A CASE STUDY APPROACH FOR TEACHING AND APPLYING PRECISION AGRICULTURE

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ABSTRACT

Students often struggle understanding precision agriculture principles and how these principles can be applied to farming operations. A case-study approach that requires students to own a recreational global positioning system (GPS) for collecting on-farm data could be a method for helping students understand and apply precision agriculture. This paper describes a case-study approach to teaching precision agriculture using student owned GPS units and geographical information systems (GIS) software to collect and analyze on-farm data. Students majoring in agronomy, animal science, and agri-business receive training in GIS software (SSToolbox 3.8) and recreational GPS units. Students were given specific instruction on how to import and export data between the GPS units and GIS software, create sampling grids, collect field boundaries, calculate area, create management zones, and collect points when crop scouting. Following instruction, the students were given a case study that required them to begin a precision agriculture program on a farm (for most students the case study is done on their family farm, but the school's farms were available for others). The students must collect data for at least three fields with six layers per field, and two of those layers must be collected with the students GPS unit. The other layers the students collect may come from a variety of sources including aerial photography (USGS-DOQQ); digital elevation models; yield maps; and planting, tillage, or pesticide application maps. The assessment of the case studies is based on a written paper and oral presentation which includes maps and descriptions for each layer and an explanation of each layer and how it will contribute to the precision agriculture management plan for their chosen farm. The case study approach provides students with GIS and GPS training and how to apply precision agriculture to a farm at a relatively low cost.

Keywords: curriculum development, teaching, case study, instruction, teaching methodolgy

INTRODUCTION

Precision agriculture is becoming widely adopted in agriculture, and students in agriculture related fields must be prepared to enter a work place that requires high tech skills (Brase, 2006). Narrow profit margins and environmental laws that limit inputs and require meticulous record keeping may soon require farmers to have a good understanding of geographical information systems (GIS) and global positioning systems (GPS). Many students do not understand the importance of the high technological changes that are surrounding the agriculture world, because they see the cost too great for adoption on small family operations. Some aspects of precision farming may be too expensive for practical economic use on smaller operations such as auto-steer tractors, but many aspects of precision agriculture can be relatively inexpensive. The USDA Natural Resource Conservation Service (NRCS) Web Soil survey data is a good example of an inexpensive method to use soils data for precision agriculture (Post et al., 2007). The web based soil survey does not require a user to own a GIS software package, but allows the user to create customized maps that a farmer could use for reference. In respect to GPS receivers, a simple recreational GPS unit can be used to collect field boundaries, mark points, and record road and irrigation lines. The objective of the introduction to precision agriculture course was to introduce students to inexpensive ways to collect and use georeferenced data from their agriculture operation in a case study approach where students used their own data from their farming or ranching operation.

MATERIALS AND METHODS

Exercises for the case study based precision agriculture course were performed using a recreational Garmin GPS unit. Student were required to purchases the GPS unit, and the Garmin Etrex Legend was recommended based on cost, functionality, and data download capabilities (via serial port). Students could choose higher-end models such as the color screen Etrex Legend and Vista which download data via a USB connection. It should be noted that Garmin GPS units that downloaded via a USB connection can be problematic, because they required the user to have administrative rights on the computer to download data from a Garmin GPS unit connect via USB cable. Currently, the student lab computer policy at BYU-Idaho does not allow for students to have administrative rights, so students had to use the instructor’s computer for downloading data.

The class utilized a computer lab with GIS software installed on personal computers. Computers had Intel Pentium 4 processors with 1 gigabyte of RAM and video cards that could support GIS software.

Software packages used for the course included SSToolbox (SST Development Group Inc., Stillwater, Oklahoma), DNR Garmin (Minnesota Department of Natural Resources, St. Paul, Minnesota), Google Earth, (Google Inc., Mountain View, California), and an internet browser (Internet Explorer was commonly used). The SSToolbox program was used for creating maps, displaying data, rectifying remotely sensed imagery, and other GIS functions. Data were downloaded from the Garmin GPS units using DNR Garmin by saving data as shapefiles in the non-projected 1984 World Geodatic System as required by SSToolbox. Google earth software was used for acquiring imagery that could not be obtained free of charge via government or University websites. Imagery taken from Google Earth was georectified in SSToolbox. An internet browser was used to surf the internet for georeferenced data such as soil survey maps and digital images (DOQQ).

