al. 1991; Mayer et al. 1992; NSF 1996; Hurd 1998). Recommendations for more effective science education include “learning by doing” (cf. AAAS 1989, 1990; Dunkhase and Penick 1990; Miller and Cheetham 1990; Uno 1990; Laws 1991; Bonwell and Eison 1991; Ramsey et al. 1997), cooperative or group learning (cf. AAAS 1989, 1990; Johnson et al. 1991; Howard and Boone 1997), inquiry-based activities (AAAS 1989, 1993; Bonwell and Eison 1991; NRC 1996a, 1996b; Ireton et al. 1996; NSF 1996) and teaching science courses that revolve around a unifying theme or relevant problem to be solved (cf. Rutherford and Ahlgren 1990; Steen 1991; Mayer et al. 1992; Ireton et al. 1996; Marzano 1998). The integration of computer-based information technologies into educational experiences, starting with introductory courses, is also encouraged (Merritts and Shane 1992; Ireton et al. 1996; NRC 1996a; Boyer Commission 1998). We have increasingly used all of these approaches successfully (see curriculum vitae and Results of Prior Support) and continue to modify our courses to incorporate more of these strategies.

At the same time that educators are evaluating how they teach science, the nature of science is changing. Contemporary science is becoming increasingly interdisciplinary, and interdisciplinary research and education are being encouraged (Sigma Xi 1987; Rutherford and Ahlgren 1990; Boyer Commission 1998; Hurd 1998). Thus, interactions between the physical, chemical, and biologic components, as well as social, political and economic considerations, have been fundamental to environmental research and education for many years.

More recently, the importance of geographic analyses, incorporating the concepts of *"place* and *scale,"* has been acknowledged in many fields, particularly environmental science. A recent report, "Rediscovering Geography: New Relevance for Science and Society," (NRC 1997), elucidates how a "geographic perspective" aids in both research and education. Techniques used by geographers for observation (e.g. field exploration, spatial sampling) and data analysis and display (e.g. cartography, spatial statistics, GIS) (p.3) can and should be applied to the study of most environmental issues in order to consider them in their proper landscape context. Direct field observation and precise spatial sampling (e.g. using GPS) are necessary not only to collect primary data, but also to check the validity of secondary data sources and interpretations made from remote sensing imagery (p. 51). Data analysis and display techniques have improved substantially in the past 25 years and have now advanced far beyond the traditional two-dimensional paper maps; GIS creates maps that are dynamic and multidimensional.

Research has also shown that visualization tools, used extensively by geographers, can play an important role in the common stages of scientific research, namely, exploration of research questions, confirmation of hypotheses, syntheses of ideas and explanations, and presentation of results to others (DiBiase 1990, MacEachren et al. 1992). Visualization tools, such as maps, graphs, and GIS layers, provide concrete representations of spatial information that may be difficult to conceptualize mentally (Friedhoff and Benzon 1989, MacEachren et al. 1992).

Visualization tools will certainly be as profitable to our students as they are to research scientists. The benefits of these tools are the rationale for adding a geographic orientation to our curriculum and include (MacEachren et al., pp. 110-124):

- providing a change in perspective from a collection of discrete data points, often gathered out of context, to a spatial representation of all data points in a single place (a map!) with reference to their surroundings;

- providing a synoptic view, extending vision to areas that are larger than we can see directly (e.g. a remedy to literally not being able to see the forest for the trees);

- allowing us to see data that are typically not tangible or visible (e.g. UV radiation, water table depth, species diversity, economic status);

- allowing us to view data at various scales and/or using various filters to select specific features or types of data;

- allowing us to transform data in a variety of ways so that they are more easily visualized (e.g. two-dimensional map to a three-dimensional map clearly showing surface trends);

- providing a means by which several kinds of data can be represented on a single image (a map) (e.g. physicochemical and socioeconomic information together);

- allowing us to depict changes in data over time (e.g. using time as a third dimension in maps).

Thus, because we want our students to enjoy all of these advantages, we plan to integrate a geographic perspective into our curriculum at all levels.

c. Project Description

Background

Alfred University is a private institution with an enrollment of approximately 2000 undergraduate students. All recent annual surveys of *U. S. News and World Report* rank Alfred University at or near the top among institutions of a similar nature in our northeastern region.

