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Precision Agriculture GIS Technologies for Mississippi

1st Edition

STUDENT Edition

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Authored by Amelia A.A. Fox, Ph.D.

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DEDICATION

This work is dedicated to our parents and grandparents who farmed. They taught us to love the Earth and leave it better than we found it.

This curriculum is also dedicated to users of those in all of agriculture who are devoted to farm production efficiency through technology adoption. Precision agriculture is often influenced by commercial equipment availability and/or technology. This curriculum is for those who devote themselves to solving complex problems involving intensely managed production systems using global position system (GPS) technology to spatially referenced soil, water, yield, and other data for the variable rate of application of agricultural inputs within a field or other agricultural production systems. The end goal for all users of this technology is to optimize inputs for agricultural production.

REVIEW

Precision agriculture is meant to improve on-farm efficiency in hopes of ultimately increasing profitability while also protecting the environment. However, this difficult process almost always includes the proper management and interpretation of data. Therefore, it is imperative that those individuals involved in making such decisions are educated on these processes. In a data-driven world, this textbook is a great resource for those wanting to learn how to utilize their data in hopes of making better informed on-farm decisions.

Dr. Mac Bean, Soil Scientist, University of Missouri, Fall, 2019

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TABLE OF CONTENTS

DEDICATION.....	ii
ACKNOWLEDGEMENTS	iii
LIST OF TABLES.....	viii
CHAPTER	
I. dBase Protocols, and File Data Types and Formats	9
Purpose	9
Lab Goals	9
Scoring Rubric	9
Chapter 1 Overview	9
dBase Protocols.....	10
File Naming Protocols and Conventions.....	11
General Rules from dBase Protocols.....	11
Exercise #1 Create file names using dBase protocols.....	12
Folder and File Management	13
Exercise #2 Managing Windows Explorer	14
Internet Resources for Mapping.....	16
Google Maps: https://www.maps.google.com	16
Exercise #3 Locate Hometown Coordinates	16
Google Earth Pro: https://www.google.com/earth/	17
Download and Install Google Earth Pro	17
Geographic Data Types	17
Geographic Data Formats.....	19
Exercise #4 Navigate a Tabular Database	21
Exercise #5 Examine Soil Attribute Data	23
Opening .dbf Tabular Datasets	25
Exercise #6 Create Graphic Plots in Excel	26
Exercise #7 Save .xlsx Spreadsheets in Different Formats	28
Chapter 1 Review	30
II. File Management and Soils Data Mapping.....	31
Purpose	31
Lab Goals	31
Scoring Rubric	31
Chapter 2 Overview	31
Connect the Drive in ArcCatalog	32
Exercise #1 Soil Data Acquisition	32
Web Soil Survey Data Acquisition.....	33
Exploring the Soils Data with ArcCatalog.....	34

Exercise #2 Preview a Spatial Data Folder.....	34
Exercise #3 Preview a Tabular Data Folder	35
Exercise #4 Relating Soil Tables to the Soil Database	36
Exercise #5 The ArcMap Document	38
Making Maps with ArcGIS Soil Data Viewer	41
Registering Soil Data Viewer 6.x an ArcMap Add-in.....	41
Relating Tabular Tables to the Access 2003 Database	43
Map Soils using the Data Relational Database.....	43
Exercise #7 Make an Erosion Map	44
Exercise #7 Saturated Hydraulic Conductivity (Ksat) Map.....	47
Compare Ksat and K Factor	48
Create More Maps	51
Chapter 2 Review	52
III. Geographic & Projected Coordinate Systems; Weather Datasets.....	53
Purpose	53
Lab Goals	53
Scoring Rubric	53
Chapter 3 Overview	53
Geographic and Projection Coordinate Systems	54
Geographic Coordinate Systems (GCS).....	55
Find Your Hometown on Google Maps.....	57
Projected Coordinate Systems (PCS).....	58
Working with Tissot's Indicatrix.....	58
Exercise #1 Review the Lab Data.....	59
Exercise #2 Mapping with Geographic Coordinate Systems	60
Exercise #3 Mapping with Projected Coordinate Systems.....	64
Goode Homolosine	65
Mollweide	66
Robinson.....	67
WGS84 UTM Zone 16N.....	67
Make a Greeting Poster Map	68
IV. Building Farm Basemaps	71
Purpose	71
Lab Goals	71
Scoring Rubric	71
Chapter 4 Overview	71
Crop Mapping in ArcGIS	72
Review Data in ArcCatalog.....	72
The Mississippi Automated Resource Information System	73
MARIS @ http://www.maris.state.ms.us/	73
Download Bolivar County Data.....	73
Create a Basemap in ArcGIS	74

Convert XY Geographic Coordinates to Points.....	75
Create a Local SSURGO Soils Map	77
Working with MARIS Files	78
Create a Geodatabase with Feature Dataset	80
Clip the Data Layers	82
Add Other Data to Basemap.....	85
Chapter 4 Review	86
 V. Navigation and Telemetry.....	 87
Purpose	87
Lab Goals	87
Scoring Rubric	87
Chapter 5 Overview	87
Navigation Systems and Telemetry	88
Tractor and Implement BUS Systems.....	91
Accuracy, Precision, and Scale	93
Create X,Y Events	94
Save Map for Editing	97
Cleaning Waypoints in ArcEditor	97
Deleting Unwanted GPS Points	100
Finalize the Field Boundaries	101
Step #1- Create Selectable Layer.....	101
Step #2 – Convert Points to Line	103
Step #3 – Convert Line to Polygon	104
 VI. Trimble Ag Farm Works.....	 107
Purpose	107
Lab Goals	107
Scoring Rubric	107
Chapter 6 Overview	107
Basemap Setup	108
Restore a Trimble Ag Project.....	108
Add Clients and Farm Fields	110
Create an Acreage Report.....	111
Exercise #1 Add SSURGO Soil Survey Data	111
The Production Scenario.....	113
Setting Up Costs.....	114
Enter Planting Records – Day 1.....	114
Enter Spraying Records – Day 21	117
Exercise #2 Manage Harvest Information – Day 192.....	118
Creating Variable Rate Prescription Maps	119
Interpolate Imported Soil Test Data	119
Create a Prescription Map	124
Chapter 6 Review	126

VII.	Financial Management Scenario	127
	Purpose	127
	Lab Goals	127
	Scoring Rubric	127
	Chapter 7 Overview	127
	Build basemap with two data frames.....	128
	Setting Data Frames.....	128
	Complete the Basemap	133
	Exercise #1 Insert Maps	136
	Exercise #2 Estimate Crop Yield per Acre.....	136
	Farm Enterprise Planning	138
	Exercise #3 Download MSU Budgets	138
	Complete Budget Spreadsheets	139
	Exercise #4 2017 Rice Production (bu50, bu58, bu64).....	139
	Exercise #5 2017 Corn Production (bu52)	140
	2017 Crop Production (po44 & po71)	141
	Exercise #6 Estimate Future Weather Patterns Ahead.....	141
	Land Grant Colleges and Extension Service	142
	Review Crop Extension Publications	143
	Calculating Growing Degree Days	144
	Download Weather Data	146
	MSUCares Weather Stations	
	~http://www.deltaweather.msstate.edu/ag_weather_products/ag_weather_products.htm (use the Cleveland weather station).....	146
	Oregon State University PRISM Weather	147
	Chapter 7 Review	152
	Textbook Resources	153
A.	SMS AG LEADER® COMPATIBLE FILE FORMATS	154
B.	ILLUSTRATION REFERENCES	156

LIST OF TABLES

Table 1	Advantages and disadvantages of geospatial data types.	19
Table 2	Projection system attributes.....	59
Table 3	Shapefile attributes and coordinate systems	73
Table 4	Costing units for production equipment, services, and inputs	114
Table 5	Simple net income calculation	119
Table 6	Calculated yield per acre estimates	137
Table 7	North Plot estimated returns for rice	140
Table 8	North Plot estimated returns for corn	141
Table 9	Upcoming production year weather estimates	142
Table 10	South Plot return estimates.....	144
Table 11	Crop planting dates.....	145
Table 12	Accumulated precipitation and growing degree days.....	147
Table 13	Scripts for calculating growing degree days.....	149
Table 14	Accumulated GDDs for MSUCares and PRISM	151
Table 15	Accumulated Potash [®] GDDs	152

CHAPTER I

dBase Protocols, and File Data Types and Formats

Purpose

This exercise will help students develop data management skills using dBase protocols. Students will manage provided datasets and download internet resources for use in this textbook. Through practice, students develop an understanding of different geospatial data types and formats used in precision agriculture.

Lab Goals

In this lab, students will:

1. Create appropriate dBase folder and file names for datasets
2. Build a file directory structure and store data using dBase protocols
3. Locate internet resources for these textbook exercises
4. Complete an answer sheet related to this lab exercise

Scoring Rubric

(50 Points)

1. Answer Sheet: Student completed the answer sheet (0 to 20 points)
2. Screen Shot: Student produced file directory structure for textbook data (folders expanded) (0 to 25 points)
3. 2 Screen Shots: Student located home town on Google Maps and Google Earth (0 to 5 points)

Chapter 1 Overview

Chapter 1 reviews data management principles and protocols. Users will create file folders on a portable hard drive using these protocols. Downloaded data will be stored and named in these folders using the same conventions. After reviewing the different geospatial data types, examine the different data formats available to users. Understanding and managing data is important because farm production data is received, edited, saved, and returned to the field enterprise in multiple formats.

dBase Protocols

Precision agriculture datasets are quite large and require specialized data management. Mapping software tends to create “relative” documents (like Adobe Photoshop) rather than “native” documents (like MS Word or Excel). Consultants need a concise and logical means to store and extract data for use in different software programs.

Think of precision agriculture mapping software as operating on the computer similar to an internet file browser. The software often “looks” at data on the hard drive, and incorporates stored data into maps. When browsing the internet, users must know the exact URL browser address to visit a website. Similarly with precision agriculture, users must know the exact “path” to the data. If data is saved in a logical place on a hard drive (or “path”), users are better able to refer to the datasets anytime and anywhere.

A computer path is the address where data is stored permanently on the hard drive. Most computers have a C:\ drive that is accessible with an MS Windows Explorer file browser. Both the files stored on the C:\ or portable E:\ drives, and the file names must follow the same logic.

Typical file folder structure for an ArcGIS project.

Keep in mind that the farm maps and reports created here have distinct paths, and these path “references” bring the data to life in the precision

agriculture software viewing window. Begin by reviewing rules about naming data files.

