DEVELOPING AND TEACHING A SITE-SPECIFIC CROP/SOIL MANAGEMENT COURSE

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ABSTRACT

Site-specific crop/soil management technologies have been available for over fifteen years. Consequently, there is a demand for classroom and laboratory education across a variety of agricultural disciplines in the University community. To meet this demand, a course was developed in 1998 to teach the basic concepts of site-specific crop/soil management. This class is designed as an upper level undergraduate and graduate class and generally has between 10 and 20 students. The students typically come from agricultural engineering, agronomy, weed science and entomology/plant pathology majors and are evenly split between undergraduates and graduates. The class is not required by any curriculum but is considered a "restricted elective" by many in the College of Agriculture. The class is designed in a lecture/lab format with two one-hour lectures and an independent laboratory. As the students generally come from various diverse backgrounds and experiences, the lectures begin with the basic concepts of global positioning systems (GPS) and geographical information systems (GIS) and proceed through explanations of coordinate systems, projections, variability, soil sampling methodology, remote sensing, etc. The laboratories are designed to be done independently (either alone or with a group) and include navigating with a GPS unit, finding and using data available from the internet, developing sampling schemes, displaying and using yield data, etc. Most of the laboratories center on increasing the students' GIS skills, hence, as the laboratories progress, they get increasingly more difficult. The class culminates with a semester project, done by groups, where each group must give a presentation of a case study involving a site-specific project. The instructor will provide field data which the groups must interpret and make site-specific recommendations for a predetermined objective. End-of-semester evaluations have shown this approach is well received by the students and most indicate they have learned a great deal.

Keywords: Geospatial, Agronomy, GIS, Laboratory Exercise

INTRODUCTION

In 1998, the Mississippi Agriculture and Forestry Experiment Station (MAFES) introduced a major research effort in precision agriculture called the Advanced Spatial Technologies for Agriculture program. This program was designed to integrate faculty in many different areas of agriculture into working groups focused on answering questions and developing methodology to bring the benefits of precision agriculture to Mississippi. Concurrent with the initiation of the research, a group of faculty decided to develop a course, housed in the Department of Plant and Soil Sciences, that would teach the fundamental concepts of site-specific soil and crop management (SSCSM). Other departments at Mississippi State University (MSU) offered courses in specific tools used in precision agriculture. For instance, the Department of Forestry offered classes in remote sensing and the Department of Geography offered courses in GIS. However, no department offered a course integrating the fundamentals of agronomy/soil science with the tools of precision agriculture.

The objectives of this class were to 1: appeal to students from a wide range of majors within the College of Agriculture and Life Sciences, 2: provide a basic understanding of the tools (Geographical Information Systems (GIS) and Global Positioning Systems (GPS), yield monitors, sensors, etc.) of SSCSM, 3: teach how to integrate traditional agronomic/soil science skills developed in other coursework with new technologies, and 4: provide the students an opportunity to demonstrate mastery of the subject via a case study. This course was taught as an experimental course in the Spring of 1998 and was approved by the University in the Fall of 1999 as Geospatial Agronomic Management (GAM). Currently the course draws from 10 to 20 students in majors such as agricultural engineering, agronomy, weed science and entomology/plant pathology. The class is usually split evenly between graduate and undergraduate students.

COURSE DESCRIPTION

This class relies heavily on other courses offered in the college to provide the traditional agronomic/soil science fundamentals, hence, it is designed as an upper-level undergraduate/graduate class. Despite the dependence on other coursework, only an introductory soil science class and an introductory weed science course are required prerequisites. We felt that an overabundance of prerequisites would limit the appeal of the course and contradict the first objective. The two required courses introduce the student to the ideas of spatial and temporal variability in soil and crop characteristics and are adequate for GAM.

The GAM class is not a required course for any major in the college but is a restricted elective in many majors. It is also a “Geospatial Elective” in Geospatial and Remote Sensing Technology Certificate program offered by the University. To get certification, a student must complete 15 hours of coursework from a mixture of required courses (9 hrs) and restricted electives (6 hrs).

The class consists of three sections or modules taught over approximately 15 weeks. Topics include GPS/GIS basics, data collection methods and sensor technology, and data analysis and interpretation of yield limiting factors. Lectures are held twice a week for one hour each and laboratories are scattered throughout the semester to coincide with lecture topics. The laboratories are focused on using GPS and GIS tools to help make agronomic decisions.