ENS has been in existence since 1971, offering a B.A. degree with an emphasis in either natural or social sciences. Like most departments in our college, we offer only an undergraduate degree. The major consists of several courses specifically designed for the program ("ENS" designation), as well as many others taught by faculty in various other departments.

The ENS program attracts many bright and motivated students. Over the last several years, enrollment in ENS courses and the number of ENS majors has remained steady or increased. Since 1994, the average graduating class has had 18 majors, making it one of the most popular majors on campus. Typically, about 12% of each class are National Merit Scholars, and about 20% are members of the Honors Program at Alfred. Also, 45% of the students who have received ARGUS (Alfred Research Grants for Undergraduate Students) grants, a prestigious and competitive award that provides students with funds to conduct extracurricular research, have worked with ENS faculty. We strongly encourage our students to double major in a "traditional" discipline (such as Geology, Biology, or Political Science) to add depth to their education and over 50% of them do. Approximately one-quarter of our seniors go directly to graduate school, and more within a few years of graduating (App. B).

In 1997, a geographer joined ENS, enabling the Division to offer courses in geography, including GIS. The University supported this change and continues to encourage ENS to pursue its interests in GIS and spatial analyses (App. C). Introduction to GIS (ENS 220) has been offered twice, and while our existing resources are adequate for such a class, we are limited by our presently inadequate means to generate spatial data from local sources, to offer GIS instruction to multiple classes during a single semester, and create large-format output from our analyses.

Proposed Project

We plan to integrate a spatial perspective and geographic analyses into our existing ENS curriculum at all levels. The requested funds will provide for software, lab equipment and peripherals, and one month of summer salary for a principal investigator (D. Sinton) to modify several extant courses with new exercises or modules. Furthermore, GIS is a recent (1997) addition to the Division, and the University will provide release-time for all three full-time ENS faculty so that the non-geography faculty can learn more about GIS data (input and availability) and GIS analytical capabilities, and the whole department will develop ways to coordinate GIS with other technology used by the department, such as our Electronic Total Station and the proposed GPS, for integration into our multidisciplinary curriculum (as per Wikle and Lambert 1996).

Spatial analyses and use of equipment in ENS courses

A top priority is to have students in several courses (App. E) involved in developing a GIS of the University campus, the village and township of Alfred, and our local field sites. Thus, the GIS is not only a tool, but will be a unifying thread that will run through many of our courses. Students in the **Introductory and Advanced GIS** classes (ENS 220 and ENS 320 - Sinton) will gather digital data, available from places such as the New York State GIS Clearinghouse, to establish data layers of topography, road, stream, and railroad networks, tax parcels, and census block data. Students will then use the GPS to add locational data from the campus and our local field sites, including academic and residential buildings, features of the local forest (the trail network, forest stand composition, exact location of identified threatened or endangered plant species, known animal habitat, etc.), location of the groundwater wells and stream gauging/sampling equipment installed and used by our department, and the delineation of local wetlands. We will use our GIS and GPS capabilities to analyze *local* environmental issues such as site remediation at an abandoned quarry and point-source pollution from local industrial or agricultural sites. Students will also digitize historical maps of the University campus and the village to show local changes over time. The large-format digitizer will allow us to take advantage of these locally-available map resources as effective and relevant teaching tools.

Comparable efforts have been successful at West Chester University (PA) and Stockton State College (NJ), using ArcView software in conjunction with state-wide, regional or local digital data (Potvin et al. 1994; Cromartie 1994). We will adapt a manual developed by the Environmental Studies Program at Stockton State (Barber et al. 1998) as a framework for modifying our Introductory GIS course. The Stockton manual blends step-by-step computer instructions with "real" data, auxiliary information to help interpret the data, and realistic lab objectives. We will adapt the manual to concentrate on local data. Stockton students who have used this ArcView manual in their Environmental Issues class are better able to visualize spatial data, interpret maps, and navigate in the field, particularly when compared to other Environmental Studies students who have not yet taken the course (Cromartie 1994).

At Alfred our students have access to two large field sites where data will be collected with the proposed GPS and integrated into a GIS. Pine Hill, about 100 hectares of university-owned, forested land, is directly behind campus. A second field site near the village of Alfred is being acquired by the University. This 800-hectare site includes several quarries and other land in various vegetative states. These sites provide an excellent opportunity for students to take equipment into the field and collect geographic data within a single class period.

