Syllabus: SSC 440: Geographic Information Systems (GIS) in Soil Science and Agriculture

Time: Lecture: Mon and Wed 12:25 – 1:15 pm, Laboratory: Friday 12:25 - 3:10 pm
Classroom: Williams Hall (WMS) Room: 2414 (CALS GIS Laboratory)
Semester: Spring 2013

Course overview, goals, and objectives: Effective stewardship of soil, land, agriculture, ecosystems, and other natural resources requires characterizing, understanding, and managing their inherent spatial variability. A geographic information system (GIS) is software developed to store, manipulate, analyze, and display spatial data. A geographic positioning system (GPS) is a satellite-based global navigation system that provides location and elevation information anywhere on the Earth. Remote sensing is information acquisition from a distance, i.e., without contact. The primary goals of this course are for students to learn to use these tools to develop: 1) a functional understanding of key GIS principles; 2) a working knowledge of a GIS (Environmental Systems Research Institute’s [ESRI] ArcGIS: ArcMap, ArcCatalog, ArcToolbox); and 3) the problem-solving and critical-thinking skills necessary to use GIS in the characterization and management of agriculture, soils, and other natural resources. This course provides a strong foundation for using GIS as a practicing soil scientist, agricultural consultant, and other natural resource professionals.

1. Instructors:
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Course website: Info: http://www.soil.ncsu.edu/academic/classes/undergraduate/ssc440.htm
Moodle website will be posted when available.

2. Course prerequisites and restrictive statements: SSC 200: Soil Science or equivalent (basic soils). Computer literacy in an MS-Windows environment. Mac users: software used is supported only in Windows. It can be run on a Mac using a Windows emulator, but we offer only limited support for this. Students with concerns about course prerequisites should discuss them with Dr. White. Concurrent enrollment in -001 Lecture and -002 Lab is required.

3. Student Learning Outcomes:
At the end of this course, a student will be able to:
1. Identify and explain the basic elements of GIS and cartography and differentiate them using appropriate discipline-specific vocabulary.
2. Describe the breadth of problems in soil science and agriculture that contain spatial components and illustrate these by giving examples.
3. Describe and give examples illustrating how GIS can be used to solve these problems by asking geographic questions, acquiring and analyzing geographic data, and developing plans to act on geographic knowledge.
4. Formulate appropriate geographic questions for agricultural and natural resource management, then acquire, analyze, and interpret spatial data to answer those questions.
5. Collect, display, manage, and interpret spatial data from various local, state, and federal agencies, including:
   a. download data from various online sources, load data into ArcMap, manipulate their appearance and develop appropriate, informative, and aesthetically pleasing maps;
   b. use the Editing and Geoprocessing tools in ArcMap to create, modify, and manipulate spatial data;
   c. project data into a common coordinate system with on-the-fly projections and reprojection tools;
   d. design and create a geodatabase for use in natural resource management.
6. Define remote sensing, aerial and satellite imaging, and lidar, and use these to create maps and address issues in agriculture and natural resource management.
7. Explain how scale, accuracy, and resolution affect spatial analysis, interpretation, and display; create maps at scales appropriate for their analysis; and calculate distances on a map using absolute scale.
8. Explain the basic principles underlying global positioning systems (GPS) and be able to: transfer data to a GPS receiver; use the receiver to navigate to a location; collect points, lines, and polygons; and download GPS data for use in a GIS.
9. Differentiate between computer-aided design (CAD) and GIS; transfer geodata from one system to the other; open a CAD file in GIS and extract a subset of layers based on CAD attributes; export GIS data to CAD files.
10. Identify spatial variability in data, outline the associated assumptions, and develop sampling schemes to capture spatial variability of plants, soils, and other natural resources.
11. Define and use basic descriptive statistics and apply the statistical tools within ArcGIS to analyze, interpret, explain, and present spatial data.

4. Textbooks:
There is no single textbook for this course. Students will be referred to: texts, book chapters, and articles on print and electronic reserve at Hill Library, posted on the class website, at other websites; and software tutorials and documentation.

Software: The core software used in the course is ESRI’s ArcGIS for Desktop Advanced. NCSU has an unlimited site license for ArcGIS Desktop that is available to all faculty, staff, and students for use on university and home PCs. All students with a personal computer and a broadband internet connection are very strongly encouraged to download and install the software to facilitate learning and completion of course assignments. That said, ESRI products are installed in Unity Computer Labs. A USB flash drive (“memory stick;” ≥ 8 GB) is required; this will be needed to store spatial data and GIS products used in and outside the laboratory.