File Naming Protocols and Conventions

Many files provided for this text are already named. There may not be a right or wrong way to name data files, but users need to practice naming files and folders in a way that is congruent with standardized naming conventions. File naming practices should always be consistent. Here are some things to consider:

- **Does the naming convention use common sense?**
Do I and others understand it? Have I documented it? Does it convey a specific thought?
- **Does the naming convention make sense to other people?**
Have you asked peers about file names? Does the name align with the project mission? Are you willing to defend the use of this name and apply it in the future?

General Rules from dBase Protocols

The following general rules are founded in dBase naming protocols and conventions. A “database: is the most rudimentary file storage device used in computing. Its structure, or form, allows users to access data in multiple ways and allows searching through massive data sets through structured questions, or queries. For these exercises, users are not permitted to break the dBase rules, in general, and especially when working with mapping or “big” data.

- Limit file or table column name length to 10-13 characters, when possible but there are exceptions to this rule.
- No symbols or special characters in any file name.
- Do not use spaces in object names. An underscore (_) is permissible but limit the number of uses to:
 - 1 underscore per raster file or folder name
 - 2 underscores per vector file or folder name
- Do not use dashes (“-“) at any time in a file name.
- Begin all file names with a letter and not a number. There is no exception to this rule.
- Avoid using reserved words and reserved notations. (ID, DBO, VE, AKA, INT, EXP, MULT, DATE, TIME, YEAR)
- Keep names short but meaningful.
- Use sensible case. All raster file names are in lower case.

Folder names that store files should be logical and short. Make individual folders for each producer (i.e. C:\FarmerFred), and inside each folder create subfolders as follows in this example:

- C:\FarmerFred\Planting
- E:\FarmerFred\Scouting
- F:\FarmerFred\Harvest

Folder and file names should contain references in priority of the data contained within. For example:

- **Peterson_field3planter_20150602** refers to the producer (Peterson), the location and job (field3planter), and the date (always in YEARMODA format).
- **Henry_nff_20160403** refers to the research (Henry), his trial (North Farm Fertility), and the date.
- **Varco_RBNSense_20130528** refers to the researcher (Varco), the location and the trial (Ramsey Bottom Nitrogen Sensing trial), and the date.

Again, data sets received or downloaded may not follow these conventions exactly but do use logical naming conventions.

Exercise #1 Create file names using dBase protocols

Given the following scenarios and employing the dBase rules cited above, develop logical file names for each dataset described below.

1. You've downloaded a Soil Survey Geographic Database (SSURGO) soil dataset for the entire Oktibbeha County, MS. The zip file folder is named "soil". Rename this file folder.
 - a.
2. Today is April 23, 2016. You just finished planting the three corn fields in northern Jackson County, MS for Farmer Fred. You will retool and plant soybean fields nearby, but you must take the corn data off the tractor computer before retooling. Name the file folder for the data and name each of the individual files created from each planting enterprise.
 - a. Name the file path for storing the planting data:
 - b. Name the three individual corn field datasets:

3. You have just finished scouting for pests on a hot July day, just two days before our national Independence Day holiday, 2017. You've noted insect populations using a GPS unit, and you are about to download the data from the unit captured on a cotton field located in Yazoo County. Farmer John is looking forward to seeing your results. Name the file path that you are downloading to your flash drive:
 - a.
4. You're collecting color infrared imagery using a SkyHawk® fixed wing aircraft and a MicaSense sensor. You'll also test another flight platform, the EFlite® Apprentice, using the MicaSense® sensor. Your subject is corn grown on the North Farm at Mississippi State and you're collecting data every month on the 5th day starting in April through October, 2017. Set up your folders for the entire year. Make a base "Imagery" folder on your flash drive for all the datasets, then make subfolders for each aircraft type and sampling date. Finally, create a file path that you'll use to name the raw data outputs (.jpg format) and another file path for the processed data outputs (.tif format).
 - a.
 - b.
 - c.

END dBase Protocols Exercise _____

Folder and File Management

When employed in precision agriculture mapping, maintaining and backing up data is a big concern. The directory structure detailed here was created by Esri® professionals, and is constantly being updated and amended to meet project needs. Below is an example of how a mapping consultant should build a project folder structure.

Always create a main project folder off the computer drive by naming it **ArcProjects**. This folder name will float to the top of the hard drive list alphabetically. The project folder will be first in line when navigating to reference datasets.

Subfolders should make some sort of sense to the users. Perhaps a user makes maps on a statewide basis. Keep the county data separated, and then name the project in a county folder.

The lowest file folder level should have a storage unit for each file type. DBFFiles are dBase files (a simplified spreadsheet), and XLSFiles are MS Excel files. SHPFiles refers to Esri Shapefiles and these are vector (point, line, and polygon) formats. RSTFiles refers to pixelated or **sensed data**. We might be using images as Grid files (GRDFiles), Tiff files (TIFFFiles) and the like.

A simplified file management of class might appear as follows:

Expanded folder structure

Exercise #2 Managing Windows Explorer

Before dedicating editing drive space for the projects folder, verify the MS Windows Explorer is set up to reveal the folder and file names in “Detail”.

1. In Windows File Explorer (right-click Start >> File Explorer). Select the View tab and change the View to “Details”.
2. Verify in the Show/hide ribbon that the File name extensions box is checked.

File Explorer Settings in View

3. Choose the Options button >> and open the Folder Options dialog. Select the View tab.
4. Uncheck the Hide Extensions for known file types option and select the Restore previous folder windows at log on.

5. Click the Apply to Folders button and choose to proceed. Click OK to close the Folder Options window and choose to display all data in Details view.

Applying file folder settings.

6. In the File Explorer table of contents, navigate to the C:\ root of the computer hard drive (personal computers only) or the flash drive (university computers), which is an external drive such as E:\ or F:\ etc.
7. Locate the folder named: **"ArcProjects"**.
8. Expand the folder name and review the different labs (chapters) in this directory. How many Chapters (CH#) are included in this dataset?
 - a. 7
9. Review the materials in the labs. Locate the different file folder names and determine what data might be stored within.
10. **When finished, take a screen shot of the directory, in .jpg file format into the answer sheet.**
11. Close File Explorer.

END Folder and File Management Exercise _____

Internet Resources for Mapping

From time to time, people need a quick mapping reference to help locate data on Planet Earth. The internet provides two excellent mapping resources to users at no charge. Review the literature about the mapping services and follow the directions given within the dialog. University computers have pre-loaded versions of these programs but users may wish to download and install the software on personal computers.

Google Maps: <https://www.maps.google.com>

Launched in 2005, Google Maps® provides satellite imagery, street maps, and first-person street views for route planning. The platform, projected in Mercator, allows individuals to readily geo-locate simple objects and surroundings.

Right-clicking on any map surface and choosing “What’s here?” will produce an approximate latitude, longitude designation. The platform is not appropriate for polar mapping due to the projection system limitations. These maps are available on the majority of smart phones used worldwide and individuals can embed the maps using the Google Maps Application Programming interface (API).

At this time, verify access to Google Maps and make a bookmark it in a browser.

Exercise #3 Locate Hometown Coordinates

1. Navigate to the Google Maps URL listed above and search to find your hometown.
2. Right-click on your hometown and choose “What’s here?”
3. Locate the latitude, longitude coordinates in the search box, and note these coordinates.
4. Close Google Maps. **Insert your hometown name and coordinates in the answer sheet.**

Google Earth Pro: <https://www.google.com/earth/>

Also launched in 2005, Google Earth is a virtual globe that provides 3D geographic information systems (GIS), satellite, and aerial imagery. The software runs in standalone and browser plugin modes. Google Earth supports 3D geospatial data with Keyhole Markup Language (KML) and features sky and street mode views, a flight simulator, historical imagery, and some advanced astronomical data. Layers of data can be rendered in Google Earth and these include borders, places of interest, roads, 3D buildings, weather, ocean and sky layers. Latitude, longitude, and elevation parameters are given by default in a user-specified coordinate system.

Download and Install Google Earth Pro

1. Navigate to the Google Earth Pro link above.
2. Download and install Google Earth on a laptop computer.
3. Launch the software and **locate your hometown.**
4. Use the Print Screen function on your keyboard to copy the desktop image of Google Earth. Paste the image into a Paint program and edit it.
5. Add the name of your hometown photo.
6. **Insert screen shot of your hometown from Google Earth.**

END Internet Resources for Mapping _____

Geographic Data Types

Data that can be presented in a visual, mapped form is referred to as “geospatial data”. It comes in two basic forms and one is not exclusive of the other:

1. **Spatial data:** describes the absolute and relative locations of features in a map. Examples include a field boundary or GPS data points.
2. **Attribute data:** describes the characteristics of the spatial features in either quantitative (measurable) or qualitative (descriptive) terms. Examples include: crop type, harvested amount, insects counted.

Spatial data can be further broken down into primary encoding features. Data can be encoded like a picture (**raster**) or as points, lines, or polygons (**vectors**).

1. **Raster/Image data:** utilizes a matrix of pixels (picture elements) to create a gridded layer that can be employed in mathematical operations.
2. **Vector data:** utilizes points, lines, or polygons to represent a phenomenon.

Source: National Imagery Mapping Agency

Both raster and vector spatial data types are “representations” of a reality, and are used to approximate the real world. Maps are not a perfect description of the world, but rather maps are a generalization of reality.

Rasters are made up of columns and rows of data pixels. The center (or centroid) of each pixel has a specific longitude and latitude (x, y) for mapping. Raster datasets tend to be very large and take up a lot of hard drive space. What makes Rasters so ideal is the mathematical functions that can happen across layers. It's possible to add two rasters together to create a new one.

Vectors, on the other hand, are not regular like rasters. Each point on a vector data layer (called a “vertex”) has a known longitude and latitude (x, y) for mapping. Rivers, building polygons, cities, and roads are easily represented by vector layers. Users can do simple mathematics on a single vector, like measuring, but they cannot add two Vectors together to determine relationships between two layers.

Vector data can be converted to Raster data but some of the fine details will be lost in the conversion. When Raster data is converted to Vector data, the resultant layers may be too coarse for any value.

This simple table that details some of the advantages and disadvantages to both data types:

Table 1 Advantages and disadvantages of geospatial data types.