Once our local GIS is established, students in several courses will be able to use the GPS in coordination with the GIS for spatial analyses using data from local sources, as well as to provide a spatial context for other geographical, geological or biological research. In **Natural Resource Management** (ENS 415 - Sinton), students develop a management plan for a local site. For instance, when students are asked to determine what undeveloped locations around campus would be suitable for construction of new buildings, they will use a "buffer" technique within the GIS to identify a space around the Observatory where light-generating activities need to be curtailed. One exercise that we will adapt for this course involves a similar buffering technique around proposed hiking trails to calculate the value of different types of timber within various buffer widths (Werner et al. 1993). A further adaptation of this exercise will involve evaluating the effect of timber harvest on deer habitat, a concern in our local area (Fillgrove 1999).

While we would like all of our students to take one or both of our GIS classes, we recognize that this will not be practical. However, because one of our goals is to bring aspects of spatial analyses into several classes in different disciplines and therefore reach a larger number of students, we intend to 1) devise/adapt exercises that can be used by those who do not have an in-depth knowledge of GIS and 2) use self-paced interactive courseware modules describing the basics of GPS, GIS and mapping, such as one developed by J. Ritter and M. Sevigny at Oregon Institute of Technology (Sevigny 1998). These modules will introduce GIS and GPS techniques to students in classes, such as those listed below, which do not regularly use GIS or GPS in their curricula. The user-friendly nature of ArcView software will facilitate students' introduction to GIS.

Students in **Environmental Geography** (ENS 103 - Sinton) study aspects of physical and human geography. In one exercise, students will use the GPS to delineate the boundaries of forest stands at a field site and then digitize a second map showing historical land use at the same site; these maps will be overlayed in a GIS. The current species composition in areas previously used for intensive agriculture will vary from the areas that had not been plowed. Such an exercise will lead to lessons on succession, the impacts of soil compaction (by agricultural equipment) on hydrology and drainage, and the legacy of land use patterns. We will also use the GPS to collect field data for analyses of micro-climate patterns. These are exercises that have been suggested by other users of GIS and GPS technology (D. Foster, pers. comm.; Potvin 1994). In fact, this course is similar to one offered at West Chester University, "Applied Environmental Science," in that it teaches about the integration of Earth's systems and fulfills a general education science requirement for non-science majors. We will adapt specific lab modules used at West Chester, including ones in which students learn about interactions between land cover, soil infiltration, and underlying geology (Potvin 1994).

Environmental Research Procedures (ENS 240 and 241) is co-taught by all three of us. It introduces students to the wide range of research techniques that environmental scientists employ. We will use this class to provide instruction (theory and practice) on both the GPS and the digitizer to augment GIS exercises that are already a component of the class. Students in this class already learn field sampling and analytical techniques. With access to a GPS, they will be able to determine the precise locations of their sampling sites (in a digital format) so that they can plot, contour, and spatially analyze their analytical results. We will implement several modules from a GIS-based lab course at West Chester University, also taught there by a three-member, interdisciplinary team, that takes advantage of local sites (e.g. wetlands, sewage water treatment plant) to study environmental issues with contemporary research techniques (Potvin 1994).

<u>Other courses (non-ENS designations but fulfill ENS major requirements)</u>

In **Surficial Geology** (GEO 201 - Hluchy) students will map the surficial deposits in the Alfred area. Most of these deposits are glacial in origin, and the areal extent of each type of deposit varies considerably, making this an interesting area to study. Students will also use the equipment to digitize soil types and then use the GIS to identify correlations between surface characteristics and the underlying materials leading to a better understanding of the relationships between geologic materials and surface topography, stability, slope, drainage, and soil attributes. In another exercise, modeled after work done at Oregon State University and the U.S. Forest Service (Forest Service Employees for Environmental Ethics, 1996), students will map a local stream channel in great detail using the GPS and our Electronic Total Station. These data will be entered into a GIS and used each year by students in the class to identify changes in stream physiography over time and to quantify sediment movement in the channel.

