Expanding GIS Applications in an Interdisciplinary Environmental Studies Program

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Colby-Sawyer College

Abstract

This session will focus on work completed at Colby-Sawyer College for expanding undergraduate student learning and research with GIS. Colby-Sawyer is an undergraduate college of 950 students located in New London, NH. The project has primarily benefited students in the Community and Environmental Studies program at Colby-Sawyer. With the support of a grant from the National Science Foundation, a team of faculty and students determined a plan for incorporating GIS throughout an entire curriculum rather than just in one course. The project results demonstrate how the application and integration of GIS can improve and advance science education; provide a highly effective method for promoting environmental literacy, technology skills and field research; and expand opportunities for collaborative efforts with community-based organizations as well as career paths for students. The presentation will include an overview of the curricular plans, equipment and instructional setting that were assembled as part of the project.

Agenda

- Program Description
- Project Overview
- Curriculum Work
- New Applications
- Assessment
- Next Steps
- Discussion

Community and Environmental Studies (CES) Program Description

- Pre-Professional Focus
  - Year long, 18-credit community-based research course
  - Required internship
  - Senior research project – capstone
- Interdisciplinary, Liberal Arts Curriculum
  - 10 participating faculty from natural sciences, social sciences, business administration, humanities and nursing departments
  - 12:1 student/faculty ratio
- Resources and Technology
  - New 30,000 sq ft. Curtis L. Ivey Science Center
  - Regional water quality lab
  - College forest
- Collaborative Relationships with Local Environmental Organizations
  - John Hay National Wildlife Refuge
  - Ausbon Sargent Land Preservation Trust
  - Lake Sunapee Protective Association
  - Society for the Protection of New Hampshire Forests

Project Overview

- Three year project with funding ($82,822) from the National Science Foundation – Course, Curriculum, Lab Improvement Program ($19,720 in matching funds for equipment) [DUE 0310432].

- Expand opportunities for undergraduate student learning and research with geographic information systems (GIS) and global positioning systems (GPS) technologies.

Project Overview

- Provide faculty training and development in the use of GIS and GPS technologies.
- Refine and expand curricular strategies for GIS and GPS instruction.
- Improve access to GIS and GPS technologies.
- Evaluate faculty teaching and student learning with the technologies.

Impact

- Improve and advance science education.
- Promote environmental literacy, technology skills and field research (Lo, Affolter, & Reeves, 2002).
- Provide
  - new approaches to multimedia instruction,
  - new understandings of environmental and social impacts
  - and expanded opportunities collaborative efforts with community-based organizations (Benhart, 2000).
- Open career paths for students.

New GIS Lab

- 24 seat dedicated GIS Lab in

  new science center
- 19 Garmin XLs
- 2 Trimble GeoExplorers
- Large format digitizer
- Plotter
- ArcView 3.2
- ArcGIS 8.3

Curriculum Map

- Used as a guiding document to identify:
  - Which skills and concepts students should know.
  - Where in the coursework they would learn them.
- Built on the following framework:
  - Skills first (hands on) to generate interest and enthusiasm for working with GIS.
  - Concepts to follow once students have a frame of reference and can visualize the result.
  - Independence. Students begin GIS work dependent upon the instructor, but must learn how to problem solve in order to advance their skills.

COURSES	CONCEPTS	SKILLS	ANALYTICAL CAPABILITIES	LEVEL	STUDENTS	ASSESSMENT
Courses in which GIS/GPS may be discussed (BIO 107, BUS 116, BUS 404, SCI 120, SOC 101, SOC 304)	* Know what GIS and GPS are * Know some capabilities of GIS and GPS (view completed projects)			**Orientation**	**Open to any student**	Include when appropriate on course evaluation
CES 101: AIR	* Know what GIS and GPS are * Know some capabilities of GIS and GPS (view completed projects) * Projection/ datum/map units * Longitude / Latitude * Geodesy * Scale	* Compass work * Reading a map * Interpreting topographic maps * Understand longitude and latitude and express locations in various units * Using a GPS unit - Data collection - Navigation – go to - Geodesy	* Use of geo data * Ground truthing	**Orientation**	**Open to any student**	Pre and post-test on geodesy Mapping skills GPS applications
CES 201: Water	* Understand dynamic functions of GIS	* Delineate a Watershed * Create a project using a module developed by the instructor or with a website (for example USEPA's "Window to My Environment" * Work with data layers	* Interpretation, identification, and description of data * Demonstrate dynamic applications of GIS	**Orientation**	**Open to any student**	Include on course evaluation
CES 202: Earth	* Bias * Epistemology * Professional Responsibility * Implications of Presentation * Understand limitations of GIS/GPS	* Use of Arcview - Create a project - Manipulate data - Analyze data - Create a layout - Disseminate data - Work with extensions (geo-processing, x-tools) * Presentation skills - Map / Written	* Dynamic interpretation * Critical interpretation of data * Communicate usefulness of data	**Introductory**	**Open to any student**	Pre-test on GIS based on UNH pre-test, add GIS component to course learning outcomes evaluation, invite observers to classroom and CES Expo
CES 250: Introduction to Geographic Information Systems New Course	* Be familiar with the range of GIS applications * Be able to articulate basic concepts in GIS including geodesy, projection, data structure and types, scale, ethics, bias, professional responsibility, and limitations.	* Be able to use both ArcView 3.2 and ArcGIS 8.3 at a basic level to obtain data from outside sources, manipulate data, and create a layout to exhibit the results of your data processing. * Use effective cartographic skills to communicate your GIS work to others.	* Describe in some detail how GIS can be applied in at least two fields to answer a question.	**Introductory**	**Any Student prereq: CIS 105 (computer applications course)**	To be developed when course syllabus is developed