Rasters (pixelated data)		Vectors (points, lines, polygons)	
Advantage	Disadvantage	Advantage	Disadvantage
Lon/Lat/Elev (x,y,z) implied in raster matrix cell position	Cell size determines resolution of data	Data is fine and detailed in most cases	Each vertex must be stored explicitly
Raster data allows math analysis between data layers	Difficult to represent or link linear features	Graphic outputs are very pleasing and easily manipulated	Analysis of vector relationships is very difficult
Each raster layer holds only one attribute	Processing and raster storage is very intensive	Geographic location of features is quite detailed	Continuous data is not easily represented by vectors (e.g. elevation, rainfall)

END Geographic Data Types Exercise _____

Geographic Data Formats

The noun “attribute” describes a quality or feature characteristic. An attribute provides users with a piece of information about an object under consideration. Look around the room you’re in presently. Would you describe the room walls as dark or light? What color (attribute) would you define them as? Look at the other students? Are they different by gender or hair color? Every object can be described by attributed characteristics. In agriculture, soil texture is described as silty, sandy, or clayey depending on the ratio of compositional

factors. Plants are described as tall versus stunted. Plant color can range from dark green (usually healthy) to yellow (chlorotic) to even black (fungus damaged). A useful agricultural attribute at harvest time is the harvest rate captured with a tractor GPS unit. Corn grain harvest attributes are described in bushels per acre or megaton per hectare.

Attribute data analyzed with statistics or mapped using GIS software is remarkably beneficial because someone, somewhere, defined the attributes of interest in agriculture research or farm production. Previously, spatial data types were examined. Think about different data formats for a moment. Attribute data is stored as:

- Labels = alphabetical names defining an object; usually categorical and/or qualitative like colors, gender, variety, or
- Numbers = numerical representations that help quantify and differentiate different objects being studied.

Attribute data is stored in matrices called “spreadsheets”, “tables”, or “databases”. Users become familiar and learn these different names over time so don’t focus too heavily on the context here. Rather, be sure to understand the different ways attribute data is presented and employed.

Attribute data can be broken down into a variety of different management systems, or models.

1. **Tabular:** stores data characteristics as a sequential data file that are organized like a single table. Each location has a different record (a row). This is the most common attribute data. However, for extremely large datasets, other models must be employed because there are limited to the number of records (or rows) of data that may be stored in programs like MS Excel (usually less than 2000 points with ease).
2. **Relational models:** organized using many tables. In order to relate the multiple tables, a database must be employed. Your soils data from SSURGO will be relational.
3. **Hierarchical:** organizes data as a data tree. There is one tree with many branches.
4. **Network:** organizes data in a complex structure. This is commonly used in road mapping networks. There can be more than one tree with many branches.
5. **Object-oriented:** a collection of data elements and operations gathered together in a single entity.

For this text, most data will be in the **Tabular** data format but at least one **Relational** data model will be examined (soil data).

Begin by looking at this data through a software program created by the Environmental Systems Research Institute (Esri, Redlands, CA) called ArcGIS

for Desktop. ArcGIS platforms allow users to examine spatial data in a visual framework, and also permits editing and manipulation of attribute data.

A user may author maps and examine spatial relationships in geographic information systems (GIS) platforms.

Exercise #4 Navigate a Tabular Database

In this exercise, examine a database example from a geospatial dataset and describe different attributes of the dataset. Consider the map below created in ArcMap software

Points (cities), lines (roads), and polygons (water and county boundary).

The previous figure is a map of Bolivar County, Mississippi. Spatial data layers in the map include:

- Bolivar County boundary (empty polygon with black border)
- Field mapping data (see red arrow)
- Several Infrastructure layers including Cities, County Roads, Major Highways, Transmission Lines, Hydrology Flowlines (not turned on), and City Boundaries.

- Two Hydrology layers including NHD Flowlines and Waterbodies

Examine the image and note details about the attribute table associated with the Major Highways layer file. The major highways are noted in black lines.

1. The first column (field) contains an ObjectID_1* header. This field is used by GIS software to note individual records (rows) of data. Ignore it for now.
2. What type of shapefile is the major highways layer (Hint: points? lines? polygons?)
 - a.
3. Locate the field (column) that contains the name of each road section. What is the field called?
 - a.
4. Is the road name field justified to the right or to the left?
 - a.
5. Locate the field named "Class". This field contains a number for classifying different road types. A higher class number indicates the road is probably wider, more traveled, and receives more funding. Road Class numbers range from 1 to 8. Is the Class field justified to the right or to the left?
 - a.
6. Now, locate the Shape_Length field. This field contains data about the road length. Find the first record (row) containing information about MS Highway 446. What is the length of MS Highway 446?
 - a.
7. Bolivar County is approximately 52,500 meters wide. Is MS Highway 446 measured in meters or feet?
 - a.
8. Is the Shape_Length field justified to the right or to the left?
 - a.

An important feature of spatial data is that it is presented in either **Alphabetical**, **Numerical**, or **Alphanumeric** format. Previously, we discussed spatial data TYPES (vector, raster) but now you are examining spatial data **FORMATS** (alpha, numerical, alphanumeric). Here are a few general rules about spatial data formats:

1. Alphabetically formatted data justifies to the **left (AL)**
2. Numerically formatted data justifies to the **right (NR)**
3. Alphanumerically formatted data justifies to the **left**
4. Exceptions include:
 - a. Zip codes: numbers formatted as TEXT (left justified)
 - b. FIPS codes: numbers formatted as TEXT (left justified)

Here's a mnemonic device to help you remember the formats:

ALNR = Alphie left no. rights!

Zoom into the region of the field data and look at attributes from soil sampling. The field, located in northeast Bolivar County, is approximately 50.5 acres. In the following map image, the hydrology group (red flow lines) has been placed on top of the field data to help relate water flow across the landscape.

Map of Bolivar County Field #52 with hydrology flow lines.

Exercise #5 Examine Soil Attribute Data

Look closely at the attribute table associated with the soil sampling dataset in the figure below. Examine the attribute table and determine the following information about the data layer:

Table										
bu52_soilattribs										
	OBJECTID *	Shape *	lon	lat	sand_perc	silt_perc	clay_perc	elev	dipole1	dipole2
	1	Point	-90.742267	33.991974	5.057096	25.693312	65.469278	47.37078	4.990385	6.567308
	2	Point	-90.742275	33.992549	5.733614	29.286804	60.925347	47.44753	3.780303	6.731061
	3	Point	-90.742275	33.993115	3.871231	30.562347	61.468527	47.51773	16.954268	18.158537
	4	Point	-90.742275	33.993692	9.153503	64.398542	20.153968	47.59494	26.405	24.0525
	5	Point	-90.742275	33.994261	44.91424	33.1073	17.785907	47.6492	33.90051	29.55102
	6	Point	-90.742277	33.994839	13.515228	29.822335	50.772694	47.72369	23.975877	21.315789
	7	Point	-90.742278	33.995408	13.25	31.875	48.882812	47.80526	21.574324	19.986486
	8	Point	-90.742267	33.995979	11.601513	32.156368	50.179296	47.91088	23.290984	21.352459
	9	Point	-90.741591	33.995979	15.077882	31.775701	47.179084	47.92812	18	17.114286
	10	Point	-90.741586	33.995407	14.977974	34.612964	44.140153	47.82981	16.975962	15.807692
	11	Point	-90.741585	33.994833	14.066496	32.608696	47.147782	47.72894	17.764205	16.207386

Attributes in a shapefile attribute table.

- How many soil samples are there in this dataset (Hint: look at the parenthesis located at the bottom of the table and confirm the answer by checking the map)?
 -
- What is the spatial data type of this layer (Hint: vector or raster? point, line, or polygon)?
 -
- The samples are located using GPS coordinates found in the lon and lat fields (Longitude and Latitude). How are these numbers formatted (Hint: Alpha or Numeric)?
 -
- What do the sand_perc, silt_perc, and clay_perc fields represent (Hint: total the three columns)?
 -
- How are these three fields formatted?
 -
- The elevation field contains data about the surface elevation above sea level. Is it measured in feet or meters?

(Hint: go to Google Earth and determine the elevation. Type in the latitude number, followed by a comma, then the longitude.)

 -

The “dipole1” and “dipole2” fields contain data about soil electrical conductivity. This data is measured in mS/m/s (millisiemens/meter/second). A higher dipole rating represents higher soil electrical conductivity. This is often times related to clay content and other soil-richness factors.

It's time look at the data table and try to manipulate it. The soils attribute table was exported and saved in the CH01_DataMng folder under the DBFFiles folder. Leave this tutorial open but minimize it on your desktop so that you can

open a copy of the soils attribute table. Refer to this document and develop the answers for this exercise.

Opening .dbf Tabular Datasets

1. Set up the desktop so that this tutorial is minimized, but visible, on the right-hand Desktop side and an empty Microsoft Excel® is visible on the left.
2. In Excel, choose File ➔ Open. Click Browse.
3. In the Open window, choose the file type drop-down and select dbf files (*.dbf).
4. Navigate to: DRIVE:\ArcProjects\CH01_DataMng\DBFFiles folder. Select the bu52_soilattribs.dbf.

Open a .dbf file in MS Excel.

5. When the file opens, note that columns containing numerical data are formatted with high decimal precision. Highlight each of the columns, one at a time, and right-click choosing: Format Cells.
6. On the Numbers tab, choose the “Number” category, and make the decimal places “2” for all field except “lon” and “lat”.
7. Make the “lon” and “lat” fields 6 decimal places. Close the Format Cells dialog box.
8. Save the file in the same folder .xlsx formatted MS Excel file.

Save a .dbf file in .xlsx format.

9. Saving the .dbf file in the .xlsx format allows users to eventually re-add this data to a map document.
10. Let's graph the sand, silt, and clay percentages of this soil. The easiest way to do this is to create a scatter plot.

Exercise #6 Create Graphic Plots in Excel

Experiment with making graphs of the different soil texture components. There are no right or wrong answers here. Try different combinations of data and graph types and start with sand percent.

1. Highlight the sand_perc field by clicking on the letter header above its field name.
2. Select the Insert tab and choose to add a scatter plot. The next image details the Insert → Chart → Scatter icon.

Create a scatter plot.

When the graph appears, repeat the process and create scatter plots for silt_perc and clay_perc. The three separate soil composition plots may appear as follows:

Example scatter plots.

3. Based on the graph outputs, what inferences might be made about sand and silt when compared to soil clay texture composition?
 - a.
4. Delete these three graphs and experiment with graphing all three datasets in a single graphic output (Hint: select all three fields by holding the Control key and clicking each individual column. Try a line graph for this purpose).

Graph of three soil compositional factors.

Exercise #7 Save .xlsx Spreadsheets in Different Formats

Users may create different datasets using a single MS Excel spreadsheet. However, before saving in a different format, the “database range” (or exact number of cells to be included) must be defined.

1. When done graphing, delete all graphs and save the .xlsx file.
2. Create a database inside of the original .xlsx file before creating other data formats.
 - a. Locate the final cell in the spread sheet. Navigate to cell “I49” and select this cell.
 - b. Tap the Control-Shift-Home keys simultaneously to select all cells within the data range.
 - c. If the Range box is not completed with the word “Database”, type it in now and save the file.