In **Hydrogeology** (GEO 464), students will use the GPS to record the exact locations of ground and surface water samples that are collected within our local watershed for chemical analyses. The ENS department established and maintains groundwater wells (see Results of Prior Support) and a stream gaging/sampling facility. Precise knowledge of the locations of these sampling sites and others within the drainage basin is necessary to produce accurate hydrogeochemical budgets for the watershed and to devise a well-head protection program. Chemical analyses are performed using equipment purchased with funds from a previous NSF-DUE grant. Results will be analyzed spatially (using the GIS) to determine trends in water chemistry, and then combined with the data layers of surficial deposits and bedrock lithology to determine the relationships between the water chemistry and watershed characteristics such as underlying geology, drainage basin physiography, channel geometry, discharge, flow paths, and land use. This approach has been used successfully by students at Smith College to study the Mill River Watershed in order to make quantitative estimates of how land use changes will affect surface water chemistry (R. Newton, pers. comm.).

General Ecology (BIO 394 - Godshalk) has long used local field sites. These sites are designated for multiple use and owned by others; we cannot physically mark plots for long-term study. Two GIS/GPS-oriented projects will be added to BIO 394. In the first, a forest site in which individual trees were laboriously measured and mapped (using traditional methods in a graduate research project over 25 years ago) will be visited by current students to directly measure changes in species composition, successional stage, and net production. The old maps will be digitized and overlayed with new data to determine how individual growth, survival, and community development are influenced by aspect, elevation, slope, distance from stream, etc. Once these data are part of our local GIS database and students regularly add data over the years, our long-term record of ecological change is established, providing students a better understanding of ecological processes that operate on a time scale greater that a single semester. Specifically using GIS and GPS for this approach is successful at other schools (Cromartie 1994.; Parendes, pers. comm.). In another new project, a local abandoned gravel mine will be assessed for potential reclamation. Maps generated with GIS and GPS of slopes, drainages, and soils will be used to plan remediation efforts that include selection of the most viable community type, species composition, need for site preparation, etc. Findings and methods of similar remediation projects in our region conducted by the U.S.D.A., the N.Y. State Department of Environmental Conservation, and a land conservancy will be adapted to this course.

Aquatic Ecology (BIO 396 - Godshalk) will be modified to more substantially consider aquatic ecosystems in the landscape context. Two new projects will introduce contemporary GIS and GPS methods adapted from ones developed at West Chester University (Potvin 1997). First, a modern approach to a standard tool of bathymetric mapping will allow students to efficiently determine basin volumes for use in subsequent determination of nutrient residence times, eutrophication indices, and areal productivity. Second, we will begin to practice wetland delineation at several nearby sites. The inefficiency of mapping local wetlands with traditional methods has made this important technique too time-consuming to be approached in class in more than a cursory way. With GPS, mapping will be a secondary effort so that students can realistically devote their efforts to field measurements and interpretation, adapting accepted methods of the USACE Environmental Laboratory (1987).

Courses offered by other faculty make up an important portion of the ENS major, and we will help our colleagues to add specific spatial analyses or introduce geographic analytical techniques into several of these courses (App. E), such as the introductory ENS course for the social sciences track (**ENS 102**), **Technology, Values and the Environment** (SOC 376); and an **Introduction to Population Studies** (SOC 388). Modifications will include 1) creating a series of maps showing population data in conjunction with variables such as pollutant emissions, income and education levels, and existing infrastructure; 2) using our GIS to have students create their own maps of population and related data, based on their own research efforts for the class; and 3) illustrating the ways in which GIS and GPS have contributed to rationalization (attempts to maximize efficiency) and modernization within groups in our society, such as industry and the military. These exercises are based on ones developed by undergraduate faculty at the Virginia Institute of Technology (Shaffer 1992) and St. Thomas University (Werner 1993) that will be adapted by making them appropriate for a smaller class size of non-science majors, characteristics of our social science classes.

<u>Use of equipment for student research</u>

All majors in ENS are required to do an independent research project during their senior year (App. D), often using equipment purchased under prior-NSF grants (see Results of Prior Support). Their projects will benefit by the addition of spatial analyses to their coursework and the increased range of research opportunities created by having a GPS and a large-scale digitizer available. Examples of current projects that will use the new equipment include research on trails and vegetation at the Finger Lakes National Forest and analysis of oil and gas well logs in western New York State. Without a large-format digitizer, these paper map resources for both of these projects are of little use.

