Isee - Integrating spatial educational experiences into soil, crop, and environmental sciences

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Abstract
Many of the concepts that our students must master in soil, crop, and environmental science courses are inherently spatial, but our ability to make these spatial patterns clear to our students has been limited. Students, however, need more geospatial skills to understand and address the increasingly complex societal problems that will confront them throughout their careers. We are developing a web-based geographic information system based on Google Earth that will allow students to access a large variety of soil and other maps for any area of the state of Indiana, USA, and we are integrating this new spatial educational experience into our curricula. We have two goals: (1) to develop the ability of our students to use geospatial information to understand how and why soils and landscapes vary spatially at scales ranging from individual fields to a region as large as Indiana, and (2) to develop our students' understanding as to how the spatial distribution of soils and landscapes impacts the distributions of crops, cropping systems, land use, and environmental and natural resource issues. This paper introduces the Isee web site (http://gis.lib.purdue.edu/isee/) and describes our first experiences using it in the classroom.

Key Words
Soil survey, visualization, spatial technologies, Google Earth.

Introduction
Many of the concepts that students learn in soil, crop, and environmental science courses are inherently spatial. Soils vary across landscapes in predictable, repeating patterns. Certain soils and landscapes are better for particular crops than others. An environmental problem may impact a whole watershed, not just the point at which a contaminant is introduced. Patterns of land uses, whether for crop production, forestry, wildlife habitat, or urban development, vary spatially in response to soils, topography, geology, human infrastructure, and many other factors.

Although we implicitly acknowledge the existence of spatial patterns in our soil, crop, and environmental sciences courses, our ability to explicitly observe these spatial patterns visually and make them clear to our students has been limited. Geographic Information Systems (GIS) allow us to visualize and analyze such complex geospatial information. It is well known that an active, visually rich learning environment, like that which GIS offers, significantly increases comprehension and retention relative to a more passive, auditory environment (Bransford *et al.* 2000). We have only begun to take advantage of the powerful, learner-centered instructional tools that GIS has to offer.

In the fall of 2005, we began using a "teaching with GIS" approach in our *Soil Classification, Genesis, and Survey* course using 3 tablet PCs and a minimal GIS dataset. We now routinely take our class on weekly, 3-hour field labs, and on two, all-day field trips using 14 tablet PCs and a GIS dataset that has grown to encompass the entire state of Indiana (92,895 km^2) (ArcNews Online, 2008). Our focus is to teach students how soils and landscapes vary spatially over many different scales, and how the soil geomorphic concepts illustrated with diagrams in the classroom correspond to actual features observed in the field. This approach has significantly altered how we teach field soil science, what we teach (we have learned many new things ourselves), and has significantly impacted student learning.

In this paper we describe our progress in moving our GIS content to a web-based platform to make it available to a larger population of students, and ultimately to the general public.

Methods

Data Layers

We have developed an approach for structuring our GIS data so that it functions as an effective teaching tool. We rely heavily on two data sets, namely, detailed soil survey data that covers the area of interest, and a Digital Elevation Model (DEM) of the same area. Each data set alone is informative, but in combination, the information conveyed is vastly greater.

DEM data is available for Indiana at 1.5 meter pixel resolution (ISDP 2009). We resampled this to 5 meter resolution without compromising the ability to display subtle geomorphic features, but with a substantial reduction in file size. A hillshade was calculated from the DEM data. The hillshade is one of the most useful layers because of how it graphically illustrates the topography. It is used extensively as a base layer for other data, particularly soils data.

Our most important layers are derived from the Soil Survey Geographic (SSURGO) Database available from the United States Department of Agriculture, Natural Resources Conservation Service's Soil Data Mart (Soil Survey Staff 2009). The SSURGO database consists of the detailed order 2 soil survey data covering the entire state. We create maps of some of the information available in SSURGO as is, but we have also created additional maps based on our own interpretations of the soil survey data and how it relates to the surficial geology of Indiana.

Most of Indiana was glaciated during the Pleistocene, and there is a very close correspondence between the various glacial deposits and the properties of the soils which formed in and on them. Thus, we rely heavily on a soil geomorphological approach in teaching soil science in Indiana. A *dominant soil parent material* map that we developed from our own interpretation of the SSURGO data is the single most useful map in our GIS dataset. Since many soils in Indiana developed in two and sometimes even three different parent materials, we define the dominant soil parent material as that material with the greatest influence on other soil properties, or a material that highlights a particular distinguishing feature. Usually, the dominant soil parent material is the lowest one in the profile, but it may be at the surface, such as in soils which contain organic soil material. By grouping soil map units with similar soil parent materials, we are able to visualize the soil landscape in new ways. Outwash plains, flood plains, dune fields, and other geomorphic features stand out in stark contrast to the surrounding till plains when a transparent dominant soil parent material layer is draped over the DEM.

A separate loess depth map provides information on the wind-blown silt that covers large areas of the state. Maps of natural soil drainage class, presettlement vegetation, soil orders, and others provide information on other soil and landscape properties.

Web Interface

Our web interface is based on the Google Earth API (Application Programming Interface, http://code.google.com/apis/earth/) and is designed to allow a user to quickly and fluidly zoom and pan to any part of the map, and to quickly switch the visible layer. As of October, 2009, only a few layers are active, but we intent to add additional layers by mid-2010. A screen shot of the web interface is shown in Figure 1. The site is accessible at http://gis.lib.purdue.edu/isee/.

Results

We are just beginning to incorporate the Isee web site into our soils courses, so a full assessment of its effectiveness as a teaching tool is not yet available. The initial student responses, however, have been very positive.