CURRICULUM MAP

COURSES	CONCEPTS	SKILLS	ANALYTICAL CAPABILITY	LEVEL	STUDENTS	ASSESSMENT
CES 301/302: Community-Based Research Seminar (Degree of work with GIS/GPS will depend on nature of course project)	* Research methods * GIS/GPS problem-solving relative to course project * Communication – knowing the audience	*Bringing in data - GPS - Outside Sources * Create own themes * Work with digitized image data - Ortho (on screen) - Topo * Communication skills - Oral - Written * Teach and assist others with GIS/GPS * GeoExplorer use	* Multiple interpretations * Understand what data should be on a map * Able to use GIS in decision-making * Able to interpret maps	**Intermediate**	**CES Majors, prereqs: CES 101, CES 201 and CES 202**	Include GIS component in group and self evaluation work, solicit feedback from host organizations, invite observers to CES Expo
CES 350: Intermediate Geographic Information Systems New Course	* Be familiar with the range of GIS applications * Be able to articulate basic concepts in GIS including geodesy, projection, data structure and types, scale, ethics, bias, professional responsibility, and limitations	* Be able to use both ArcView 3.2 and ArcGIS 8.3 at a basic level to obtain and create data, manipulate data, and create a layout to exhibit the results of your data processing * Use effective cartographic skills to professionally communicate GIS work to others * Be able to use the ArcView and ArcGIS help files, as well as to find other sources of assistance to independently problem-solve your GIS questions. * Teach and assist others with GIS/GPS	* Describe in some detail how GIS can be applied in at least two fields to answer a question, * Be able to provide a rationale for using GIS as a method for analyzing data * Plan a GIS project to include: the research question, rationale for using GIS, obtain data (from outside sources and/or create your own), manipulate the data, analyze the results	**Intermediate**	**Open to any student, prereq: CIS 105 and CES 202 (Earth) or CES 250 (Introduction to GIS)**	To be developed when course syllabus is developed
CES 485: Internship	* Depends on nature of internship but may include: - Interaction with GIS professionals - Job shadowing - Career experience	* Depends on nature of internship	* Depends on nature of internship	**Advanced**	**CES majors**	Post internship interviews with students and supervisors, build into internship learning contract when appropriate
CES 486: Senior Research Seminar – Capstone (not every capstone project will incorporate GIS/GPS)	* How to construct a research question using GIS/GPS	* Advanced presentation skills - Power Point - Web * GeoExplorer use including programming	* Greater analytical independence * Able to assist and advise decision-makers	**Advanced**	**CES seniors**	Solicit feedback from community organizations/ mentors, invite observers to CES Expo, build into student exit Interviews
Post Grad						Inquire if/how students are using GIS/GPS on the job

CURRICULUM MAP (cont.)

New Applications: Integration of GIS Across the Curriculum

- GOALS
  - Inform students about this tool: encourage them to take the GIS course.
  - Learning in Context: They will remember more if they use the tool to solve a problem.

GIS Modules in Courses

- Social Science: Sociology, SOC 101
- Science: Biology, BIO 107 Ecology
- Community and Environmental Studies: CES 101 Air

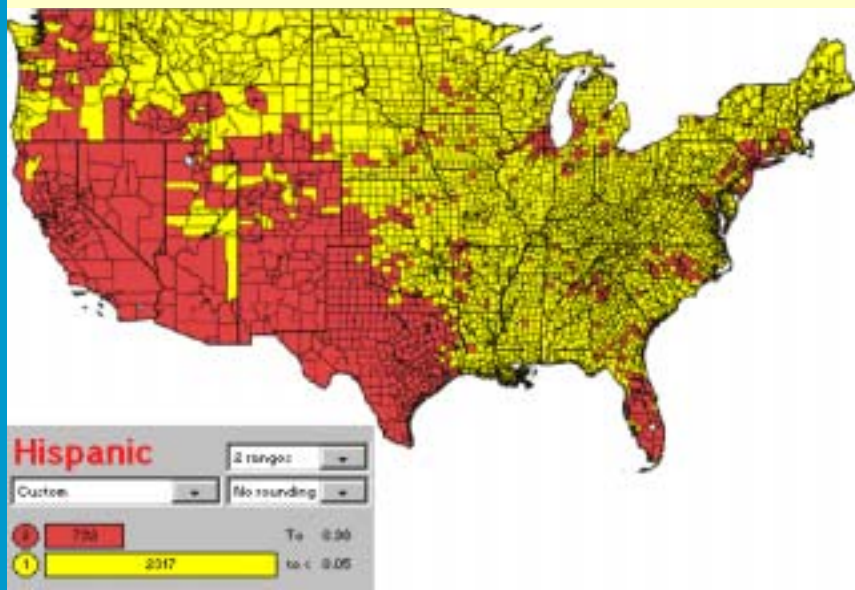
The Best Pedagogy for Non-Majors?