Another current research project, coordinated with the U.S.G.S., involves five students over the past two years doing a hydrologic and biogeochemical characterization of the Tully Moraine (central New York) and small glacial lakes nearby. This project will likely continue for several years and will be greatly improved by the availability of a GPS and enhanced GIS capabilities. Students will use the GPS to map the specific locations of wells, springs and lake water and sediment sample sites so that 1) the same sites can be revisited during subsequent sampling excursions and 2) digital maps of data (water levels, chemistry, etc.) can be compiled and analyzed. Future research projects that our undergraduates will be undertaking include a complete hydrologic and biogeochemical budget for a local watershed (Canacadea Creek, where our hydrologic field station is located), and analysis of the Canacadea Creek bedload which frequently transports large rocks, leading to management problems.

Students are encouraged to present their findings at local, regional, and national conferences, and some of our students have won awards doing so. By having a portable GIS computer (included in this proposal), students will be able to do "on-the-fly" GIS analyses and demonstrations, and use the plotter to create graphic material suitable for poster presentations.

Equipment Request

A **GPS** uses a system of orbiting satellites to gather precise locational data. Our request is for a Trimble Pathfinder Pro XR, a device that can produce very accurate locational information and is well-suited for field work in "GPS-hostile" locations such as our valleys and forests. This GPS unit will allow us to use real-time differential processing, an important feature that allows us to revisit a particular point with a known location. Since we will be establishing plots for long-term ecological research at our field sites, the ability to return to an exact location is critical. Moreover, we are far from the closest sites providing differential data (Warren, PA; Youngstown, NY), and the quality of a real-time beacon receiver assures that we will receive the differential broadcasts at remote locations, such as our field sites.

We will use **ArcView** GIS software as the platform for adapting many of the exercises from other schools. We are currently able to adequately teach GIS to only a small number of students (5 or less) in a single class, without having to have more than two students per computer. More ArcView licenses will enable us to teach more students in each class, and use our GIS capabilities concurrently, i.e. in two or more classes scheduled at the same time during the semester.

A **digitizing tablet** allows students to create a digital file of map elements and other drawings. This is crucial for class projects and student research in our area of New York, where local and regional data are not often available in a digital format and we wish to take advantage of previously created paper maps. A large-format tablet (36" x 48") will be appropriate for digitizing maps available through the county, town and village offices, as well as side-by-side orthophotoquads from state and federal agencies.

Presenting the results of spatial analyses is best done visually. Every ENS major creates a poster presentation of his or her senior research, and many of the students present their research at professional meetings. A **large-scale plotter** will enable us to generate large, multi-color images, maps, and charts for classes and other public presentations where other projection devices are unavailable. A **portable computer**, loaded with our GIS software, will be used in our existing multimedia classroom where we have a video projector but currently no computer that can run our GIS software. A portable computer will also permit us to mobilize our GIS capabilities and use them with other existing projection devices on campus, and it will allow us to download data from the GPS in the field.

Equipment on Hand for the Project (see also Appendix A)

Our primary GIS work is done with ArcView (3.1) and ArcInfo (7.2) on a Gateway 2000 G6/200 computer. This unit is networked to twelve Gateway computers (G6/200 or E-3100), shared with the Computer Science Department, that we use to teach GIS. We also maintain our own departmental computer lab, which consists of four Gateway computers and six Macintosh computers. The additional ArcView licenses requested in this proposal will allow us to run the GIS software on as many as sixteen computers at a time, in both our departmental lab and the shared computer science lab, which will be required to engage an entire class in laboratory exercises involving GIS analyses.

Implementation and Equipment Maintenance

When Alfred University invested in GIS equipment in 1997, it made a commitment to incorporate GIS teaching and technology into its curriculum. The annual maintenance fees for ArcView and Arc/INFO software are paid by the College of Liberal Arts and Sciences. University funds will be used to purchase the extended, on-site repair warranty on the plotter and for the maintenance of the other equipment.

d. Experience and Capability of the Principal Investigators

Dr. Diana Sinton is a geographer who uses GIS in a wide variety of natural and social science applications. She teaches introductory and advanced GIS courses, and directs GIS-based research by ENS majors. Students work on three of her on-going GIS research projects: trail and vegetation work on the Finger Lakes National Forest; a social and economic history of Allegany County, New York; and mapping visualization of New York oil and gas drilling logs for further exploration. She is familiar with or has previously used all of the requested equipment.