3. Save the same file in a .csv format using the same general name but changing the extension. **CSV (Comma delimited) (*.csv)**. Answer Yes to keeping the data in the same format.
4. Re-open the .xlsx file once more. Save this time as a MS .txt file. **Text (MS-DOS) (*.txt)**. Again, answer Yes to keep it in this format and close all of the MS Excel worksheets. Answer No to resaving the documents.
5. Open a blank MS Word document on the desktop and navigate to the DBFFiles folder.
6. Choose the All Files (*.*) dropdown and select the .csv file to open first.
7. Examine the contents of this file. How are the data fields separated?
 - a.
8. Close the file and do not save it.
9. This time, open the .txt file. How are the fields separated (Hint: choose File → Options → Display and display all formatting marks).

Show all formatting marks.

The data is stored in tab-delimited format. This isn't very useful for statistics or mapping. However, users can easily convert the tab notations to a single space for employment in SAS.

1. In MS Word, tap the Control and F key simultaneously. This will open a navigation window. Choose the Navigation Search dropdown and select Advanced Find....
2. Select the Replace tab in the Find and Replace window.
3. Click the More>>> button to open advanced options.
4. Click one time in the Find What: box and then click the Special dropdown button.
5. Select Tab Character or enter “^t” in the Find what box.
6. Click one time in the Replace with: box and then tap the space bar 1 time only. This will launch a service to replace all tab characters with a single space.
7. Click the Replace All button.
8. How many tabs are replaced by this automated function?
 - a.
9. Examine the contents of this file. How are the data fields separated?
 - a.
10. Save the file and close the MS Word .txt document. Answer Yes to any prompts to save the data in this format.

11. The text file is ready for modeling in SAS or other statistical software programs.

In later chapters, we'll model the differently formatted datasets in precision agriculture software packages. Knowing how to create, manage, and save datasets in different formats is an important skill.

END Geographic Data Formats Exercise _____

Chapter 1 Review

In this chapter, readers explored spatial data types. Following dBase rules, the exercise created file folders to hold spatial data in a logical manner. Vector and raster data types, and alpha and numerical datasets were examined. Our investigation revealed that letters and numbers are stored differently inside of databases, or spreadsheets. This exercise presented ways to graph tabular data in MS Excel. Finally, you experimented with saving the data into different file formats for use in other software programs.

In coming chapters, this training will delve deeper into understanding why humans practice such the specialized form of data management called "geographic information systems" or GIS.

CHAPTER II

File Management and Soils Data Mapping

Purpose

The purpose of this lab is to help students understand relational databases and their utility in mapping complex (Big Data) datasets. Students will examine data in Windows File Explorer and ArcCatalog, and manage soils geospatial datasets in ArcGIS using the Soil Data Viewer.

Lab Goals

In this lab, students will:

1. Download a soil relational database from the Geospatial Data Gateway
2. Review tabular data formats in different file management platforms
3. Manage soils spatial and tabular data by relating features in an MS Access® relational database
4. Complete an answer sheet related to this lab exercise

Scoring Rubric

(50 Points)

1. Answer Sheet: Student completed answer sheet (20 points)
2. Screen Shot: Student completed soilmu_a_ms011 shapefile construction through relational database mapping exercise (20 points)
3. Attached: DBF shapefile table (10 points)

Submission Instructions: For this exercise, answers are submitted in the answer sheet, and .dbf shapefile table output is uploaded to the course portal.

Chapter 2 Overview

Chapter 2 trains students to obtain SSURGO soil data from the Geospatial Data Gateway for a county in Mississippi. Bolivar County is located in the Yazoo Basin about 2 hours southwest of Memphis, TN. Bolivar is the second largest county by land area in Mississippi (906 square miles), yet fewer than 3% of the population are employed in farming. Two-thirds of the county land is utilized for farming with an average farm size of 932 acres (Census of Agriculture, 2012). Grains, oilseeds, dry beans, dry peas, and soybeans are the top commodities

although corn, wheat, rice, and some cotton are farmed in the county. Sweet potatoes and melons also contribute to the farm commodity base.

The soils in Bolivar are as varied as the landscape, which is carved out by historical Mississippi River floods. Common soils found in the region include Alligator clay, Dubbs and Dundee silty loams, and Sharkey and Tunica clays. The county terrain is generally flat with little or no slope. Inland elevations average around 150 feet.

Connect the Drive in ArcCatalog

Before beginning any mapping exercise, use ArcCatalog to connect the flash drive to the mapping software.

4. Open ArcCatalog. In the Table of Contents, select the C:\ drive and click the Disconnect Folder button on the toolbar.
5. Click the Connect Folder button on the toolbar and navigate to the flash drive. Select the flash drive at the root and click OK.

Connect to Folder function.

Exercise #1 Soil Data Acquisition

Agricultural data for mapping is easily available through many of the online resources reviewed in the last chapter. The Soil Survey Geographic Database (SSURGO) is both a spatial (vector) and tabular dataset created by the USDA Natural Resources Conservation Service (USDA-NRCS). The vector soil units

(polygons) are linked to a database in order to allow mapping of multiple soil components and properties in a simultaneous manner. Chemical and physical soil properties, and their potential to produce crops, are integrated in a Microsoft Access® database. The data used to create the SSURGO compilation was obtained from a combination of field observations, site descriptions, and laboratory analysis. The SSURGO dataset is broadly available throughout the United States and is free to all users.

For this chapter, users have access to the dataset in the CH02_Soils data folder. However, there are times when users need to download the data for other projects. **Follow these instructions to download county soil data ONLY for projects other than this chapter.** The chapter data is found in the CH02_Soils folder.

Web Soil Survey Data Acquisition

1. Navigate to the Web Soil Survey website at:
2. <https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>
3. Click Start Web Soil Survey (Start WSS) button
4. Select the Download Soils Data tab. In the Download Soils Data menu, expand the Soil Survey Area (SSURGO) menu item.
5. Fill out the worksheet as follows:
 - a. State = Mississippi
 - b. County = Bolivar
6. When available, select the download “wss_SSA....” link highlighted in red as in the image below and proceed to download the dataset.

The screenshot shows the Web Soil Survey (WSS) website interface. The 'Download Soils Data' tab is active. Under the 'Download Soils Data for...' section, the 'Soil Survey Area (SSURGO)' option is selected. The 'Options' section shows 'State' set to 'Mississippi' and 'County' set to 'Bolivar'. The 'Download Links' table lists the download link 'wss_SSA_MS011_solidb_US_2003_[2018-09-17].zip' which is highlighted in red.

Name	Area Symbol	Data Availability	Version	Template Database	Download Size	Download Link
Bolivar County, Mississippi	MS011	Tabular and Spatial, complete	Survey Area: Version 14, Sep 17, 2018 Tabular: Version 14, Sep 17, 2018 Spatial: Version 6, Oct 8, 2017	solidb_US_2003 Access 2003 Version 36	26.2 MB	wss_SSA_MS011_solidb_US_2003_[2018-09-17].zip

Download Soils Data tab.

7. In your browser, locate the data download and click to launch it.
8. When the extraction utility file opens, choose to extract the data into the DRIVE:\ArcProjects\CH02_Soils\SHPFiles folder.

Unzipping the shapefile.

9. Close the Extraction utility when completed.
10. In File Explorer, navigate to the \ArcProjects\CH2_Soils\SHPFiles\ folder and locate the MS011 folder.
11. There are two additional folders in this file folder.
12. Double-click to open the spatial folder. This folder contains shapefiles used by ArcGIS to create a mapping layer. How many files are located in this folder (Hint: count them all).
 - a.

Exploring the Soils Data with ArcCatalog

In the previous exercises, data was reviewed or examined through the file utility called Windows File Explorer. A single spatial data file presented in mapping software is actually constructed from multiple files. The file set that creates a spatial dataset, which can be viewed as one, single spatial file using ArcGIS ArcCatalog as the primary viewing utility. Both File Explorer and ArcCatalog provide important functionality in mapping data.

Exercise #2 Preview a Spatial Data Folder

1. Open the Windows File Explorer file manager on the computer desktop and minimize it to about ½ the screen.

2. Drill down into the \ArcProjects\CH02_Soils\SHPFiles\MS011\Spatial folder. There are around **30 files** in this folder when looking at the data in Windows File Explorer.
3. Open a copy of ArcCatalog. Maximize ArcCatalog to fill the rest of the monitor window.
4. Expand the \CH02_Soils\SHPFiles\MS011\spatial folder. [If you cannot see your flash drive, connect to the folder In ArcCatalog. Locate the Connect to Folder button (yellow and black “+” sign) and select it. Select the flash drive folder. Click OK.]
5. How many files are in the CH02_Soils\MS011\spatial folder?
 - a.
6. Select the first file named soilmu_a_ms011.shp and click the Preview tab in the ArcCatalog viewing window.
7. Verify the Preview: dropdown defaults to Geography. Describe what this is.
 - a.
8. Click the Preview dropdown and select: Table.
9. Describe what this is.
 - a.
10. Return to Geography view.
11. Select the soilmu_l_ms011.shp file and preview it in Geography mode. Is anything visible?
 - a.
12. Choose to preview it in Table view. The file is empty. Both the soilmu_l_ms011.shp and soilmu_p_ms011 files are empty. For this exercise, delete these files. Right-click on the empty file names and delete them. Did the deleted files disappear from File Explorer?
 - a.

Examine the rest of the files in the folder. Use the first soilmu_a_ms011.shp file for this class but the other files might be useful later.

Exercise #3 Preview a Tabular Data Folder

1. In ArcCatalog, collapse the \MS011\spatial folder and expand the tabular folder.
2. What file format are the tabular files created in (Hint: what is the extension of the file name to the right of the period)?
 - a.
3. How many files are in the tabular folder (Hint: count them or right-click on the folder and choose Properties)?
 - a.
4. Select different .txt files in this folder and choose to preview them in Table mode. Not every file is populated, and that's OK.

5. In ArcCatalog, collapse the tabular data folder and located the soildb_US_2003.mdb file with an icon that looks like a silver tin can. This is the MS Access database that powers the data behind the shapefile.
6. Click the plus (“+”) sign to expand the Access database. Select the first file inside the database and use the down arrow to review each file.
7. Are all the files populated with data? or are there some empty files in the Access database?
 - a.
8. Scroll down to the “mapunit” file. Select and preview it in Table mode. Scroll to the right and note the names of the different fields (columns). What does the prefix “mu” stands for?
 - a.