- Instructor demonstration?
- Student tutorial?
- Student assignment with careful directions?

GIS Module for SOC 101: Sociology

- Use GIS and census data to illustrate sociological concepts.
- Explore correlations between variables such as age, level of education, gender, race, etc.
- Work with a variety of spatial scales from block groups to states.

CENSUS 2000 SHORT FORM (SF1)
HISPANICS AS A PERCENT OF TOTAL POPULATION

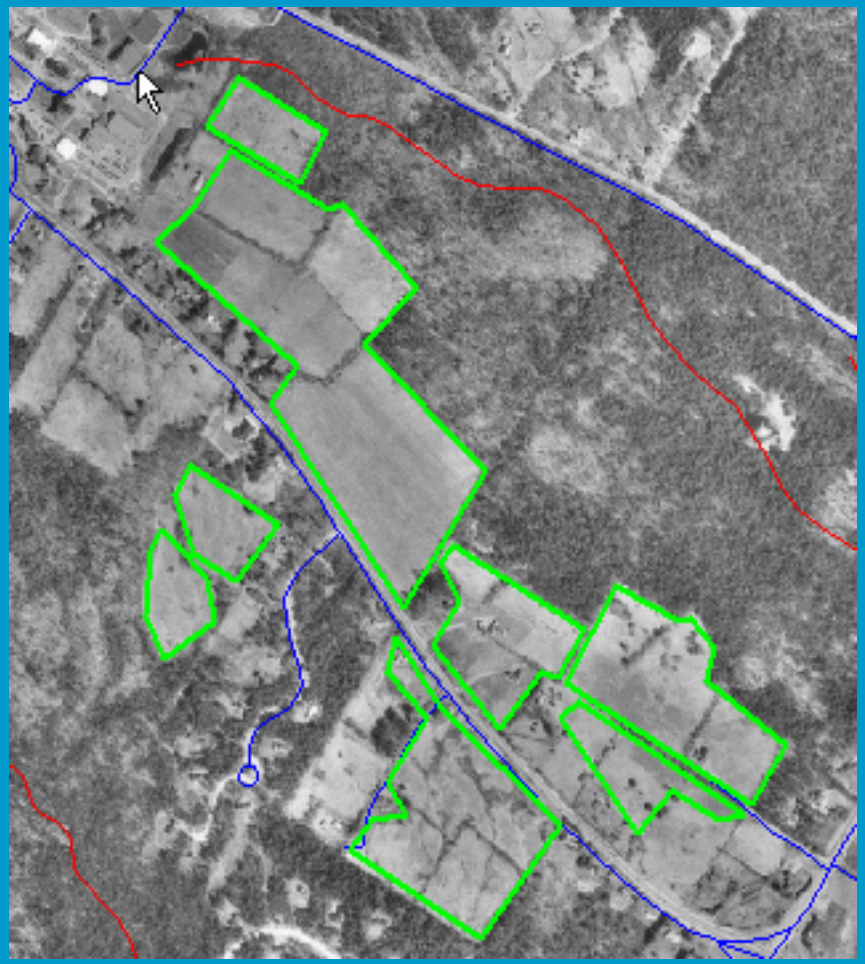


Module for BIO 107: Ecology

- Objective: quantify landscape values in a patchy habitat (fields in forested landscape).
  - Number of patches
  - Area of patches (mean and total)
  - Perimeter
  - Perimeter/area
  - Shape: $S = P/(2\sqrt{(\pi \times A)}$

The Task

- View aerial photograph, identify location, identify fields as habitat.
- Use graphic tools to draw lines around fields.