Course Background

Agronomy (Agron) 286 is a three credit course in the department of Agribusiness, Plant and Animal Science at Brigham Young University-Idaho, Rexburg, ID. The course consisted of one 2-hour lecture followed by a two hour lab. Although, only one hour of the 2-hour lecture period was used for lecture or demonstration, and the additional hour was utilized for lab time. Student numbers for the class is maximized at 20 to increase the availability of the instructor to the students. The class consists of students from many different disciplines including agribusiness, agronomy, agricultural systems (engineering and mechanics), animal science, natural resources, and horticulture. The course is an introductory course to GIS, GPS, and precision agriculture, but other topics were introduced which included soil sampling methodology and data management.

Course Design

The course design is based around a case study approach and the objectives of the course are in table 1. Lectures, laboratories, and exams were designed to help students complete the case study. The students' case studies were to implement or improve precision agriculture practices on their farming or ranching operations. If students do not have a farm they can use, the school farm (200 plus acres). Most students enrolled in the class came from agriculture operation and were not currently using precision agriculture practices.

Lectures

The course consisted of nine lectures given during a 13 week semester (the other 4 weeks were used for exams and case study reports). Lectures were designed to provide students with basic information in GIS, GPS, and precision agriculture principles. The lectures utilized 45 min of a one hour period. The remaining 15

Table 1. Course objectives for the introduction to precision agriculture class.

	Objectives
1	Understand what GIS is and how to use it
2	Use a GPS system to collect data
3	Learn basic mapping making for displaying collected data
4	Create management zones based on soils, yields, or other collected data
5	Create sampling schemes based on grids and management zones
6	Understand the capabilities of yield monitors and auto-steering
7	Use remote sensing and other sensor based data to make decisions
8	Develop a precision agriculture program for a farming or ranching operation

min was used to introduce a laboratory assignment. Lectures were written in PowerPoint format and made available for students to download from the course website (Blackboard) in note format (three slides per page with lines for notes). Topics for individual lectures are provided in Table 2.

Laboratory Exercises

The course consisted of 10 laboratory assignments that provided students with hands-on experience in GPS, GIS, and precision agriculture. The laboratory assignments build on each other and were designed to repeat parts of previous assignments so as to provide reinforcement of important concepts. The laboratories were designed to be completed in a 3 hr period. Students were provided with step by step instruction for new material, but must refer back to old laboratory guide sheets for steps that have been previously covered. The laboratory assignments provide the students with training needed for them to collect data on their farm operation for developing their farm's precision agriculture management plan. Students were encouraged, if possible, to collect

Table 2. Lecture topics and concepts for the introduction to precision agriculture class.

Week	Lecture Topics	Concepts
1	Introduction to Precision Agriculture	Spatial Variability
		Advantages vs. disadvantages
		Data layering for problem solving
2	Introduction to GPS	How GPS works
		Reducing GPS error
		Datums, Projections, Coordinates
3	Introduction to GIS	What is GIS
		Representing spatial information
		Spatial data structures
4	Mapping Making Basics	Map types (e.g., posting and grid)
		Cartographic principles
		Displaying graduated data
6	Data Management	GIS file structure
		Data types
		Data backup
7	Soil Management	Spatial variability
		Grid soil sampling
		Interpolated maps
8	Remote Sensing	Physical properties of light
		Imaging sensors and platforms
		Applications and products
9	Yield Monitoring	Yield monitoring methods
		Calibration of yield monitor
		Mapping yield data
11	Guidance Steering and Auto-steering	Components
		Types of steering
		Advantages vs. disadvantages

data from their farms to complete the requirements for laboratory assignments and their case study (precision agriculture management plan). Laboratory assignment topics are provided in Table 3.

Exams

Students were given two examinations (week 5 and 10) during the semester, and each exam had a written and practical portion. Examinations covered materials covered previously in lectures and laboratories, and exams were comprehensive only in the sense that each topic addressed built on previously presented materials. The written portions of the examinations used traditional examination methodology including multiple choice, fill-in-the-blank, and labeling questions. The practical portions of the examinations required students to complete exercises, such as creating maps, based on materials covered in laboratory assignments.