An integral part of this course is the ESRI Virtual Campus. Virtual Campus courses consist of self-paced,
web-based GIS instruction modules built around either specific ESRI GIS software packages (e.g., ArcGIS 10) or specific disciplines (e.g., Forestry and Hydrology). With the generous support of ESRI and NC State Humanities Extension and Publications, ESRI Virtual Campus online GIS training courses are available to NCSU affiliates at no charge. Your initial homework assignments will include completion of several modules of the Virtual Campus Course “Learning ArcGIS Desktop (For ArcGIS 10),” for which you will be provided a login code. These codes may not be passed on to other individuals.

5. Course organization and scope:

Week 1: Course Overview and Introduction to GIS
   A. What is a GIS?
   B. Importance of GIS
   C. Major Areas of Practical Application
   D. Economic impact
   E. GIS = maps + databases

Assignments:
   Class Introductions Forum
   ArcGIS Install Forum
   ESRI Virtual Campus Learning ArcGIS Desktop 10: Module 1: Getting Started with ArcGIS Desktop
   Learning ArcGIS Desktop Forum

Lab 1: Introduction to ArcMap, Exercise and Quiz

Week 2: Maps and Cartography
   A. What is a map?
   B. “Cartographic abstraction”: selection, classification, simplification, exaggeration, symbolization
   C. Map types: reference and thematic
   D. Computer cartography vs. GIS
   E. GIS vs. paper maps
   F. Map elements: distance, scale, direction, legend, projection, coordinate system
   G. Scale, accuracy, and resolution in GIS

Assignment: Virtual Campus Modules 2: Creating Map Symbology and 8: Designing Maps with ArcGIS

Lab 2: North Carolina Physiographic Regions Map, Exercise, and Quiz

Week 3: Spatial Data Models: Vector and Raster
   A. Vector model: points, lines, and polygons
      a. Topology
      b. Features and attributes: computed vs. associated attributes
      c. Feature overlay
   B. Raster model: grids, cells
      a. Grids: continuous variables (e.g., elevation, soil pH)
      b. Images (digital photographs)

Assignment: Virtual Campus Modules 4: Organizing Geographic Data and 5: Creating and Editing Data

Lab 3: Doak Field Map with Image Background: querying maps; Exercise and Quiz

Week 4: Georeferencing and Coordinate Systems (last unit for 1st exam)
   A. Geographic coordinate system: latitude and longitude
   B. Geoids, spheroids, ellipsoids, and datums
   C. Projected coordinate systems
D. Projections and transformations
E. Common world and U.S. coordinate systems:
   a. Universal Transverse Mercator
   b. State Plane Coordinate System

Assignment: Virtual Campus Module 3: Referencing Data to Real Locations
Lab 4: Map: NC Roads, Soil Systems, UTM zones; Distances and Projections: Exercise and Quiz
Homework: Practice Quiz for Exam

Week 5: Geospatial Data Collection and Sources
   A. Geospatial data: sampling the world
   B. Primary vs. secondary data
   C. Primary data sources
   D. Surveying, GPS, sampling, remote sensing
   E. Errors and accuracy: data quality, certification, metadata
   F. Important secondary data sources
      a. Government agencies, private sector, WWW

Lab 5: Center for Environmental Farming Systems (CEFS) Map using On-Line Data: Exercise and Quiz

Week 6: First Hour Exam (covers Weeks 1-4). And Digital Soil Survey
   A. Methodology
   B. Products: Paper, Digital
      a. US General Soil Map (STATSGO2)
      b. SSURGO
      c. Soil Data Mart
      d. Web Soil Survey

Lab 6: Soil Map Units and Realistic Yield Expectations: Exercise and Quiz

Week 7: Global Positioning System (GPS) and Basic GPS skills
   A. What is GPS
   B. How Does it Work
   C. GPS Components
   D. Accuracy and Errors
   E. Differential GPS (DGPS)
   F. GPS Planning Software: ArcPad 7.1

Lab 7: a. ArcPad and Preparing to Collect GPS Data Exercise and Quiz
       b. Landscaping Governors Scott Courtyard: Field Data Collection and Map

Week 8: Remote Sensing
   A. Definitions
   B. Electromagnetic spectrum and radiation physics
   C. Aerial and satellite photography and imaging
   D. Resolution: spectral and spatial
   E. Image processing, orthorectification
   F. Image interpretation and classification
   G. Lidar and topographic mapping

Lab 8: Air/Satellite Image Interpretation and Classification Exercise and Quiz;

Week 9: Statistics and Spatial Variability
A. Statistics, spatial statistics
B. Research, study types
C. Independent vs. dependent variables
D. Continuous data
   a. Sampling
   b. Frequency distributions and descriptive statistics
   c. Correlation, regression
E. Discrete data

Lab 9: Return to CEFS: Lidar Elevation and Grid Soil Test: Descriptive Statistics Exercise and Quiz

**Week 10: Interpolation** (last unit for 2nd Exam)
A. What is interpolation?
B. Characteristics of interpolators
C. Deterministic interpolators
D. Evaluating interpolations