Other Benefits

- Quantitative literacy
- Spreadsheet literacy
- Aerial photo interpretation

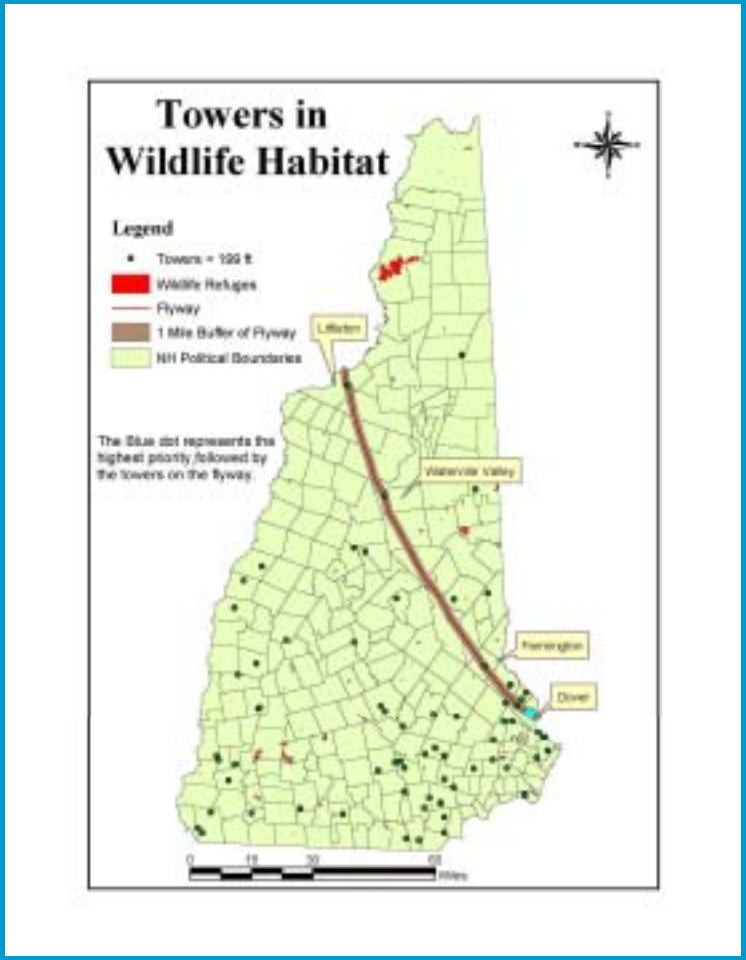
Incorporating GIS in the CES Curriculum

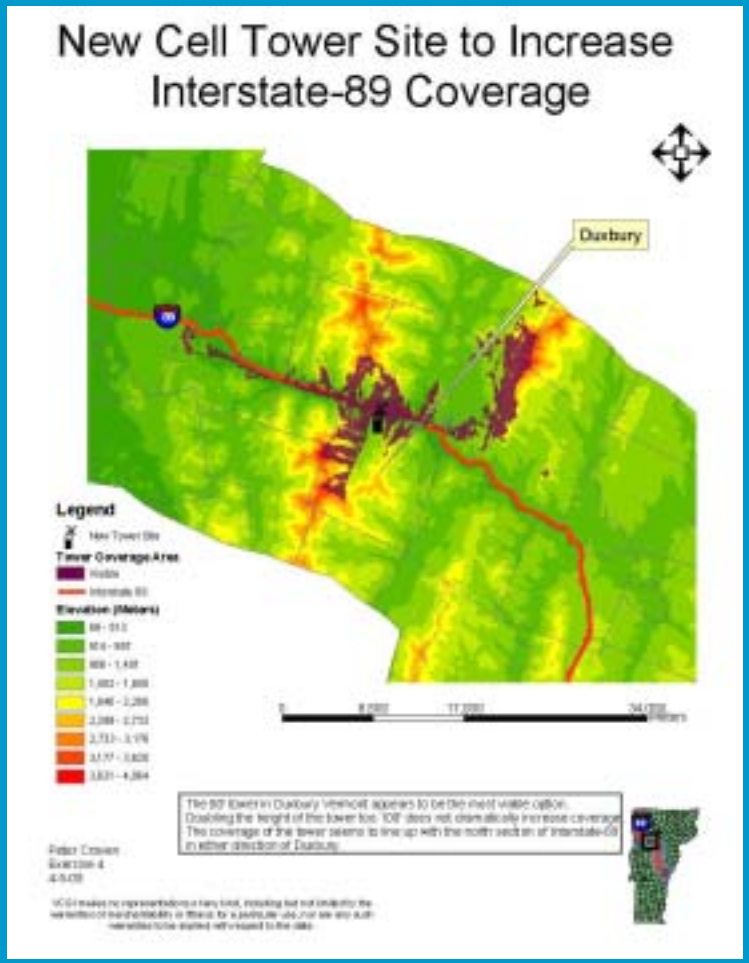
- Introduce GIS and GPS through learning how to read maps and use GPS units. View completed projects with ArcReader.
- Complete introductory tutorials.
- Work through skills exercises at increasing levels of difficulty. Learn basic concepts.
- Use GIS as a portion of the work in a class project (determined by course instructors).
- Develop and carry out an independent project focused on or including a GIS component.

Model for CES 101: Air

- Goal: introduce students to GIS and a few of its capabilities.
- Basic principles, map reading and GPS use.
- Introduction to GIS but not hands-on yet.
- Pre- and Post-test.