A soil “map unit” is a geographic unit of the SSURGO vector shapefile. The tables within the dataset provide detailed information on soil properties and suitability for different management and production purposes. ArcGIS software can bring related tables into a mapping project and output several different types of maps.

Exercise #4 Relating Soil Tables to the Soil Database

The term “relate” means to join two or more tables, or give an accounting of a sequence of events. The soils relational database used in this exercise is quite complex and it will take some time getting used to the intense data management required to interact with it. Be patient and be prepared to work slowly through this exercise.

Relational databases are a popular means of handling “Big Data”. Big data refers to an extremely large collection of data sets that can be analyzed computationally to reveal patterns and trends. A computer provides fast processing speed but the relational database imparts the necessary structure for related multiple sets of data. The relational data format was invented by E.F. Codd at IBM® in 1970.

1. In ArcCatalog, minimize the soildb_US_2003.mdb database.
2. Expand the tabular folder again. Select the “cdfeat.txt” file in the tabular folder and click the Preview tab to view it in Table mode. What does this table suggest about different soils?
 - a.
3. The numbers in this table help refer, or “reference”, data from this table to other tables.
4. Select the “chorizon.txt” file. This file gives information about the makeup of different soil layers. Again, the numbers relate to several different tables. Each “|” (pipe) symbol is a delimiter that creates a field. There are many fields that can be created from this table. (Don’t be surprised if you get an error message here)

5. Now, locate the “chtextur.txt” table in the tabular file folder. View the file in Table mode. What does this table data represents?
 - a.
6. Take a guess here....Does soil texture have an effect on the erodibility of soils?
 - a.
7. Finally, locate the “muaggatt” and “mutext” files and view them in Table mode.

These Mapunit Aggregated Attribute and Mapunit Text tables relate all MUKEY and MUSYM fields to individual shapefile polygons. They are very important and must not be destroyed or altered. Think of a relational database as feeding information slowly through several data channels but every data channel recognizes a uniform key to refer data forward. The following graphic (Figure 15) helps visualize the complex relationships between different fields (columns) of data found in different relational tables.

SSURGO Table Diagram

Soil relational database. Used with permission from: UCDavis, California Soil Resource Lab.

Remember that we will work with spatial vector and raster data types in this class, and both data types are supported by either tabular or relational data formats. The SSURGO soils data will incorporate multiple data tables (.txt format) into a vector shapefile (polygon map units) and aid in creating interesting map

subjects. To learn more about the soil data in Access, refer to the Soil Data Access Query Guide located in the Utility folder. It's time to build a map.

Exercise #5 The ArcMap Document

In geographic information sciences (GIS) an ArcMap document is a file that contains one or more maps that are associated to tables, charts, reports, and different layers. We used ArcCatalog to preview the data that will map in ArcMap.

1. Close both ArcCatalog and File Explorer.
2. Open a new, empty ArcMap document.
3. The ArcMap document is made up several different components. Examine the following image and note the different ArcMap features.

The ArcMap document format.

The ArcMap text menu (File, Edit, Bookmarks....etc) gives users many basic tools for making maps. The toolbars have most of the text menu tools

ready for point-and-click launching. On the left side, is the Table of Contents (the **TOC**, for short) that displays the data in the map. The rest of the screen is a viewing window for looking at the data.

Float the mouse over the Standard toolbar. Standard tools help create, open, or save the map. Users can copy and paste from this bar, and may also choose to revert edits. The Standard toolbar also has an Add Data button for adding files to an empty map, and a Scale window for adjusting map size.

One very important consideration when using referential software like ArcMap or Adobe Photoshop is that the user is responsible for saving the map/image data. There are NO automatic saves in this software. Users must continually save a map in order to maintain its integrity. In these lessons, users are reminded over and over to ***Save the Map!***

The Tools toolbar is used for map navigation and data query within an active frame. Users can zoom in and out, pan, zoom to whole extent, and move back and forth between zoom distances. Using the Select Features button, a user can choose individual vector features for simple analysis. The Select Elements is the most important tool used when mapping. It is a standard mouse cursor. The Identification tool, allows a user to look at map attributes with point and click. There are other tools on this toolbar but we'll encounter them later.

The Soil Data Viewer tool is used extensively in this exercise. We'll cover it's utility later in this exercise. Note the Data, Layout, and Refresh views at the bottom of the ArcMap document. To the right, locate a notation of your Geographic Units. The Table of Contents lists the map data by several different methods. We'll use List by Drawing Order and List by Source for this exercise. Finally, the map is made, or constructed, in the Map Viewing Window.

4. If it's difficult to view any of the toolbars, float the mouse tip over the gray blank space just past the text menu line. Right-click in the grey space and view the different toolbars available. For now, work with only four different toolbars. Turn on the following toolbars and dock them as **shown in previous image**:
 - a. Soils Data Viewer toolbar
 - b. Standard
 - c. Tools
5. Choose to save the first, empty map. Click File ➔ Save and navigate to the DRIVE\\ArcProjects\\CH02_Soils folder. Save the map here and name it: Lab02_Soils.mxd

In the next step, verify the “Extensions” or tools are turned on in ArcMap. Ensure the map is fully functional by turning on all the processing extensions available.

6. In the Customize text menu, choose Extensions....
 - a. Verify the following extensions are checked (check all extensions if available):
 - i. 3D Analyst
 - ii. Geostatistical Analyst
 - iii. Spatial Analyst

Setting ArcMap Extensions.

7. Click Close to shut off the Extension wizard when finished.
8. Save the map (Hint: click the save icon on the Standard toolbar).
9. Locate the Add Data button (yellow and black “+” sign) on the Standard Toolbar.

10. Click the Add Data button and navigate to Folder Connections → DRIVE:\ArcProjects\CH02_Soils\SHPFFiles\MS011\spatial.

11. Add the soilmu_a_ms011.shp file to the map.
12. This map covers the entire county. In a moment, we'll explore data at the farm site level but for now, let's look at data on a county-wide basis.
13. Save the map and explore the Soil Spatial shapefile.
14. Right-click the soilmu_a_ms011 file in the TOC and choose Open Attribute table. How many records (or soil polygons) are there in this dataset?
 - a.
15. How many fields (columns) are in this table?
 - a.
16. Which field holds name to the map unit symbol?
 - a.
17. Which field holds a numerical map unit key so that tabular files can relate to the shapefile?
 - a.
18. Close the attribute table and save the map.

Making Maps with ArcGIS Soil Data Viewer

The Soil Data Viewer for ArcGIS is an ArcMap extension that helps build thematic maps. There are over 90 tables in the soil survey Access database and the Soil Data Viewer creates easy-to-access map outputs by relating the tables to the soil polygon shapefile. The Soil Data viewer creates thematic maps with units showing soil suitability for different applications. Each polygon of soil in the map is assigned a different map unit, and each map unit can be associated, or related, to several different soil components. Multiple soil components are aggregated to create a final map utility output. This all happens behind the scenes, but users must be aware that it is occurring.

If you have not already obtained the Soil Data Viewer extension for the computer, go to http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053614, and download and install the most recent version of the toolbar. When have completed the installation, be certain to load the toolbar by:

1. Adding the Customize ➔ Extension for Soil Data Viewer
2. Right-clicking in the blank grey space of ArcMap and opening the toolbar
3. Save the project.

Registering Soil Data Viewer 6.x an ArcMap Add-in

*****Only perform this registration on a personal computer*****

The Soil Data Viewer 6.1 installer no longer automatically registers Soil Data Viewer as an add-in to ArcMap. To manually register Soil Data Viewer 6.1 as an add-in to ArcMap, do the following:

1. Using File Explorer, navigate to C:\Program Files (x86)\USDA\Soil Data Viewer 6.x.
2. In directory C:\Program Files (x86)\USDA\Soil Data Viewer 6.x, double click the file named "SDVArcMapAddin.esriAddin".
3. There are two files in this directory where the non-extension portion of the file name is "SDVArcMapAddin", "SDVArcMapAddin.dll" and "SDVArcMapAddin.esriAddin". If file name extensions are currently hidden, a user won't be able to distinguish between the two.
4. To display file name extensions in Windows XP, open My Computer or File Explorer, select "Folder Options" from the Tools Menu, click the tab labeled "View" and clear the "Hide extensions for known file types" check box.
5. To display file name extensions in Windows, select Control Panel > Appearance and Personalization > Folder Options, click the tab labeled "View" and then clear the "Hide extensions for known file types" check box.
6. In the "ESRI ArcGIS Addin Installation Utility" dialog that comes up, click the button labeled "Install Add-In."

This will add the Soil Data Viewer toolbar, a toolbar with only one button, to ArcMap, but that toolbar will not yet be docked. To dock the Soil Data Viewer 6.x toolbar, open ArcMap, click in the grey area to the left of the "x" at the top of the Soil Data Viewer 6.x toolbar, drag that toolbar into the toolbar area at the top of the ArcMap window, and release the mouse button. The docked Soil Data Viewer tool bar looks like this:

Soil Data Viewer Tool

If the Soil Data Viewer toolbar/button is not visible in ArcMap:

7. Select "Toolbars" from ArcMap's Customization Menu. Scan through the list that is displayed and look for "Soil Data Viewer Toolbar".
8. If the list does not include "Soil Data Viewer Toolbar", Soil Data Viewer has not yet been successfully registered as an add-in to ArcMap.

9. If the list does include "Soil Data Viewer Toolbar", look to see if there is a check to the left of that entry. If there is, Soil Data Viewer Toolbar should already be visible in ArcMap.
10. If there is no check to the left of "Soil Data Viewer Toolbar", left click on "Soil Data Viewer Toolbar" to add the Soil Data Viewer toolbar to ArcMap.

Relating Tabular Tables to the Access 2003 Database

In order to relate tables in the Access database to the ArcMap shapefile, a user must define the Access database "path" to the data tables in the tabular folder.

1. With SSURGO soilmu_a_ms011 shapefile loaded in the main viewing window and TOC choose to save the map.
2. Minimize ArcMap and open File Explorer.
3. Navigate inside of the
DRIVE:\ArcProjects\CH02_Soils\SHFiles\MS011\tabular folder.
4. Copy the path in the File Explorer path line (highlight the path and hit Control-C).
5. Navigate up one level to the MS011 file folder.
6. Double-click on the soildb_US_2003.mdb file name to launch it.
7. If necessary, select to Stop All Macros and click the Enable Content button (Not everyone will experience this problem).
8. When the SSURGO Import window opens, paste the copied tabular folder path into the box as follows: **DRIVENAME:\ArcProjects\CH02_Soils\SHFilesMS011\tabular**
9. Click OK and wait while the processing loads. The tables in the tabular folder are being related to the tables in the Access database.
10. When the Soils Reports window opens, scroll up and down in the Map Unit Symbol/Name window and note the different symbols associated with different soil types.
11. Under Report Name, drop down the selection list and note the different soils reports that are possible.
12. When finished, do NOT make any selections.
13. Click Exit to close the Soils Reports window.
14. Exit the Access soil database without saving. Close File Explorer.