In a class of 44 freshman and sophomore college students in a *Crop Production* class during the fall semester of 2009, 41 (93%) indicated that they had previously used Google Earth, validating the choice of Google Earth as an interface that is already familiar. The students were asked to respond to a number of questions on a scale of 1 to 5, with one being "strongly disagree" and 5 being "strongly agree." The average response for the question, "I learned something new today," was 4.2; for the question, "I feel Isee is a valuable tool for expanding my knowledge," the average response was 4.3; and for the question, "If given the option, I would further explore the Isee web site," the average response was 4.0. The response to the latter question is particularly noteworthy because one of our goals is to create a site that students will want to explore on their own.

In a *Soil Classification, Genesis, and Survey* class consisting of 9 graduate students and 1 senior undergraduate, we asked groups of 2 students each to use Isee to develop a diagram or a written set of rules that explained how natural soil drainage class is related to soil parent materials and topography in central Indiana. The goal was to see if we could use Isee to lead students to the type of mental models that field soil scientists develop as they are mapping soils in the field. This exercise required students over a 2 hour laboratory period to compare two different map layers at 4 different places chosen by the instructor to be representative of particular "end member" situations. Of the 5 groups, only one developed a diagram that explained the situation clearly, 3 created reasonable, but not particularly clear diagram or rules, while one group struggled to create even a simple diagram. As experts, it is easy to forget how difficult and time consuming it can be for the novice to conceptualize soil landscape models that explain how soils occur in a particular area. Thus, in the future we plan to pace the exercise differently, particularly to allow students more time and with more feedback from the instructors along the way.

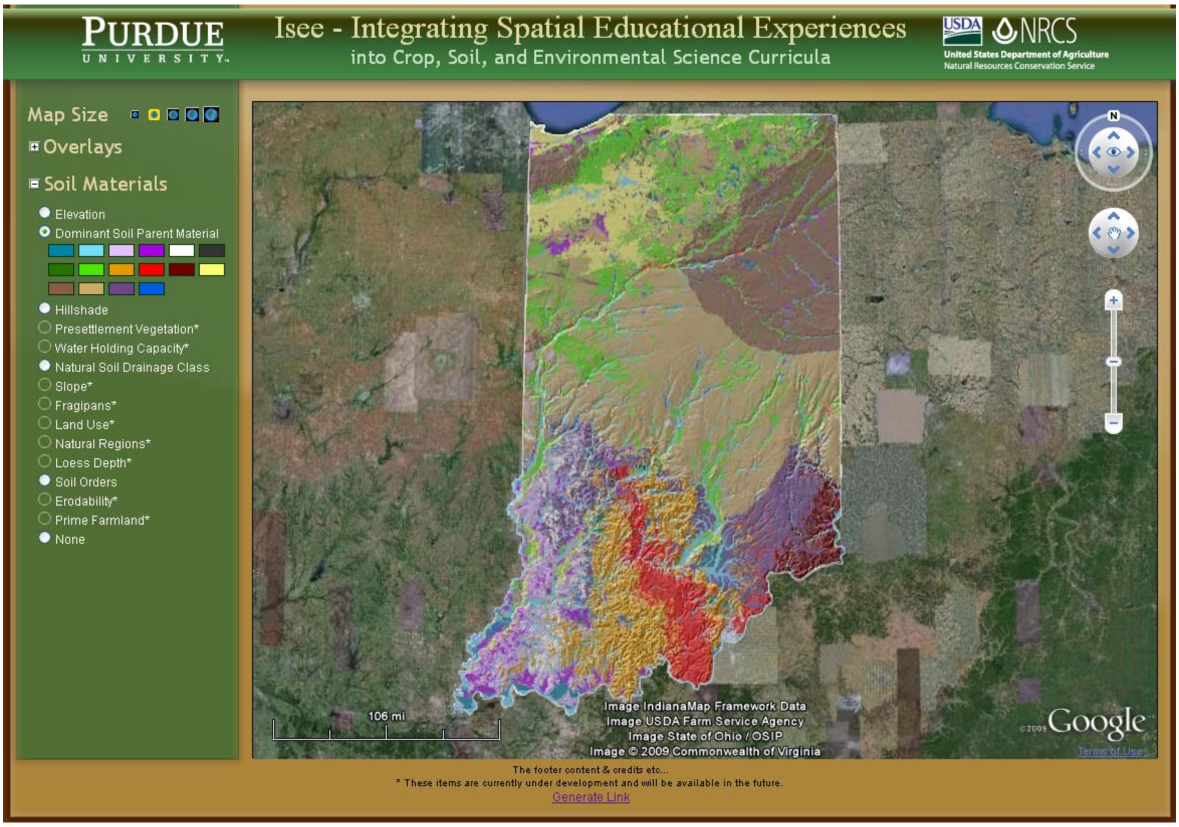

Figure 1. A screen capture from the Isee web site with the Dominant Soil Parent Material map of Indiana being displayed. The normal Google Earth controls are used to navigate the map. When the user moves the cursor over the color swatches in the left panel, the legends appear in popup boxes. If needed, the user clicks on a swatch to open a panel on the right side of the screen that provides additional explanation.

Conclusion

Soils information based on detailed soil survey data combined with digital elevation models and delivered via fast Web 2.0 technologies provides exciting new possibilities for learning about soils and landscapes at various scales. We have only begun to exploit the potential of this approach for soils teaching and research, both for students in our classes, as well as for educating the general public.

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