Lab 10: a. Interpolating CEFS Lidar Elevation and Soil pH; b. CEFS P-Index Map

**Week 11: Precision Agriculture**
A. Definition and rationale: agronomy, environment, economics
B. Tools: GIS, GPS, variable rate technology (VRT)
C. Spatial Variability in Agriculture
D. Yield monitoring and mapping
E. Yield-limiting factors
F. Characterizing soil spatial variability
G. Site-specific soil management: prescription maps
H. Grid sampling, management zones, realistic yield expectations
I. Remote sensing (RS) for site-specific mgt.
J. Applications: agronomy, horticulture, turf, animal waste


Lab 11: a. Lime Prescription Rate Map Exercise and Quiz; b. Is Variable Rate Liming Profitable?

ArcGIS Quick Reference (Lab 11) Resource

**Week 12: 2nd Hour Exam (Covers Weeks 5-10). And Computer Aided Design (CAD) and GIS**
A. Introduction to CAD
B. Common Uses
C. Similarities and differences between CAD and GIS
D. Coordinate systems
E. CAD and GIS Overlap
F. Parcel Example
G. Future Together

Lab 12: Acquiring and Georeferencing Google Earth Images Exercise

**Week 13: Hydrologic Modeling using GIS**
A. Spatial Models
B. Hydrologic Modeling
C. Stream Delineation Process
D. Stream Classification  
E. Watershed Identification  
F. D-8 versus D-Infinity Methods  
G. Additional Hydrologic Extensions: ArcHydro and TauDEM  

Lab 13: CEFS Stream Network Map Exercise

**Week 14: Creating, Viewing, and Analyzing 3D Surfaces: ArcScene and 3D Analyst Extension**

A. Why?: topography, any continuous “z” parameter  
B. Slope, aspect, hillshade, viewshed, cut/fill  
C. ArcGlobe and ArcScene  

In-Class Exercise/Homework Assignment: 3D Analyst Tools for Surface Analysis

**Week 15: Case Studies:**

1. Wetland Identification: Potential wetland mitigation cost resulting from the construction of the Western Wake Freeway *(Triangle Expressway)*  
3. Riparian Buffers  
   a. References:  
      i. North Carolina’s Riparian Buffer Protection Rules  
      ii. Guide to Implementing Neuse River Basin and Tar-Pamlico River Basin Riparian Buffer Rules for Forest Management Activities  

**Week 16: Final Exam Section**

Lab exercise: Practice Take-Home Final Exam  
Take-Home Final  
In-Class Final  

6. Projected schedule of reading assignments: as above.  


Regular laboratory exercises and homework as outlined above and assigned; all will be posted to the course website. Two 50-min exams and one comprehensive two-part final (in class and take-home) will cover all material presented in the course. Students in SSC 540 are expected to demonstrate a higher level of competence in class and web participation. SSC 540 students will take the same exams as those in SSC 440, but any multiple choice questions will be replaced by “fill-in-the-blank;” they will also complete a half-term GIS project related to their thesis or dissertation research and/or career goals.

Near the end of the semester, students will be asked to complete the standardized NCSU on-line ClassEval. During and after the course, we welcome any suggestions that you may have for improving course content and facilitating learning (see Feedback, below).

8. Proportion of final grade that derives from attendance, exams, quizzes, projects, etc.:  
   Attendance and class participation: 10%  
   Hour exams: 30%  
   Lab exercises/quizzes, homework assignments, and contributions to the glossary and forums: 30%  
   Final Exam: 30% total: 15% in-class; 15% take-home.
Letter grades will be assigned on a percentage basis: 96.7-100 = A+; 93.3-96.6 = A; 89.9-93.2 = A-; 86.5-89.8 = B+; 83.1-86.4 = B; 79.7-83 = B-; 76.3-79.6 = C+; 72.9-76.2 = C; 69.5-72.8 = C-; 66.1-69.4 = D+; 62.7-66 = D; 59.3-62.6 = D- and < 59.3 = F.

9. Policies on incomplete grades and late assignments:
In accordance with NCSU policy (Grading REG 02.50.03), an incomplete grade will be granted only in cases where a serious interruption in a student’s work was not caused by their own negligence. The following penalty will be assessed for unexcused late submissions: 20% grade reduction for each day (or part thereof) that an assignment is late; thus, an assignment turned in 4+ days after the due date will receive zero credit.

10. Policies on attendance, (excused and unexcused) absences, and scheduling makeup work:
Class attendance is required. Students should discuss prospective excused absences with the instructor beforehand whenever possible and as soon as possible after emergency absences in order to schedule makeup work. Please see NCSU Attendance Regulations for definitions of “excused” and “emergency” absences. The distance education section is taught in synchrony with the campus section; DE students are expected to keep up.