Case Study

The case study was to develop a precision agriculture management plan for the students' agriculture operations. Students were required to hand-in a written report including maps of their precision agriculture management plan and

Table 3. List of laboratory exercises and objectives for the introduction to precision agriculture class.

Week	Laboratory exercise	Objective
1	Geocaching	Become familiar with a GPS unit and its capabilities
2	GIS software orientation	Become familiar with GIS software (Arcview 3.x) and its capabilities
3	Creating Field Boundaries and Marking Points	Use a GPS to obtain a field boundary Mark points of interest within a field
4	Creating and Sampling soil sample points	Create a soil sampling grid Upload data to GPS Navigate to points
6	Draw field boundaries using aerial imagery or other data	Obtain aerial imagery Draw a field boundary in GIS
7	Data management	Develop data structure of client, farm, and field Import and export data
8	Finding data	Find and download useful data from the internet Use USDA-NRCS's soil data mart
9	Yield Monitors and Data	Learn the components of a yield monitor Import and manage yield data
10	Interpolation of point data	Create interpolated maps using simple spatial statistics
11	Auto-guidance	Identify components Set and drive auto-steering lines

give a 15 – 20 min oral presentation which includes a question and answer session. Written reports included types of precision agriculture technologies and data that the student can implement on their farm/ranch operation including a description of how the technology or data will be beneficial. Students had to include maps of data layers that were collected from their farm/ranch operation. As part of the data layer portion of the written report, students were required to obtain or create field boundaries, soil survey maps, USGS aerial imagery, management zones, regions of interest, and soil sampling grids for at least three fields/pastures/ranges of their operation. Students were also required to include three additional layers which may include yield maps, fertility maps, prescription maps, auto guidance lines, wildlife habitat, range type, and hydrology.

RESULTS AND DISCUSSION

The case study approach used in the introduction to precision agriculture course has been very successful in helping students identify affordable precision agriculture methods that they can be adopted for their agriculture operations. The courses case study approach helped students realize that they can purchase a recreational GPS unit and a simple precision farming software package (e.g., John Deere’s Apex or SST Development Group’s Summit software) for less than $1000 and easily recoup the cost in improved management. Additionally, data such as aerial imagery and soil surveys can be obtained for free via the internet. The greatest benefit to the students was that they collected, created, and analyzed data from their own farming/ranching operation, so when they left the class, they have some data already in-hand for applying precision agriculture to their operation.

Students were more motivated to learn about precision agriculture in the case study approach, because it had two advantages over traditional teaching methods. First, they were working with data and scenarios that were their own (or in other words students had ownership). Second, students did not have to wait to apply what they learned in the classroom until they return to the agriculture operation, because they had already been applying it.

Student’s precision agriculture management plans varied greatly because students come from diverse agriculture operations including tree farms, orchards, row crops, and livestock operations. A student who grows has tree nurseries on pivot corners used the precision agriculture tools such as soil survey maps to find additional pivot corners that have suitable soils for growing trees (Fig. 1). A ranching student used hydrology, soils, and aerial imagery data to create new pastures and propose new fence lines. An agronomy student redesigned the irrigation practices based on field boundary maps, aerial imagery, and irrigation ditch maps (Fig. 2). Examples from students’ case studies of how they applied precision agriculture to their current farm management practices are located in table 4.

Student evaluations of the course were very positive, and students commented how they liked being able to use their own agriculture operations. Students also commented on how amazed they were that so much precision agriculture technology could be applied to their operation at a relatively low cost. Students said they were not aware of how beneficial precision agriculture could be to their operation. Some student comments about the course are included in table 5.