The first module introduces the students to the tools of SSCSM and discusses GPS/GIS technology. The course outline for this module is as follows:

- Lectures
    - GPS
        - History of the GPS system
        - Explanation of the NAVSTAR satellite system
        - Triangulation
        - Accuracy
        - Sources of error
    - Differential correction
        - Satellite sources(subscription)
        - Coast Guard beacon system
        - Wide Area Augmentation System (WAAS)
    - GIS
        - Definition and description
        - Basics of geospatial data
        - Advantages/Power of GIS applications
        - Data Formats
            - Vector
            - Raster
        - Coordinate systems
            - Latitude/Longitude
            - Universal Transverse Mercator (UTM)
            - State plane
        - Data Analysis
            - Interpolation
            - Kriging
- Laboratories
    - Real time navigation with a GPS system
    - Introduction to ArcMap (ESRI, Redlands, CA)
    - Web Soil Survey (NRCS, 2010)

The second module covers the topics the theory of SSCSM and data collection methods and sensor technology and integration of these concepts with GIS. Lectures and laboratories for this module are as follows:

- Lectures
    - Introduction to site-specific crop/soil management
        - Definition of spatial and temporal variability
        - Integration of spatial/temporal variability in SSCSM plans
        - Goals of SSCSM
        - Definitions of successful SSCSM plans
    - Data and collection methods used in developing SSCSM plans
        - Plant characteristics

        - Tissue tests
        - Height
        - Yield
        - etc
    - Soil characteristics
        - Fertility
        - pH
        - Texture
        - Apparent electrical conductivity
        - etc.
    - Sampling schemes
        - Grid based
        - Directed sampling
    - Sensor technology
        - Yield monitors
        - Electrical conductivity meters
        - Remote sensing
- Laboratories
    - Imagery, field boundaries, and sample points
    - Soil data entry and visualization
    - Soil EC_a, elevation, etc

The third module explains data analysis and interpretation of yield limiting factors and development of SSCSM plans. This section is designed to give an overview of the concepts involved since some of the statistical methods are beyond the scope of this GAM course. Topics included are:

- Lectures
    - Statistical analysis of the data
        - Means
        - Medians
        - Coefficient of variation
        - Skewness
    - Determining outliers and data filtering/cleaning
    - Correlation
    - Basics of factor analysis/principle component analysis
    - Determination of yield affecting factors
    - Development of SSCSM plans
- Laboratories
    - Soil based management zones
    - Yield based management zones
    - Variable rate application maps

In addition to the lectures and laboratories, the GAM course has two 1-hour exams and a semester project. The exams generally consist of eight to ten essay questions. Two lecture sessions at the end of the semester are scheduled for presentation of the semester project by three-person groups.

LECTURE CONTENT

The lectures are intended to convey a range of theory, concepts, and thoughts to the students. Initial lectures in each section are somewhat broad-based. As the lectures continue, they become more specific as the students gain insight into the subject. For instance, the initial lecture on GPS covers the basic concept of navigation using an analogy of using a roadmap to reach a destination to using GPS technology to reach that same destination. The last lecture in the module covers very specific ways of removing minute sources of error to increase the accuracy and precision of the GPS determined location. This method of teaching is repeated throughout the sections.

As there is no single source of information on SSCSM that fits into this teaching method, a wide variety of sources provide the lecture content. Many of these sources can be found via the internet. Excellent explanations of how the GPS system works can be found on many of the commercial providers (www.garmin.com, www.trimble.com) websites as well as government websites (www.gps.gov). Books, meeting proceedings, and journal articles also provide sources of information as the module topics become more detailed. Examples of relevant journal articles include Whelan and McBratney, 2000, Robert, 2001, and Dobermann et al, 2004. For topics outside the specialization area of the instructors, speakers are invited to lecture for one or two class meetings (more class meetings can be arranged if the speaker requests them).

The amount of time spent on the lecture topics is somewhat variable. Student interests and career goals are considered when determining how much time is spent in any particular area. For instance, if the majority of the class is interested in field consulting positions, then more lectures may be devoted to infield scouting methods. There are also two "free" lectures at the end of the semester that can be used to cover any topics the students suggest and students are encouraged to find topics of interest to them. A request for topics is made about half way through the semester in order to arrange speakers if the topics are out of our area of specialization. Lastly, two lectures are used for presentation of the group projects.

