ABSTRACT

Technological advances have allowed natural resource information to become available in large databases over the Internet. We have developed a laboratory exercise that introduces students to geographic information systems (GIS) and soil and land use databases available from the Natural Resource Conservation Service (NRCS), National Survey Database Access Facility. The exercise involves an introduction to spatial data using the State Soil Geographic (STATSGO) database and county soil surveys using a prototype survey of the Dade County area, Florida. In addition, students are introduced to the concept of scale by identifying land use problems utilizing online county soil survey data (1:12 000 to 1:63 360) and STATSGO data (1:250 000). Students had difficulty using the online soil survey due to the absence of map sheets and quickly identified the advantages of spatially referenced data available from STATSGO, which was viewable in map form using GIS software. This laboratory exercise introduced an application of GIS, spatial data available from the NRCS, and online soil surveys to introductory soil science students to solve a hypothetical regional planning problem. In addition to enhancing students' interests in GIS and associated technology, the exercise effectively demonstrated scale differences by comparison of information available from the STATSGO database and county soil surveys.

TEACHING PROCEDURES

Course Description

The introductory soil science laboratory course at the University of California–Riverside, designated as ENSC 100L, is taught as an independent laboratory course (3 h/wk) that accompanies an introductory soil science lecture course (ENSC 100) (3 h/wk) directed to environmental science students. Most students take the courses concurrently and are juniors and seniors with educational backgrounds of environmental sciences, biology, or geology. The lecture course introduces students to the basic principles of soil science, while the laboratory section focuses on applications of these principles. This laboratory exercise was taught in the 7th wk of a 10-wk quarter. The lecture portion of the 7th wk included a discussion of soil classification and soil survey. Most students had not been introduced to geographic information systems or to online database information before this exercise.

Hardware and Software

The laboratory exercise was taught in a computer laboratory equipped with personal computers (Pentium, 100–200 Mhz), each having Internet access. The software system used to view the spatial data was ArcView 3.1 GIS (Environmental Systems Research Institute, Redlands, CA), as much as possible on factual information (Brown and Miller, 1989). The soil survey has been used for many years in the USA as an aid in farm planning; however, in recent decades the use of the soil survey has expanded into other areas. Today soil surveys are frequently used as a guide for land-use planning, urban development, and design by conservationists, engineers, government agencies, and educators.

Soil surveys are becoming more available to the public by means of a state soil geographic database (STATSGO) and a soil survey geographic database (SSURSGO). These soil geographic databases are spatially referenced to specific locations at the state (STATSGO) and county (SSURSGO) level. From overlays of information within these databases, mathematical and statistical relationships can be developed with the results presented as two- and threedimensional maps (Scott and Smith, 1995).

The objectives of this teaching–learning exercise were to familiarize students with data available over the Internet from the USDA-NRCS National Soils Data Access Facility (NSDAF), particularly soil surveys and the STATSGO database, and to introduce concepts of scale by comparison of county and state level survey information.
Table 1. A descriptive summary of NRCS databases and their uses.