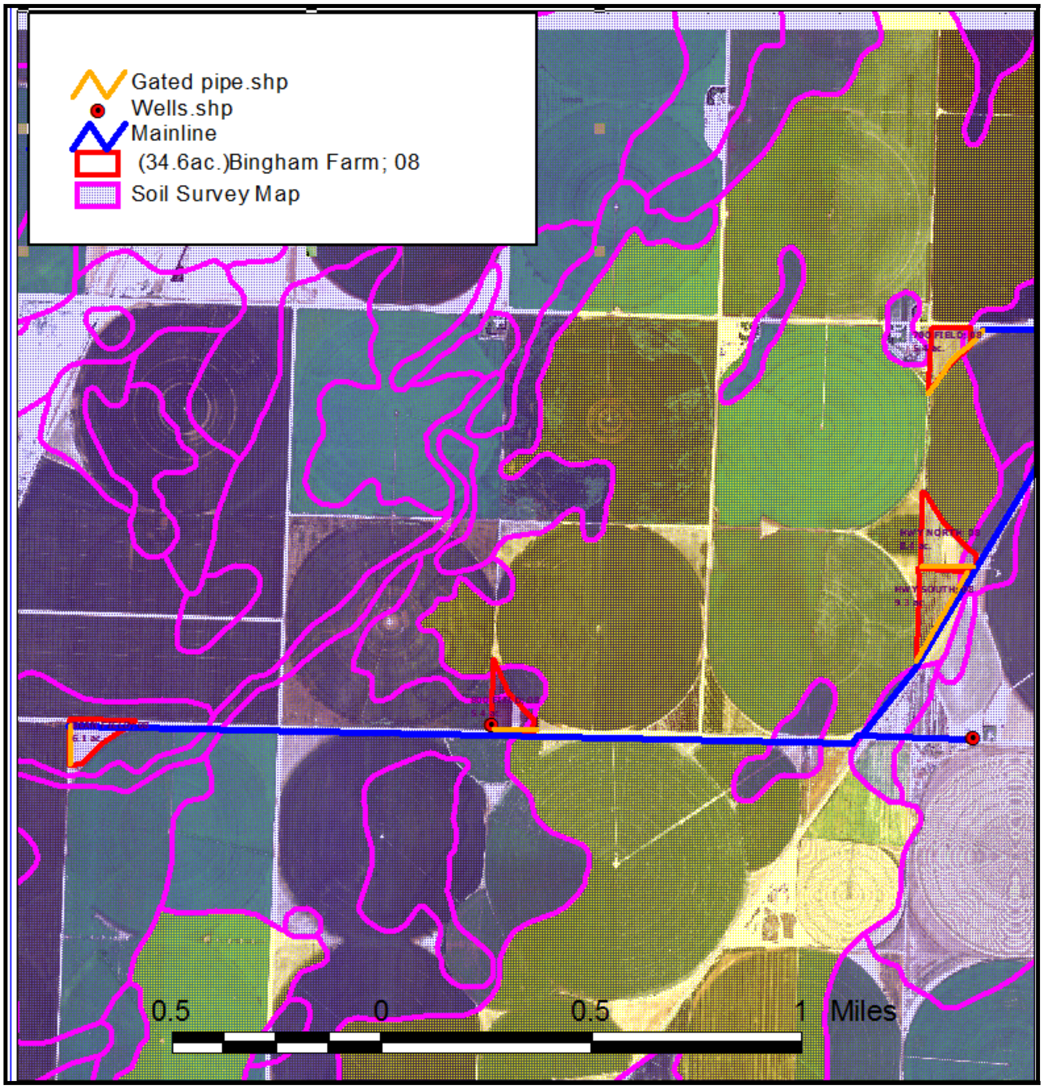

Figure 1. A map developed by a student as part of his case study project that shows field boundaries (red), irrigation system, aerial image, and soil types. The student has selected the soil type best for growing nursery trees (yellow area) for identifying additional pivot corners for expansion of his operation.