Map Soils using the Data Relational Database

After completing the process of relating multiple tabular tables (.txt) to the Access (.mdb) database, create some meaningful maps.

Exercise #7 Make an Erosion Map

1. Return to the previous ArcMap document.
2. Right-click the soilmu_a_ms011 layer and Open Attribute Table. List the names of the fields in this table:
 - a.
3. Close the attribute table but be sure to keep the shapefile selected in the Table of Contents.
4. Click the Soil Data Viewer one time.

5. In the Please select a soil map database wizard, navigate to the \CH02_Soils\SHPFiles\MS011\ folder and select the soildb_US_2003.mdb file. Click Open.

Relating the soil database to the vector file.

6. The Please select a soil map layer wizard should appear. Verify the soil shapefile is the same file as currently in your map. Click OK.
7. A Soil Data Viewer wizard appears. Note in the TOC different soil Attribute folders available.
8. Below the TOC, click the Advanced Mode radio button. Only certain advanced features will work with this database. We'll make at least two advanced maps in the beginning of this exercise then we'll make a few basic maps too.

9. Expand the Soil Erosion Factors folder. Select the K Factor, Rock Free option. A large grey arrow indicates this layer is selected. Read the Attribute/Folder Description.
10. What does an Erosion factor K indicate?
 - a.
11. What unit does this model calculate soil erosion into?
 - a.
12. How wide is the range of K values?
 - a.
13. What do higher values indicate?
 - a.
14. What is Ksat?
 - a.
15. Click the Ratings Options tab in the viewing window. Review the default settings and note the aggregation method (dominant condition). More than one table component is used to create the K Factor map and data is aggregated by dominant conditions, which first groups like attribute component values and then sums the percent composition of all values. (Read more by clicking the Method Description button).
16. Click Map to generate the map.

The default color ramp is not appropriate for this map. A Thematic Map presents topics, or themes, in a graphic manner. If mapping both soils and water, we might want to use blue, red, and green colors. In this case, the map represents quantitative data that is ranked low to high. In most thematic maps, Red = bad and Green = good. Change the Symbolology of the map.

1. Right-click the K Factor layer and choose Properties → Symbolology tab.
2. Click the color ramp and choose the color bar that presents Green to Red. If green represents high themes (is backwards), left-click the header "Symbol" and Flip Symbols.
3. Uncheck the <all other values> check box. Click OK to close the Properties dialog box.
4. Review the K Factor data layer and determine where erosion potential is highest.
5. Now, examine the attribute table for the K Factor layer. Right-click the layer → Open Attribute Table.
6. Has a new field been added? Verify the name is: KfactRF.
7. Right-click the KfactRF field and sort in ascending and descending order. The lowest and highest values in the KfactRF field are Null and 0.64, respectively.

This shapefile is not permanent and the KfactRF field will disappear each time you make a new map. To save this shapefile as a permanent file, simply export the file and save it under a new name.

1. Close the attribute table.
2. Click the Clear Selection button only if it is visible (it may not be visible so skip to the next step).

Clear Selection

3. Right-click the K Factor, Rock Free name in the TOC and choose: Data ➔ Export ➔ Export Data
4. Choose to Export: All features. Click the Output feature class navigation button and navigate to the \CH02_Soils\SHPFiles folder.
5. Save the file there naming it: KFact_RF.shp. Saving will take a little time. Don't add it back to the map just yet.

Saving an exported soil relational vector file.

Exercise #7 Saturated Hydraulic Conductivity (Ksat) Map

1. Right-click and remove the K Factor, Rock Free layer from the TOC. Save the map.
2. The Soil Data Viewer is still open on the Windows Task Bar. Find it and open it up again.

3. With the Soil Data Viewer open, choose the Soil Physical Properties attribute folder → Saturated Hydraulic Conductivity (Ksat), Standard Class.
4. Select the Attribute/Folder Description tab.
5. What does Ksat refer too?
 - a.
6. What units are used to express Ksat?
 - a.
7. When is Ksat important?
 - a.

Very low Ksat numbers implies water sits on top of soils and does not saturate through the soil. The Ksat soils are prone to topsoil erosion. Very low KFactor numbers indicates soil has low erodibility.

8. Before mapping, click the Rating Options tab.
9. Under the Layer Option, verify the Depth Range radio button option is selected.
10. Make the Top Depth range "0" centimeters and make the Bottom Depth "25" centimeters. Click Map.

There's a lot of black lines impeding a user's ability to see all the map colors. Change the Symbology here again.

1. Save the map. Right-click on the Saturated Hydraulic Conductivity (Ksat) layer and choose Properties.
2. Change the color ramp to Red to Green. Red is low and Green is high.
3. Click OK to apply the changes. Verify the Clear Selection button is not active (if active, deselect it).

4. Right-click the Saturated Hydraulic Conductivity layer in the Table of Contents and choose: Data ➔ Export Data.
5. Export All features of this shapefile to the same \CH02_Soils\SHPFFiles\ folder naming it: Ksat.shp.
6. Add it back to the map. Remove the Saturated Hydraulic Conductivity layer from the map.
7. Click Add Data and add the Kfact_RF shapefile to the map. Save the map.

Compare Ksat and K Factor

Agricultural maps create an opportunity for producers, scientists and data provides to observe phenomenon and make inferences about physical relationships. Suppose a soil scientist would like to estimate soil erosion. Would the scientist consider only one soil factor? Probably not. Instead, they'd look at multiple soil components across the entire soil horizon, and at hydrology and wind data, in order to surmise the causal effects of erosion. Observation (inductive) science is a lot like a relational database where an expert understands the nature of the multi-layers and can infer, or hypothesize, about causal effects. Next, compare Ksat and Kfactor data layers to see if any inferences might be made.

1. Move the Kfact_RF layer to the top of the TOC over the Ksat layer.
2. Turn on the Kfact_RF layer. Remove the soilmu_a_ms001 layer from the map, and save the map.
3. Double-click the Kfact_RF shapefile name (soilmu_a_ms011) and launch the Properties dialog box. Choose the General tab and rename the layer: Kfactor, Rock Free
4. Click the Symbology tab. In the Show: box, choose Categories ➔ Unique values.
5. Click the Fields – Value: dropdown and choose: KfactRF. Click the All All Values button and uncheck the <all other values> box.
6. Click the Symbol name and choose Properties for all symbols...

Setting the Layer Properties in the soil shapefile.

7. Set the outline color of the polygons to No Color and click OK and OK again.

8. Low (green values) have low erodibility while high values (red) have high erodibility. Save the map.
9. Open the Ksat Properties dialog. On the General tab, change the name to: Saturated Hydraulic Conductivity.
10. Select the Ksat Symbology tab and then choose: Categories → Unique values. Uncheck the <all other values> box.
11. In the Value Field dropdown, choose: KsatClass. Click Add All Values.
12. Click the Color Ramp and choose: Green to Red.
13. Select the Symbol name over the colors and choose Flip Symbols (Low is bad or red, High is good or green).
14. Select the Symbol name over the colors again and choose Properties for All Symbols. Make the Outline Color = No Color. Click OK and OK again.

Setting Symbol properties.

15. Toggle the K Factor layer on and off. What relationship is there to K Factor erodibility and Saturated Hydraulic Conductivity, according to this map?
 - a. When Ksat is high, erodibility is ??? answer =
 - b. When Ksat is moderate, erodibility is ??? answer =
 - c. When Ksat is low, erodibility is ??? answer =
16. Are there relationships between Ksat and Kfactor?
 - a. Write your answer here...

One cannot make inferences about an entire soil profile from this map alone because there's only data at the soil surface here. Other maps are needed to look deeper in the soils in order to compare K Factor to Ksat. Look through the Soil Data Viewer list and determine if there might be other layers that could help users understand soil erosion.

Create More Maps

Work independently here to create more maps in the Soil Data Viewer. **Take a screen shot of each map created and save the screen shot to your answer sheet.** Do not export the files to a permanent feature class because your dataset will get too large.

1. Launch the Soil Data Viewer again, in Basic Mode, and proceed to create the following database tables:
 - a. Vegetative Productivity → Yields of Irrigated Crops (Component) →
 - i. Crop = Rice, Yield = Bu (Field Name: ricebu)
 - b. Vegetative Productivity → Yields of Non-Irrigated Crops (Map Units) →
 - i. Crop = Corn, Yield = Bu (Field Name: cornbu)
 - ii. Crop = Cotton Lint, Yield = Lbs (Field Name: cottonlbs)
 - iii. Crop = Soybean, Yield = Bu (Field Name: soybu)
2. In Advanced Mode, proceed to create the following 3 maps:
 - a. Soil Physical Properties
 - i. Percent Clay → Surface Layer (Field Name: percclay)
 - ii. Percent Sand → Surface Layer (Field Name: percsand)
 - iii. Percent Silt → Surface Layer (Field Name: percsilt)

Chapter 2 Review

The previous exercise was complex but the data created is useful for other mapping and research projects. Agricultural mapping often requires the end-user to develop datasets through multiple means including using data provided by “Geospatial Data Providers” as well as data collected on-farm. Regardless of where the data originates from, the same data management (dBase) rules apply.

In this exercise, you downloaded the USDA-NRCS SSURGO spatial and tabular dataset, which is available in most U.S. counties. After reviewing the different data formats (.txt, .dbf, .mdb) and applying simple tools to create bigger datasets, final maps were created. The maps allowed a viewer to perform simple, visual analysis of soil features, and also create tools to estimate crop productivity.

In the next chapter, we’ll take a step away from farm mapping and look at global mapping conventions. All maps originate from ancient cartographic processes, and these age-old traditions are still used today in the most modern software platforms. Learning about Geographic and Projected Coordinate systems will help manage an ever-growing agricultural dataset in the coming weeks.

Think of data management and coordinate systems as the two most difficult, yet important, subjects to teach in mapping “Big Data”. However, with practice, anyone can become an expert at both.

CHAPTER III

Geographic & Projected Coordinate Systems; Weather Datasets

Purpose

The purpose of this lab is to train students to apply projected coordinate systems for different mapping exercises, and to calculate growing degree days for making predictions about crop maturity.