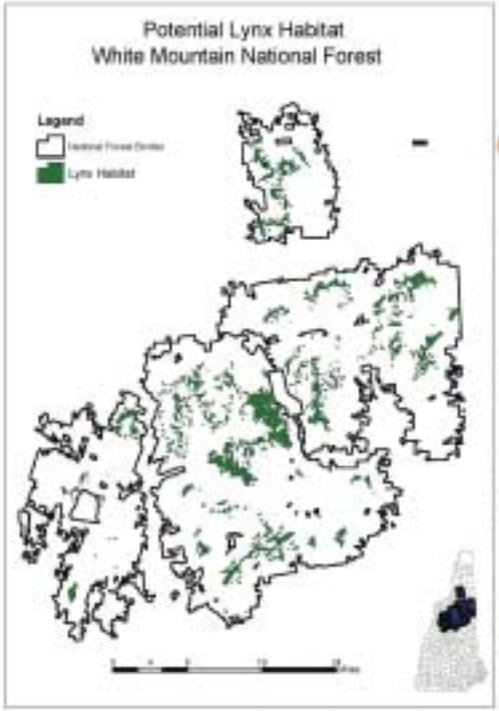
GIS Class - Examples of Skills Exercises



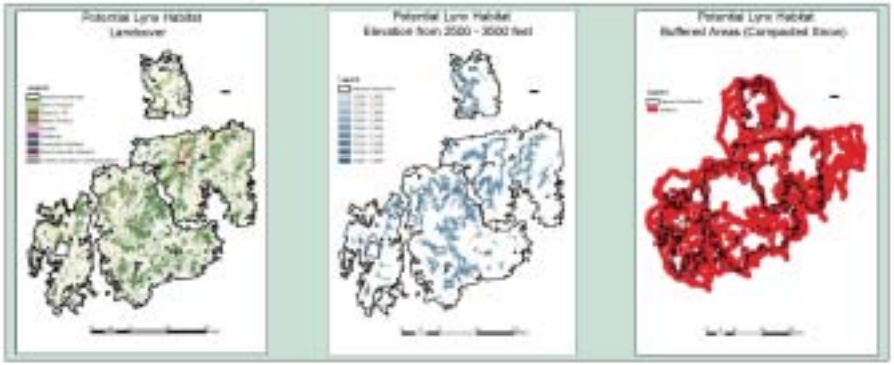


Example of Student Project

Canadian Lynx Habitat Analysis of the White Mountain National Forest



A combination of three different maps (shown in the blue box at the bottom of the poster) were used to identify potential Canadian lynx habitat in the White Mountain National Forest (WMNF). The three maps were: Land Cover in the WMNF, Elevation in the WMNF, and a composite map of three different buffered areas within the forest. Through research it was shown that the Canadian Lynx prefers habitat in boreal mixed wood and boreal coniferous forests. The land cover data for New Hampshire was manipulated to show only the tree species that are contained within these forests. Also shown on the land cover map are the alpine areas, the wetlands, and the early successional forests with in the WMNF, all identified as beneficial for Canadian Lynx habitat. The second map created to determine potential Lynx habitat was an elevation map of the WMNF. This map only shows elevations that range from 2,500 feet to 3,500 feet. This number was found because Canadian Lynx prefer higher elevations below tree line, the tree line in New Hampshire generally falls around 4,000 feet. The third map used was a composite of three different areas in the national forests, alpine ski areas, snowmobile trails, and roads. The Canadian Lynx has larger paws allowing them to function better in deep snow, because of this the Canadian Lynx tend to stay away from areas with compacted snow in the winter. The three areas identified as compacted snow were then given a one mile buffer to show were Lynx habitat would most likely not be found. Once all three maps were complete, the first two — elevation and land cover — were placed in a co-occurrence map showing where the two beneficial habitats overlapped. The final stage in identifying the Lynx habitat was to place the buffered areas over the co-occurrence map. All the remaining Canadian Lynx habitat that was not covered by the buffered areas represents the potential lynx habitat in the WMNF, and is shown in green on the large map. The latest management plan for the White Mountain National Forest identifies the Canadian Lynx as a species of concern in the forest. The WMNF can now take a map similar to the "Potential Lynx Habitat" map and compare it to the proposed land management plans for the forest, potentially conserving the prime Canadian Lynx habitat.