LABORATORY CONTENT

There are nine laboratories designed to give the students "hands on" experience with the GPS/GIS tools of SSCSM. The laboratories are "independent" in that there are no scheduled meetings. The students are provided a copy of ArcMap (ESRI, Redlands, CA) through an ESRI software promotion (www.esri.com/slpromo). Laboratory assignments are available via the students "myCourses" webpage. The students are generally allowed two weeks to complete each assignment to allow ample time for questions.

The first laboratory is unique and requires the students to be placed in groups of three. If possible, each group has a student from a different major and at least one is a graduate student. This allows each group member to be exposed to a different perspective of SSCSM with the graduate student generally providing leadership and, at least, more experience. The laboratory teaches the student to navigate using real time GPS. Nine or more locations are selected around campus representing significant historical, athletic, etc. points. The students are provided with a WAAS corrected GPS receiver and some basic software instructions and must then navigate to each point. To complete the assignment, each group must turn in a list of the significance of each location.

The other eight laboratories explore the uses of GIS. The second laboratory uses Web Soil Survey (NRCS, 2010) to introduce the student to the power and availability of GIS to the public while the second introduces them to ArcMap (ESRI, Redlands,CA) in particular. The remaining laboratories walk the students through the process of creating a SSCSM management plan. They start by requiring the student to develop a soil sampling mechanism for a field. This involves downloading imagery of the field from the NRCS Geospatial Data Gateway (datagateway.nrcs.usda.gov), creating the field boundary, and designing a sampling scheme (usually grid based). Each successive laboratory builds on this field. Soil fertility data, pH, elevation, EC_a**,** yield, etc. are provided to the student as they progress through each assignment as if they had made the measurements themselves. The last laboratory requires the student to develop a variable rate application map to correct a yield limiting soil fertility problem.

As the semester proceeds and the students' GIS capabilities increase, the laboratories become more demanding. Initial laboratory instructions are complete with screenshot images and notes such as "click on this icon" to lead the student through the exercise. This type of instruction diminishes through the semester. Screenshots are still provided to ensure the student does not get confused as to the goal of the assignment, but the GIS tool instructions are almost nonexistent.

SEMESTER PROJECT

At the end of the semester, a group project is required of all students. This project merges the lecture and laboratory experience. This assignment also serves as an assessment tool in determining student progress. Students are divided into groups as in the real time navigation laboratory. They are then told they will serve as consultant to a producer wanting to implement SSCSM technologies. They are given a location which may be coordinates, a physical address, or simply driving directions to the field. They are also provided soil fertility data and historical yield data (usually covering three years). They are then expected to develop a SSCSM plan including appropriate crops, best management plans, variable rate fertilization, etc. The groups are free to use any geospatial resource available except other students or faculty with the exception of the instructors. This includes requesting additional information that may be available from the instructors. Examples of additional data might include irrigation management data, soil EC_a measurements, elevation, etc. The students are required to turn in detailed reports, as might be expected of professional consultants, outlining their SSCSM plan and the reasoning behind their recommendations. The plan must be supported by figures developed in the GIS and may include field boundaries, sampling grids, soil fertility interpolations, topographical changes and potential results. After these reports have been graded and any errors or questions resolved, the groups must then present the report orally to the rest of the class for discussion. Students are graded equally on the written report and the oral presentation.

SUMMARY

In summary, we have developed a course called Geospatial Agronomic Management to fill a need in the College of Agriculture and Life Sciences brought on by the advent of precision agriculture technologies. This course attracts both graduate and undergraduate students interested in GPS/GIS technologies and SSCSM. This class is not required but is used as a restricted elective in many of the departments within the College of Agriculture and Life Sciences. The class attracts both undergraduates and graduates from many of these departments to create a diverse class. Lectures in the class introduce the students to GPS/GIS tools, concepts of spatial and temporal variability, data collection and analysis, etc. Laboratories are designed to provide “hands-on” training in SSCSM technologies and move the student through the process of designing a SSCSM plan. The end-of-the-semester class project allows the students to show their progress in understanding SSCSM and serves as an assessment tool for the instructors. The class has generally been well received by the students. End-of-the-semester student evaluations have consistently given the course a score of greater than four out of five.

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