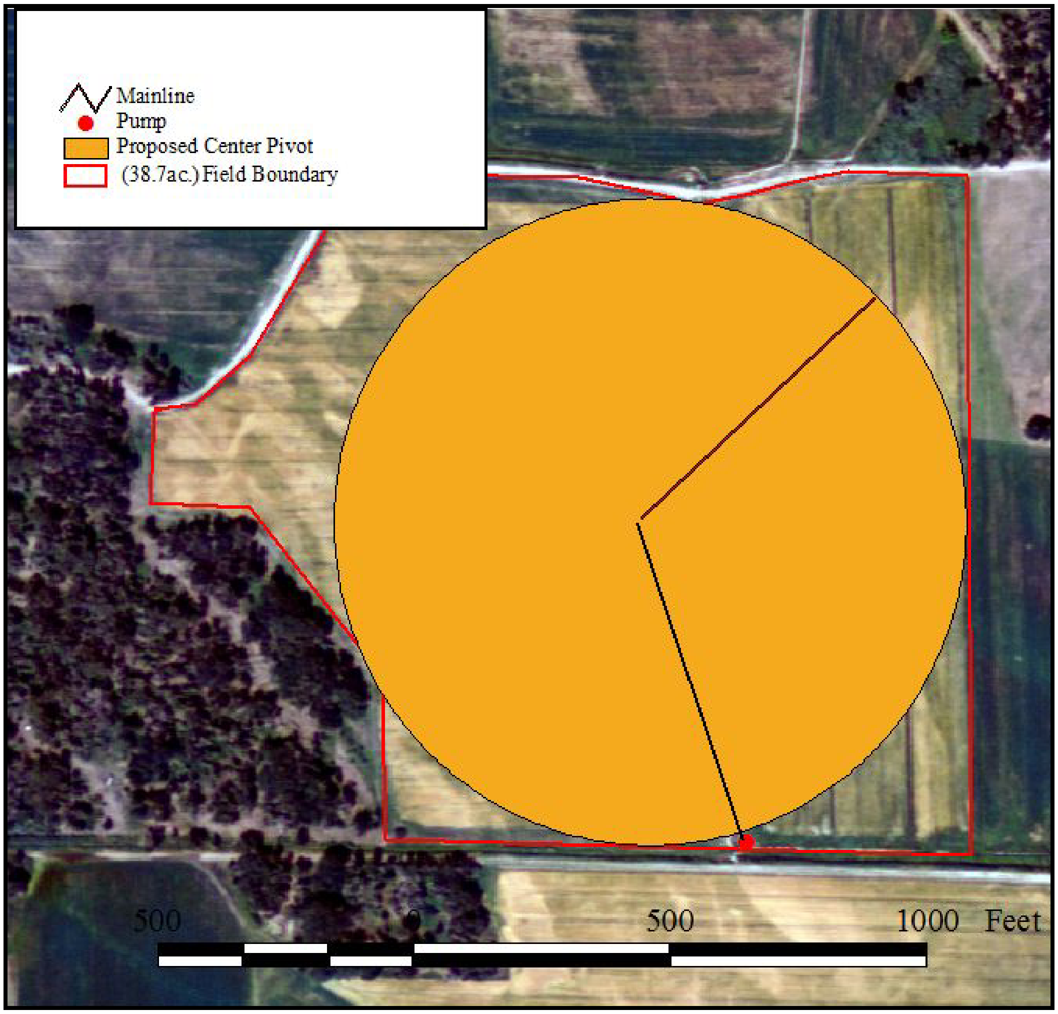

Figure 2. A student used the field boundary and aerial image to propose the coverage of a pivot irrigation system including placement of mainline and pump.

Table 4. Examples from some student's case studies of how they applied data they collected (layers) precision agriculture to their operations.

Layers	Application
Soil survey maps	Created management zones for seeding and fertilization and identified potential rental ground based on soil type
Hydrology features	Redesigning pasture areas and fence lines
Field boundaries	Created soil sampling grids and improved irrigation management
Imagery	Produced field boundaries, marked rock outcroppings, and identified high lime areas based on soil color
Grid maps	Sampled field for creating fertility and prescription maps.

Table 5. Students' responses to course evaluation question of how they benefited from the case study approach of developing a precision agriculture management plan for their operation.

	How did you benefit from the case study approach?
1.	By having the opportunity to use the precision agriculture from my family farm, I was able to have a true life experience. I learned how to better manage the farm with new technology.
2.	The final project was very beneficial in helping me understand how I could apply GPS on my own personal operation.
3.	The final project was the highlight of this class. I was able to effectively use the knowledge and skills that I learned throughout the course for application to my families farming operation. I was able to use the skills I learned from software such as SST, DNR Garmin, and ArcMap to map out our farm. The project allowed me to advise and analyze potential precision applications to our family farm. One application I used was to evaluate the potential application of using sprinkler irrigation vs. the existing furrow irrigation.
4.	I really like how we take seven to ten layers of information (soil type, irrigation, etc.) to draw conclusion to why my yield was so low.
5.	It helped me realize how important technology is in agriculture. It has shown me how to plot sampling points and GPS routes. I was able to make my own field boundaries and management zones.

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