Kristofor L. Kebler

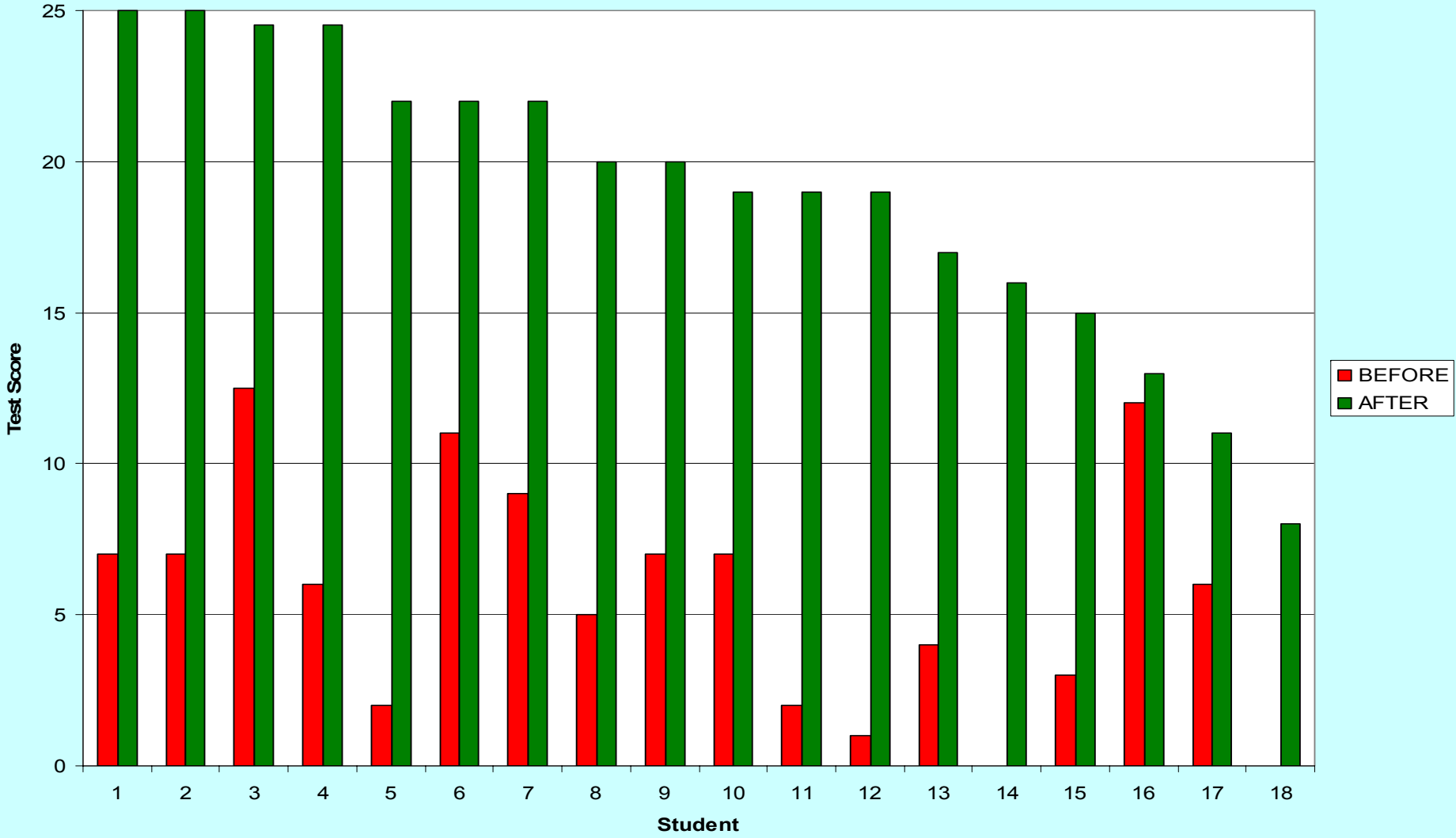
Keys to Success

- In the introductory phase, 'hook' students by having them work through context-based tutorials that introduce them to mapping capabilities.
- As their GIS knowledge and experience deepens, challenge them with short exercises.
- Be sure that students have lab time to work with GIS when an instructor or TA is present to help, but try to resist the urge to help too much.
- "Spiral" approach to teaching and learning emphasizing basic skills while regularly introducing new challenges.
- Move students along to the point where they develop their own projects (this is a big leap).

Assessment

- Pre- and Post Test in CES101.
- Pre- and Post Survey in Sophomore and Junior Year.
- Application of Skills in Third Year Project and Capstone.