Lab Goals

In this lab, students will:

1. Perform a projection mapping exercise
2. Create a map greeting poster from a projection system
3. Calculate growing degree days from two different weather datasets
4. Complete an answer sheet related to this lab exercise

Scoring Rubric

(50 Points)

1. Answer Sheet: Student completed the answer sheet (0 to 40 points)
2. Screen Shot: Student produced map poster greeting (0 to 10 points)
3. Bonus points: Student predicted off-site location using map technology (0 to 5 points)

Submission Instructions: For this exercise, submit an answer sheet containing all the elements of the required work. Insert the map into the answer sheet in .jpg format.

Chapter 3 Overview

This week's exercise will be light and enjoyable. In this chapter, users will learn about coordinate systems that reference real data into the virtual mapping world. All data collected on a farm references to a known location. Defining "known" locations in a computer requires sophisticated map algorithms that are easy to apply once an end-user understands when and where to employ them. A fun mapping exercise called "Tissot's Indicatrix" will guide in creating global and local maps with accurate reference information.

Geographic and Projection Coordinate Systems

The Earth we exist on is round, or geoid, in shape. Once thought as flat, cartographers 2000 years ago began to hypothesize our world as a spheroid. Millenniums of philosophic and scientific data gathering provided evidence that the world is not only round but rather ellipsoidal, or flattened at the poles. Finally, the Jason-1 satellite monitor of 1992 approximated the “geoidal” shape of Earth by measuring the differences in gravitation across the global surface. Modern computer-aided mapping of farm, terrestrial, and aquatic ecologies takes into account these different interpretations of the Earth’s surface, and adjusts map output based on user defined criteria.

It’s important to recognize the “real” shape of our Earth when mapping. Without a sense of reality, maps would be inconsistent and inaccurate. Software end-users are not required to know how the software manipulates space of the input data, but all users must be aware of the adjustments as they occur. The following graphic depicts some of the inconsistencies between the spheroidal, ellipsoidal, and geoidal surface definitions.

Gravimetric Datum Orientation

Note the presence of three different Earth centers in these graphs. Earth's center is a reference point from which all other measurements can begin. We call this point a **DATUM**. In 1984, the World Geodetic System (WGS84) became the standard for all mapping and navigation through Global Positioning System (GPS) technology. The WGS84 standard creates a coordinate system (longitude, latitude in decimal degrees) that compromises between a spheroid reference for raw altitude AND a geoid reference for nominal sea level. From this, all objects on Earth can be pin-pointed and measured to a high degree of accuracy.

Geographers and scientists use two different coordinate systems to map the Earth. **Geographic Coordinate Systems (GCS)** are used to model a round, 3-dimensional Earth while **Projected Coordinate Systems (PCS)** are employed to make flat maps. Geographic Coordinates Systems are the oldest and were first used in global navigation. However, Projected Coordinate Systems help us maintain integrity of a map's **SHAPE, AREA, DISTANCE, and DIRECTION (SADD)** because surfaces are warped when moved from a 3-dimensional model to a 2-dimensional map. A projection system cannot preserve all SADD features, so the system adopted to project into must be chosen carefully.

Geographic Coordinate Systems (GCS)

Data collected and converted into mapping files is gathered either with or without the aid of Global Positioning Satellite (GPS) technology. Maps created before 1984 were created through drafting, or hand-drawing, procedures. In 1984, the World Geodetic System became the standard for recording geographic coordinates (Longitude, Latitude) on a 3D Earth model.

Think of a round, 3-dimensional Earth. The Earth's center of mass is known to within 2 cm of error. We name this center, the Earth's defined center, the **DATUM** of our reference ellipsoid.

NGIA World Geodetic System (WGS84) Model

Locate the red dot in the image below. This is the surface coordinate reference 0,0 degrees longitude, latitude.

World Map with 0,0 meridian marked in red

The 0,0 decimal degrees marked in red above falls on the Prime Meridian running north to south through Greenwich, England. The Equator, is the Principle Parallel dividing the northern and southern hemispheres. While the Prime Meridian is an arbitrary construct, the Equator provides geographers with an estimate of Earth's rotational axis.

Continuing to model on a 3-dimensional Earth system, we find locations by moving on the x-axis (right or left horizontally) by longitude and the y-axis (above or below, vertically, the equator) by latitude by units called **DECIMAL DEGREES or DEGREES, MINUTES, SECONDS** (these units can be converted back and forth).

Latitude and longitude lines on a 3D Earth model Source: Fedstats.gov

The 3D model works fine for active navigation but it does not allow for mapping area because the area under the units (decimal degrees) change with one's position to the North and South poles. Many online map programs state geographic coordinates as latitude and longitude, but this is not correct. ALWAYS state longitude and latitude in the x-axis, y-axis format by reading decimal degrees as, for Mississippi State University:

-88.790005 degrees longitude and 33.455646 degrees latitude.

The z-axis represents elevation above the Earth's surface from mean sea level. Mississippi does not have a great deal of elevation variation but mappers will encounter z-axis data from time to time.

Find Your Hometown on Google Maps

1. Open a copy of Google maps on the computer desktop. In the Search box, type in your home address and zoom to it.
2. Did you arrive at your home? If so, right-click on the house or building and choose: "What's here?".
3. Note in the Search Results window that two coordinates are posted in small print. THESE COORDINATES ARE POSTED IN REVERSE. Both Google Maps and Google Earth post the coordinates as latitude, longitude but we always speak in **Longitude, Latitude!!!!**

A device to help remember the correct x,y,z order is to say:

The LONger the LATter, the higher you'll climb to the skyZ!!

Bing Images, 2016

Projected Coordinate Systems (PCS)

Imagine that the Earth's skin is peeled and removed in a 1 inch thick section across the entire globe. Imagine again trying to flatten the skin into a map. Practice this with an orange and it becomes apparent that the Earth's surface warps in an unrecognizable manner. Therefore, in order to map a 3-dimensional Earth in a 2-dimensional manner, a special coordinate system is required for making areal maps. This second, complimentary system is called a Projected Coordinate System (PCS).

Keep in mind that all projected coordinate systems are first referenced by a GCS. Applying a second coordinate system over a GCS simply corrects for the warping of shape, area, distance, and/or direction (SADD). Users may map and measure distance in GCS but **cannot** measure area in a GCS. A mapper must **apply** a PCS over the GCS in order to create flat maps that measure areal units. This is particularly important in farm mapping.

Working with Tissot's Indicatrix

Projecting, or unfolding the spherical Earth onto a flat map, has been a problem in mapping since the Earth was theorized as spherical. Projection systems are meant to reduce distortion but they almost always introduces some acceptable space-warping in order to preserve the maps integrity.

Most projection systems **cannot simultaneously** preserve all angles, areas and distances. Projection systems that preserve angles (areal shapes) are named **CONFORMAL** systems. Systems preserving area measurements are called **EQUAL-AREA**. Distance measurements are preserved by **EQUIDISTANT** PCS. Only a round globe can actually preserve all different warps simultaneously. Like the WGS84 compromise of different Earth shape definitions, PCS are a compromise to preserve SADD

The choice of projection depends on a map's use, scale and audience. Nautical charts are usually created using conformal projections while making continental maps typically employs equal-area projections. Hybrid projections minimize distortion by merging conformal and equal-area projections, these can be used to create visually pleasing maps of the entire Earth.

The following mapping exercise will help users appreciate the different map projection systems. The 19th century French cartographer Monsieur Nicolas Auguste Tissot created the [Tissot's Indicatrix](#) (or Tissot's Ellipse). The Indicatrix is a mathematical contrivance that presents a grid of infinitely small circles to help visually measure the degree and type of projection distortion. Follow the exercise instructions and answer the questions within the tutorial. Submit the answered questions in the chapter answer sheet.

Refer to the table below and review the best PCS for preserving map characteristics (shape, area, and/or distance):

Table 2 Projection system attributes

Projection Type	Circle Attributes	Sign Attributes	Example
Conformal (preserves shape)	Area and size changes while shapes remain constant	Cross sizes change but always intersect at 90 degree angles	Mercator (meter); State Plane (feet)
Equal-Area (preserves area)	Area remains constant while shape of circle changes	Crosses will not always meet at 90 degree angles	Mollweide; Hammer; Bonne; Goode's Homolosine
Equidistant (preserves distance along a path)	Circles tend to distort in east-to-west directions if north is held constant	Crosses distort east-to-west	Equidistant azimuthal and cylindrical; Cassini
Hybrid	Area and size of circle changes	Size and cross-hair angle changes	Robinson

Exercise #1 Review the Lab Data

1. In File Explorer, navigate to the textbook data folder and expand the CH03_ProjSys\TissotsIndicatrix folder. This lab folder contains a geodatabase shapefile folder called TissotsIndicatrix.gdb and a premade map at the root of the folder (.mxd format).
2. When finished, close File Explorer.
3. Open ArcCatalog and review the data in the CH03_ProjSys folder. The subfolder named: "TissotsIndicatrix" contains mapping data used in this exercise.
4. Drill into this folder and expand the geodatabase named TissotsIndicatrix.gdb.

A geodatabase (GDB) is a spatial data storage device and management framework built especially for ArcGIS mapping. GDB files can be read by a few other software packages but often times, an end user will convert GDB files back to shapefiles (.shp) to map in programs outside of ArcGIS.

Geodatabases store GIS data in a central location for ease of use and long-term management. The GDB can be leveraged in servers and mobile environments, and is associated with more complex databases such as SQL (Sequel), Oracle, and others. Think of a geodatabase as a "can" in which a user stores data and links that data to a map. Once linked to a map, the GDB and map can be shipped via email without losing connection from an altered path. In GIS, it's likely to encounter GDB files, so think of them as "shapefiles and raster files in-a-can".

5. Examine and preview each of the feature class layers in the geodatabase. The Countries layer contains how many records (Hint: preview in table mode)?
 - a.
6. Which field (column) contains the country name?
 - a.
7. Are fields in this geodatabase feature class capitalized or in lower case?
 - a.
8. Review the GraticuleIntersections feature class. What type of vector file is this (point, line, polygon)?
 - a.
9. In geography mode, find the 0,0 Decimal Degrees point. Where is this located (Hint: float the mouse over the map and find 0,0 Decimal Degrees)?
 - a.
10. Select and review the GraticuleSubset. What type of vector file is this?
 - a.
11. In geography mode, find the 0,0 Decimal Degrees location on this grid. Where is it located?
 - a.
12. Examine the TissotEllipses. in geography mode. Are they identical in shape and size?
 - a.
13. Describe how the circles are different.
 - a.
14. Locate the 0,0 Decimal Degrees location on these circles. Where is it?
 - a.
15. Finally, examine the World30 grid. Where is the 0,0 Decimal Degrees location in this grid?
 - a.
16. Now, return to the Countries feature class in geography mode and locate the 0,0 Decimal Degrees location. Where is it.
 - a.
17. Examine the distortion of Antarctica and Canada? Are they distorted like the TissotEllipse?
 - a.
18. Close ArcCatalog.