Dr. Michele Hluchy is a geologist whose teaching duties are divided between the Geology Department and the Environmental Studies Program. She has attended workshops on teaching critical thinking, has presented papers dealing with the teaching of laboratory and research techniques to undergraduates, and has taught workshops for Alfred University's Institute for Math and Science Education for pre-and in-service K-12 teachers. She has supervised 63 independent study courses in the past 10 years, most of which have been student research projects and has participated in three NSF-sponsored Undergraduate Faculty Enhancement programs addressing strategies for teaching students about problem-solving and water resources.

Dr. Gordon Godshalk is a limnologist and teaches general ecology, aquatic ecology, introductory environmental science (with Hluchy), environmental data analysis, and other courses and supervises independent studies. He has participated in several workshops on teaching critical thinking and national conferences exploring ways to improve undergraduate curricula. He has presented papers on specific techniques used in his classes and has been the chair of the Education Section of the Ecological Society of America. His research interests center on aquatic decomposition and the fate of organic matter in lakes, streams, and wetlands.

e. Evaluation

Our plan to assess the effectiveness of our proposal involves steps for planning, formative and summative evaluation (Hannah 1996). The following table describes our proposed steps.

Planning Evaluation	Formative Evaluation	Summative Evaluation

1. Meet with ENS Coordinating Committee to describe project and for suggestions of courses that will benefit from the addition of specific spatial components.	1. Meet at end of first year with the same committee to see if spatial exercises have been integrated and if any other courses could benefit during the second year.	1. Meet at end of the second year with the committee to discuss efforts and decide how to continue updating spatial exercises in courses.
2. Gather information on specific spatial assessment skills tests and design plan for implementing spatial-visualization tests in ENS 101 and 103.	2. Conduct spatial visualization tests and student interviews in ENS 101 and 103, 2000-2001 academic year.	2. Conduct second set of spatial visualization tests and interviews in 2001-2002. Adapt the test for use in other ENS classes, and track student improvement throughout Major.

An important component of the plan involves a study of the connection between environmental science education and spatial visualization, based on an earlier study by Orion et al. (1997), who evaluated undergraduate geology students on their spatial-visualization skills at the beginning and end of a year-long geology class to determine the course's effects on students' spatial-visualization skills; their results showed that the improvement of these skills, based on two independent spatial aptitude tests, was substantial. We propose to conduct a similar experiment with two of our lower-level ENS classes, comprised both of science and non-science majors. Students will be tested twice per semester using the spatial aptitude tests to assess changes in spatial and visualization skills. Testing the students in this manner will provide us with both formative and summative evaluation results, since we will offer these classes twice during the time period of this project. To follow up on the tests, we will interview students about their spatial skills, following Orion et al. (1997). These types of knowledge surveys have been shown to be particularly beneficial in gaging student learning (Brunkhorst 1996; Nuhfer 1996).

f. Dissemination of Results

We will use a variety of printed, oral, and digital means to distribute the results of our project. Articles discussing the results of our spatial integration and evaluation of students' visualization skills will be submitted to one or more journals such as the Journal of College Science Teaching, the Annals of the Association of American Geographers or the Journal of Geoscience Education. We will also share our findings at the meetings the Council of Undergraduate Research, the Association of American Geographers, the Geological Society of America, and the Ecological Society of America, because we feel that it is important that we share our results with our colleagues in our own individual disciplines. We will continue to encourage our students to present their research at regional meetings of professional societies and special conferences for undergraduate research.

We plan to share our ideas and findings with other regional colleges with similar interests or programs. We have already been in contact with the Geography programs at Edinboro University (PA), SUNY Geneseo (NY), and Colgate University (NY) to discuss methods of teaching GIS and integrating GIS and GPS into our undergraduate curricula.

As environmental data are increasingly available digitally, we will use our ENS home page (http://las.alfred.edu/~ens) as a place where students, faculty, and colleagues can gather information from the locally-based GIS we create. Alfred University is also a member of the New York State GIS Data Sharing Cooperative, and we will make available all of the GIS data we create; this allows our data to be used by other academic institutions and not-for-profit agencies.

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