CES 101: Fall 2003/2004



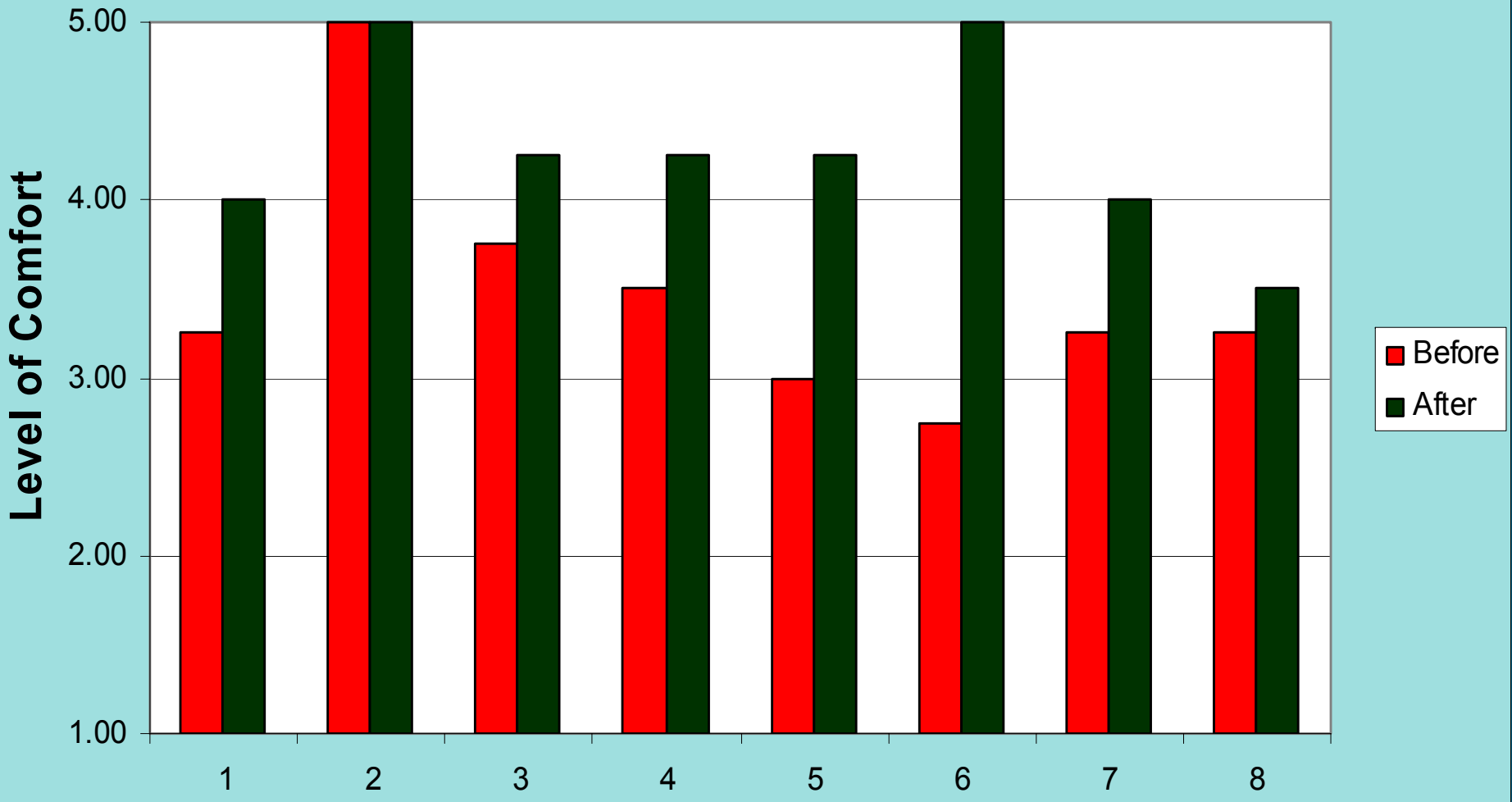
Topographical Knowledge

Question: How comfortable are you with…

	BEFORE	AFTER
Using topographic maps	3.7	4.2
Understanding the significance of map projection	3.1	4.1
Understanding the significance of a map datum	2.6	3.9
Understanding longitude and latitude	4.2	4.4
AVERAGE	**3.40**	**4.15**

* scale: 1= Not comfortable, 5= Very comfortable
** n= 26 for BEFORE, n= 19 for AFTER

Compare: Topographical Knowledge



GIS Competence

Scale:

1 = Unable to do
2 = Able to do to some extent
3 = Able to do well
4 = Do well enough to teach others

n = 26 for BEFORE (n = 15 for last 4 questions)
n = 19 for AFTER (n = 15 for last 4 questions)

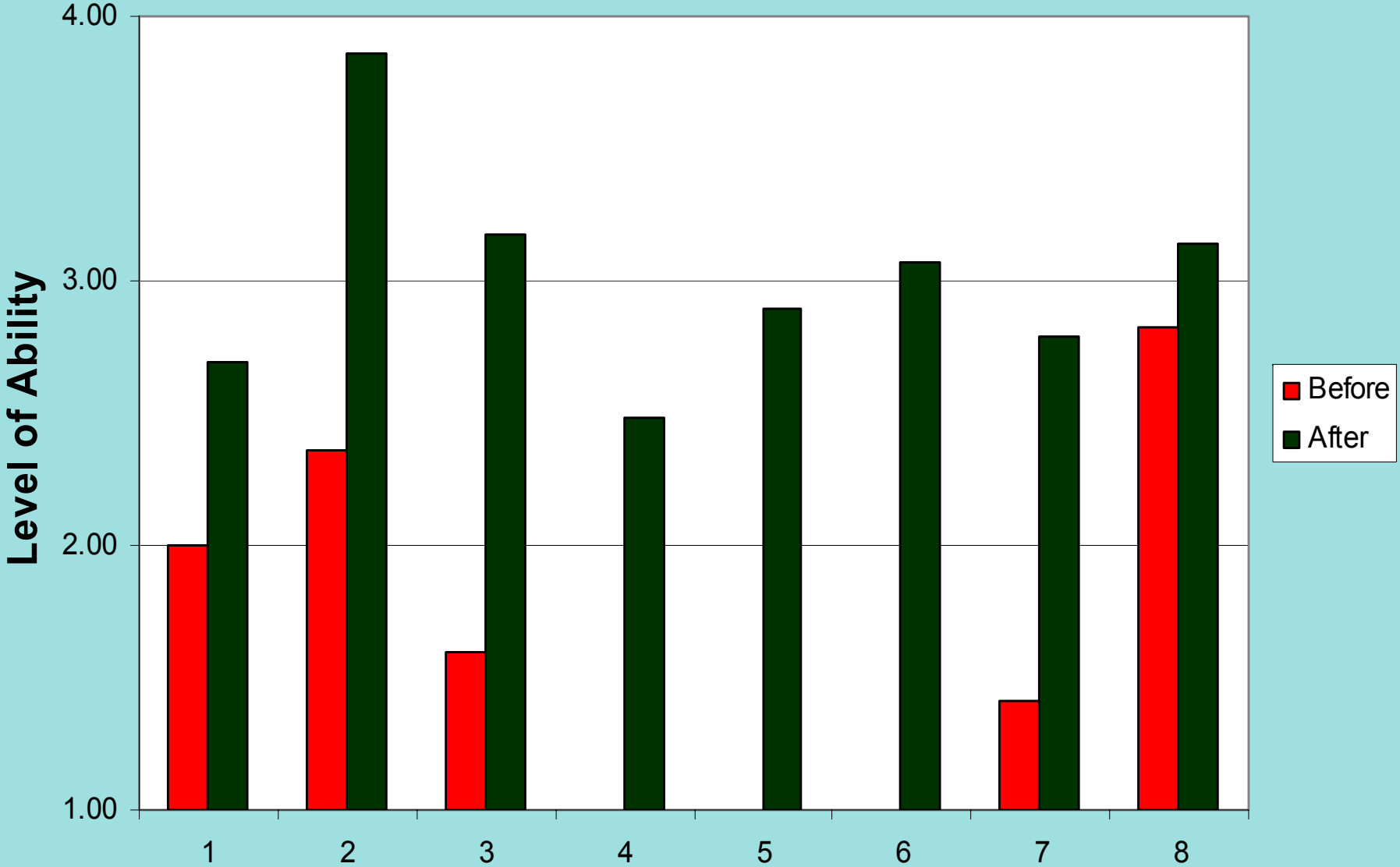
Please indicate, using the scale below, your ability to perform the actions listed.