11. Academic Integrity Statement:
NCSU policy on academic integrity resides in the Code of Student Conduct (POL11.35.01). By participation in this course, students acknowledge tacitly the utilization and implication of the Honor Pledge: “I have neither given nor received unauthorized aid on this test or assignment.” It is the instructor’s understanding and expectation that the student’s signature on or submission of any test or assignment means that the student neither gave nor received unauthorized aid. For additional information, please visit the Office of Student Conduct.

From the NCSU Policies, Rules, and Regulations, “Code of Student Conduct”:

“7. ACADEMIC INTEGRITY
7.1 The free exchange of ideas depends on the participants' trust that they will be given credit for their work. Everyone in an academic community must be responsible for acknowledging their use of others’ words, research results, and ideas, using the methods accepted by the appropriate academic disciplines. Since intellectual workers' words and ideas constitute a kind of property, plagiarism is like theft.
7.2 Furthermore, as a reader you may want to follow other writers' paths of research in order to make your own judgments about their evidence and arguments. You will depend on those writers' accuracy and honesty in reporting their sources. In turn, your readers will depend on yours.
7.3 The free exchange of ideas also depends on the participants' trust that others' work is their own and that it was done and is being reported honestly. Intellectual progress in all the disciplines demands the truthfulness of all participants.
7.4 Plagiarism and cheating are attacks on the very foundation of academic life, and cannot be tolerated within universities.”

Section 8 of the Code defines academic dishonesty and provides information on potential sanctions for violators of academic integrity.
12. Statement for Students with Disabilities:
Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Services Office at 1900 Student Health Center, Campus Box 7509, 515-7653. For more information on NC State’s policy on accommodating students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG 02.20.1).

13. Statement on Laboratory Safety and Risk Assumption
All students are expected to exercise proper safety precautions in the classroom/laboratory. Safety guidelines will be reviewed during the first class and as required during the semester. In this laboratory, the primary safety concerns are ergonomics and electricity. Our classroom, the CALS GIS Laboratory, contains numerous computer workstations. While this classroom is not expected to present any hazard beyond which might be expected in a normal classroom, this equipment is valuable, fragile, and must be treated accordingly. There is a great deal of electrical energy coursing through this classroom, so students should exercise the same ordinary prudence afforded any electrical device.

14. Statement on extra expenses: We do not anticipate any activities requiring “pass-through” charges.

15. Statement on transportation: We do not anticipate any activities requiring students to provide transportation.

16. Student Conduct:
The NCSU Code of Student Conduct describes the kind of student behavior that disrupts and inhibits the normal functioning of the University and the actions that the University will take to protect the community from such disruption. It is your duty as a member of the University community to read, understand, and adhere to the Code of Student Conduct.

NCSU is committed to providing all students with an educational experience and background that will serve as a platform for success in future academic, professional, and personal endeavors. A learning environment that fosters professionalism is central to accomplishing these objectives. For this reason, activities such as drinking, eating, sleeping, tobacco chewing, smoking, cell-phoning, texting, web-browsing, or reading of non-class materials or any other activities that are disruptive to the classroom or laboratory learning environment will not be tolerated. You can be asked to leave for the remainder of the class period if these rules are violated. In addition, it is important to recognize that the equipment and classroom facilities used in our teaching endeavors are the property of the tax payers of North Carolina and as such, will be treated with respect.

17. Educational Philosophy:
This course will be conducted utilizing principles of collaborative, participatory learning. What does that mean? Learning by teaching yourself, learning by doing, learning from others, learning by teaching others, and guided discovery, with your instructors, your fellow students, and yourself as guides. The primary objective of the laboratory section is to maximum the time that you practice “hands-on” learning.

Workload: This syllabus outlines our optimistic and intensive learning objectives for this course. To realize these objectives will require considerable effort by all of us. You need to learn and understand basic principles and how to apply them using the core functionality of very powerful (thus quite complicated...) software. To master course material and software will require that you use it frequently
to complete laboratory exercises, homework assignments, and exams. Rob and I are excited and enthusiastic about GIS and its potential to help us better manage natural resources; we use it frequently in our own work. We hope to develop and nurture within you a similar sense of excitement and enthusiasm about GIS that will make realization of the learning objectives a satisfying pursuit for all of us.

We will attempt to make this course as “paperless” as possible. With some designated exceptions, students should submit all assignments in digital form, usually via the course Moodle site, but sometimes via email or USB flash drive as directed.

**Feedback!** As the semester progresses, we can and will customize this course to better meet your needs. To help us do that, we urge you to communicate with us about any aspect of the course at any time. If you do not understand something, ask. If the course is moving too quickly or too slowly, you find the workload oppressive, or you’d like a supplementary exercise, say so. If you have problems with software functionality or the course website, tell us. If there is a particular application or functionality that you would like us to cover, let us know. Please work with us to make this the best course possible.