<table>
<thead>
<tr>
<th>Database</th>
<th>Description</th>
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<tr>
<td>MUIR (Map Unit Interpretation Database)</td>
<td><a href="http://www.statlab.iastate.edu/soils/muir/">http://www.statlab.iastate.edu/soils/muir/</a> -- A collection of soil-related properties, interpretations, and performance data for a soil area and its map units, map unit components, and component layers</td>
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<tr>
<td>OSC (Official Soil Series Descriptions)</td>
<td><a href="http://www.statlab.iastate.edu/soils/osd/">http://www.statlab.iastate.edu/soils/osd/</a> -- A national collection of 18,000+ detailed soil series descriptions</td>
</tr>
<tr>
<td>SC (Soil Series Classification Database)</td>
<td><a href="http://www.statlab.iastate.edu/soils/sc/">http://www.statlab.iastate.edu/soils/sc/</a> -- Contains the taxonomic classification of each soil series identified in the USA</td>
</tr>
<tr>
<td>NSSL (National Soil Characterization Database)</td>
<td><a href="http://www.statlab.iastate.edu/soils/natch_data.html">http://www.statlab.iastate.edu/soils/natch_data.html</a> -- Includes physical, chemical, and mineralogical data and pedon descriptions</td>
</tr>
<tr>
<td>STATSGO (State Soil Geographic Database)</td>
<td><a href="http://www.ftw.nrcs.usda.gov/stat_data.html">http://www.ftw.nrcs.usda.gov/stat_data.html</a> -- Contains spatial data made by generalizing detailed soil survey data at a mapping scale of 1:250,000 except for Alaska (1:1,000,000)</td>
</tr>
<tr>
<td>SSURGO (Soil Survey Geographic Database)</td>
<td><a href="http://www.ftw.nrcs.usda.gov/ssur_data.html">http://www.ftw.nrcs.usda.gov/ssur_data.html</a> -- Contains spatial data from original soil survey maps at scales ranging from 1:12,000 to 1:63,360 and is the most detailed level of mapping done by the NRCS</td>
</tr>
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which was developed for use on desktop personal computers (PC).

Internet Database Information

All of the data used in this exercise is accessible through the online USDA-NRCS NSDAF Web site (http://www.statlab.iastate.edu/soils/nsdaf/f). Soil geographic data can be accessed within the facility’s Web site. The STATSGO database can be purchased on an individual CD-ROM (49 states excluding Alaska) or downloaded interactively for each state as an individual zip file. The STATSGO data are available in the U.S. Geological Survey (USGS) Digital Line Graph (DLG-3) format. The NRCS soil map symbols are not normally carried within the DLG-3 file; however, these map symbols are made available as a unique ASCII file when NRCS soils data are distributed in the DLG-3 format. The STATSGO data are also available in ArcINFO 7.0 coverage, ArcView 3.0 coverage, and GRASS 4.13 vector formats. In this exercise we used STATSGO data in the ArcView 3.0 coverage format for the states of Colorado and Florida. Colorado was selected for its obvious changes in topography that influence soil patterns and precipitation and therefore land use. These contrasts are useful for demonstrating STATSGO capabilities. Florida was selected because an online, Order 2 soil survey for the Dade County area is available at http://www.statlab.iastate.edu/soils/nsdaf/dade/front.html. In addition, a bound copy of the Soil Survey of Dade County Area, Florida was available to the students.

Lecture

The exercise was taught to two class sections, approximately 15 students per section. The first half-hour of the laboratory period began with a review of taxonomic classification, and a review of soil mapping units (consociations, complexes, associations, undifferentiated soil groups, miscellaneous land classes), types of soil surveys (Orders 1–5 and their applications), and six NRCS online databases (Table 1).

Assignment

The laboratory exercise was broken into three parts: (i) STATSGO database introduction (interactive with GIS software and STATSGO database information), (ii) online county soil survey introduction (interactive with NSDAF web site), and (iii) an integrated scale comparison of the STATSGO data and a county soil survey (hardcopy and interactive with NSDAF Web site).

STATSGO

Because of the long time required to download data from the NSDAF site to 15 computers accessing the Internet from one ethernet connection, Colorado STATSGO data was downloaded, unzipped, and placed into an easily accessible file on each PC before the beginning of the laboratory period by the instructors. This process took approximately 2 h and varied depending on the speed of each computer. The Colorado STATSGO data was not manipulated in any way before the laboratory period. Students were provided with written step-by-step instructions detailing how to display the data within the GIS software. Two instructors were present to aid those students who had questions.

Students were required to display map units with various properties (agricultural land classification and hydric soils) and answer questions based on their observations (Table 2). These questions were designed to introduce students to a few types of information available from STATSGO and to familiarize students with the scale of the STATSGO database information.
**Soil Survey**

Students were introduced to the Dade County area soil survey as a large scale (Order 2 survey) source of information relative to STATSGO data. The county soil survey questions were designed with a threefold purpose: (i) to orient students to the Web site by encouraging them to search for information, (ii) to familiarize students with the type of information that can be obtained from soil surveys, and (iii) to introduce students to the scale at which county soil surveys are made (Table 2).