	BEFORE	AFTER
Acquire new data from the web/other sources	**2.23**	**3.53**
Communicate what GIS is to others	**1.62**	**3.53**
Create a project	**2.04**	**3.42**
Use GIS software	**1.65**	**3.37**
Create a layout	**1.73**	**3.37**
Create maps and know what data to include	1.73	3.32
Assist others to understand the benefits and limitations of GIS	1.50	3.32
Assist others in using GIS software	1.31	3.32
Present and communicate GIS work to others	1.35	3.26
Analyze and interpret data	2.19	3.21
Evaluate the appropriate uses of GIS	1.58	3.21
Understand the limits of data available	1.50	3.21
Use GIS in decision-making	1.38	3.21

GIS Competence (cont.)

	BEFORE	AFTER
Describe scale and accuracy and how they are used in GIS	1.53	3.20
Share data with others	2.19	3.16
Work with image data	2.00	3.16
Create own themes	1.62	3.16
Teach others to interpret GIS data	1.27	3.16
Manipulate data	2.08	3.05
Identify and communicate data needs to a professional	2.00	3.05
Teach the use of GIS software to others	1.19	3.00
Explain the differences between data types (vector, grid, image, etc.)	1.53	3.00
Describe the concept of map projection and coordinate systems	1.47	2.93
Augment analysis with added data layers	1.35	2.89
Construct of research question using GIS	**1.38**	**2.84**
Communicate with GIS professionals	**1.31**	**2.84**
Bring in data from a GPS unit	**1.62**	**2.74**
Interpret a dynamic analysis	**1.38**	**2.53**
Describe the term geodesy	**1.07**	**2.40**
AVERAGE	**1.83**	**3.24**

Compare: GIS Competence



GIS Competence: Biggest Improvement

- Assist others in using GIS software.
- Communicate what GIS is to others.
- Present and communicate GIS work to others.
- Teach others to interpret GIS data.

Consultant Comments

Brad Anderson, GIS Outreach Coordinator, University of New Hampshire.

Strengths:

- Community-based, hands-on projects.
- Emphasis on unstructured, independent, problem solving.
- Students are encouraged to use the analytical component of GIS.
- Lab "an excellent tool for teaching GIS skills."

Consultant Comments

Opportunities:

- Prepare students for meetings with "clients."
- Introduce ArcGIS 9.1 and 9.2.
- Work with GIS professionals in the lab.
- Provide more opportunities for student presentations.

"This course (Capstone) appears exceptionally well geared toward preparing students for environmental analysis using GIS in a professional environment…"

Future Plans / Next Steps

- GIS modules in:
  - Business?
  - Humanities?
  - Nursing?
  - Art?
- Managing multiple platforms.
- Responding to changes in technology and student learning/ability.
- Expanding applications as part of community-based projects:
  - Impervious surface
  - Aquatic ecology
  - Watershed management
  - GIS workshops (ArcReader) for community partners.

Discussion

Sources:

Benhart, J., Jr. 2000. An approach to teaching applied GIS: implementation for local organizations. *Journal of Geography*. 99(6): 245-252.

Lo, C.P., Affolter, J.M., & Reeves, T.C. 2002. Building environmental literacy through participation in GIS and multimedia assisted field research. *Journal of Geography*. 101(1): 10-19.