**Scale Comparison**

The integrated portion of the exercise involved a comparison of a soil property mapped at the state level (STATSGO) and the county level (Dade County area soil survey). The purpose of this exercise was to compare a specific soil property at two different mapping scales. Students were given the following scenario involving regional transportation planning:

Due to the population increase expected in the near future within the state of Florida, regional transportation planners have begun to review the suitability of land surrounding major cities for local road construction. As a southern Florida regional planner, your task is to verify the road suitability classes of soils at the county level, specifically west of the city of Miami (Miami Ridge area). Within Phase 1 of the review, data generated using the STATSGO database show the soil capability classes of the five map units within the Dade County area (Fig. 1). Use the online soil survey to verify the suitability of map units at the Order 2 soil survey level and answer the relevant questions.

The students were provided with a printout of a Dade County map created from STATSGO data displaying the suitability classes for road construction at the Order 5 soil survey level (Fig. 1). This map indicates that soils in the Miami Ridge area have moderate limitations for local road and street construction. Students were asked to identify the road construction classes of the consociations on the Miami Ridge using the Dade County area soil survey. After identifying the suitability classification of the five map units within the Miami Ridge area, students found that only one map unit had a moderate limitation for road and street construction, while the other map units were rated as having severe limitations.

Within STATSGO, the map unit encompassing the Miami Ridge may contain soils with moderate as well as severe limitations; however, at small scales (e.g., STATSGO) only one or the other can be displayed. For the purpose of this exercise, we chose to represent soils of the Miami Ridge as having moderate limitations for road and street construction. This decision was made to provide contrasting data on road limitations for the Miami Ridge area between the Dade County Soil Survey and STATSGO data, and enabled us to demonstrate one limitation of STATSGO and small scale surveys. There are up to 21 components within a STATSGO map unit that total 100% of the unit, unlike county soil survey map units, which typically have one to three components (Fig. 2). Within STATSGO, the user can choose the criteria to represent the entire unit, whether the criteria make up 1% area of the map unit or 51%. This inherent error and other aspects of STATSGO are discussed thoroughly by Thorson et al. (1996).

**STUDENT RESPONSE**

Students were asked to comment on the laboratory exercise at the end of the period. Most students were frustrated by the steep learning curve when dealing with unfamiliar software and noted that the most difficult portion of the exercise included the task of joining the STATSGO soil components table with the polygon attribute table. However, after managing this task, students were pleased with the maps they generated and appeared to enjoy the exercise.

![Fig. 1. Limitation classes for local road and street construction in Dade County, Florida, generated from STATSGO data.](image-url)
Students were frustrated with the lack of visual representation associated with online Dade County soil survey and appreciated the map sheets within the bound version. Answers to the written portion of the exercise demonstrated that all students gained an understanding of scale differences and the applicability of small and large-scale surveys.

CONCLUSIONS

This laboratory exercise successfully introduced environmental science students to an application of GIS and a few of the NRCS databases available on the Internet within one 3-h laboratory period. It gave them an appreciation for the differing scales of these databases and the applicability of different surveys for regional and local investigations.

We plan to improve this laboratory exercise in the future by the following methods:

1. Encourage students to complete an online ArcView tutorial available on the Internet from the Environmental Systems Research Institute (ESRI) before this laboratory exercise.
2. Preprocess the data to a readily viewable form (join the polygon attribute table with soil components table before the laboratory period).
3. Include a scanned county soil survey map sheet and the general soils map for an on-screen relative comparison of detail between Order 2 and Order 5 surveys.
4. As more and more soil surveys are published on the Internet, we plan to incorporate counties that are closer to our own campus.
5. As the national SSURGO database becomes more complete we plan to use it in conjunction with this exercise to provide spatial data at the county level.

ACKNOWLEDGMENTS

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REFERENCES