Exercise #2 Mapping with Geographic Coordinate Systems

1. Open an empty ArcMap document. Save it in the CH03_ProjSys\TissotsIndicatrix folder as: "CH03_TissotsIndicatrix".

2. Click the Add Data button and navigate into the CH03_ProjSys\TissotsIndicatrix\TissotsIndicatrix.gdb. Select all the files and add them to the map at the same time.
3. Verify you are in List by Drawing Order in the Table of Contents. Save the map.
4. Move the TissotsEllipses layer above the Countries layer and below the GraticuleSubset layer.
5. Right-click the Graticule Intersections layer (point file) and choose Properties → Symbolology.
6. Click the Symbol button one time to open the Symbol Selector wizard.
7. Scroll half-way down the options and choose: “Cross 1”. Click OK and OK to close the Properties wizard and save the map.
8. Click the World_30 symbol to launch the Symbology Selector. Make the symbol: “Lake” and click OK.
9. Describe the distortion of circles in the North and South Poles. The North and South poles should appear distorted.
10. Locate 0,0 Decimal Degrees. Verify the location is the same as suggested in an earlier map (off the southern coast of West Africa).

Below is an example of how the map should appear and where to find the Measure tool for the next exercise. Examine the image and verify the map Symbology appears as suggested in the TOC. Next, open the Data Frame Properties wizard to guide you through the exercise.

A formatted Tissot's Indicatrix map.

It's time to begin experiencing different coordinate systems. First, let's experiment with 3-D mapping coordinate systems. We'll save the map for each exercise in order to preserve the basemap set up.

1. Begin by saving the map one more time.
2. Save the map again and this time name the new version: CH03_GCSmapping.mxd.
3. Right-click the Layers name in the TOC. Choose Properties → Coordinate System tab. Verify the Geographic Coordinate System (GCS) applied to this data is WGS84.

4. Move the Data Frame Properties box to the left-side over the TOC (see above) so the map viewing area is visible. Expand the Geographic Coordinate Systems folder and choose USA and territories → NAD 1927.
5. Right-click the NAD 1927
6. Click Apply and choose the Transformations button.

The next exercise involves “transforming” from one datum (WGS84) to an older datum (North American Datum of 1927). Remember that different GCS systems use different definitions of the Earth’s shape. In 1927, the North American Datum referenced Meade’s Ranch, Kansas, as the central point of reference in the U.S. Today, we use the modern WGS 84 satellite-derived datum discussed earlier.

IMPORTANT NOTE: The Geographic Coordinate Systems Transformation wizard will guide users through this process. Do NOT change the Convert from: or Into choices. The software can convert in either direction.

Transforming a geographic coordinate system.

1. Choose the Using (choices are sorted by suitability for the layer’s extent) dropdown.
2. Select the NAD_1927_To_WGS_1984_3 option (again, don’t worry about the direction of the transformation but choose the correct transformation) and click OK and Yes to close the Warning: box.
3. Click Apply and observe any changes to the map. Notice any changes in the map? It may be difficult to see changes but there are minor adjustments, especially near the Central Meridian.
4. Reopen the Data Frame (Layers) Properties box, if it closed and change back to WGS 84 (Hint: Geographic Coordinate Systems → World → WGS 1984 at the bottom of the list.)
5. Try different Geographic Coordinate Systems and note the subtle changes before trying Projected Coordinate Systems.

Many different geographic coordinate system algorithms exist. However, while in GCS, a user cannot measure area. To prove this point try the following:

6. Locate the Measure tool on the Tools Toolbar. In the Measure wizard, select the Choose Units drop down. Note the Distance units.
7. Is it possible to measure in feet and meters with this tool?
 - a.
8. Return to the Choose Units dropdown again and select Area. Is it possible to measure Area in a GCS using this tool?
 - a.
9. It is not possible to measure area in a GCS but it is possible in a PCS. Save and close this map.

Exercise #3 Mapping with Projected Coordinate Systems

In the previous exercise, you examined changes to the map on a global scale when applying different 3-D geographic coordinate systems. In the next exercise, you will apply 2-D projected coordinate systems that are typically reserved for local mapping. However, several PCS's aid in making beautiful global maps, and users might be familiar with a few of these styles.

1. Reopen the original CH03_TissotsIndicatrix.mxd map and save it as: CH03_PCSmapping.
2. Double-click the Layers name in the TOC to launch the Data Frame Properties dialog box. Choose the Coordinate System tab.
3. Minimize the Geographic Coordinate Systems folder, if necessary, and expand the Projected Coordinate Systems folder.
4. Set the map and Data Frame Properties wizard up so that it's possible to work with both simultaneously.

Setting Data Frame Properties.

For the initial part of this exercise, select different folders and apply projected coordinate systems. The objective is to describe the different distortion as it relates to the given system. Later in this exercise, you'll make a greeting poster out of a famous projection system known to most cartographers.

Goode Homolosine

1. Scroll to the bottom of the Projected Coordinate Systems folder, and locate and expand the "World" folder.
2. Select the Goode Homolosine (Land) system. Select it and click Apply. If necessary, zoom to the full map extent on the Tools toolbar (Hint: click the globe one time).
3. In Goode Homolosine (Land) describe the angle of the crosses?
 - a.
4. Are the circles similar in size throughout the entire map?
 - a.
5. Are the crosses distorted more over land or sea?
 - a.
6. In the Data Frame Properties wizard, switch to Goode Homolosine (Ocean).
7. Again, look at the crosses. Are they more distorted over land or sea?
 - a.

Goode Homolosine makes excellent world maps by distorting either the land or the sea to preserve the other.

Mollweide

1. Again, in the Projected Coordinate System → World folder, choose and apply the Mollweide (world) PCS.

This map may look very familiar. The Prime Meridian (central-most longitude line) is at 0,0 decimal degrees. Now, re-center this to North America.

2. Locate the Add Coordinate System button on the Data Frame Properties wizard and choose New... → Projected Coordinate System.
3. Label the new system Name: World_Mollweide_USA.
4. Click the Projection: Name: dropdown and choose Mollweide.
5. Set the Central_Meridian to -105.00 (the approximate geographic center of the U.S).
6. Note the Geographic Coordinate Systems is GCS_WGS_1984.
7. Click OK and Apply.

Create a new PCS called World_Molleweide_USA

8. The map is now centered over the USA. Where is the greatest distortion in this map?
 - a.

Every time you set the central meridian closest to the mapping area, the map distortion closest to the center is reduced. Distortion increases with distance away from the central meridian.

Robinson

1. Apply the World → Robinson PCS. Double-click on Robinson in the World folder. This time, change the Central_meridian to -105.00 and click Apply.
2. Where are the regions of greatest distortion?
 - a.
3. Does Antarctica look larger than it really is?
 - a.
4. A Polar PCS is needed to help visualize the polar masses with the least amount of distortion. Choose the Projected Coordinate System → Polar folder → South Pole Stereographic PCS.
5. Click Apply. All meridians (longitude lines) converge in this PCS. Where is the greatest distortion? Near or away from the converged meridians?
 - a.
6. Use the Measure tool → Area → Meters and determine the approximate size of Antarctica in square kilometers. Be sure to pick up the Measure an Area tool before beginning this exercise. It's located next to the Measure Line tool and is the shape of an irregular rectangle.
 - a.
7. Close the Measure tool and save the map.

When mapping agriculture, we typically employ a PCS that measures in meters. This is for both scientific and agricultural purposes. Land surveyors always measure in feet in the U.S. but other countries prefer meters for survey too.

WGS84 UTM Zone 16N

The Universal Transverse Mercator (UTM) projection systems creates a Cartesian coordinate system (x,y) to reference locations on Earth. It's similar to a geographic coordinate system in that longitude is horizontal and latitude is vertical but it differs in that it produces an X,Y grid of false eastings and northings from a point of origin on the map that is south and west of a known location.

Southern U.S. UTM Zones (noted in thick black lines).

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Mississippi farms fall into either the UTM 15N or UTM 16N zone depending on location. Farms on the border of the two zones can be mapped with either system. The degree of accuracy in the zone is near the center between the two thick black lines. Mapping with UTM produces units of meters instead of decimal degrees, but the software will show either unit, depending on the user preference.

1. Choose to apply the Projected Coordinate System → UTM (Universal Transverse Mercator) → WGS 1984 → Northern Hemisphere → WGS 1984 UTM Zone 16N.
2. Note the Central_Meridian of UTM 16N. Estimate how close is it to Mississippi State? (Hint: Go to Google Maps, locate MSU, right-click → What's Here? and apply the longitude...a negative number).
 - a.
3. **Bonus points (5 points):** Determine what city east of Mississippi State University is on the longitude (meridian) -87.00?
 - a.

Just for fun, float around ArcMap and try different PCS projections. Note the distortion and change the meridian to the MSU campus in order to preserve its shape, area, distance and direction. When finished, save the map.

Make a Greeting Poster Map

This exercise requires users to gather information and apply a PCS in order to create a greeting poster map.

1. Locate your hometown longitude (meridian) in Google Maps.

2. In the CH03_PSCmapping ArcMap document, change the PCS to World → Bonne.
3. Change the Central_Meridian to your home town and click Apply.
4. Locate the Layout View button in the bottom left-hand side of the viewing screen. Click it to enter into the Layout mapping window.

The Layout Tools toolbar assists in moving the map design layout while the Tools toolbar tools will continue to help move and reshape the actual map.

ArcMap Layout and Tools toolbars

5. Adjust the map size on the whole page until a poster-sized creation is possible with room for a title and other inset items.
6. Right-click the gray blank space in the toolbar region and launch the Draw toolbar. Drag and anchor it to the bottom of your ArcMap document and save the project.
7. On the Draw toolbar, click the Text dropdown and choose to add a balloon with a greeting from your home town...
8. Add a Title to the map and decorate the map using Draw tools.
9. Change the map Symbology to create a great looking poster.
10. Use the file Insert menu to add pictures to the map.
11. Right-click on an image and choose Order → Send to back to keep the map surface in front and center.
12. In the bottom left-hand corner of the poster, make a text box with your name, the projection type, and date.
13. Save the map.
14. In the text menu, choose File → Export Map...
15. Save the map as a .jpg and insert it in the answer sheet.

CHAPTER IV

Building Farm Basemaps

Purpose

The purpose of this lab is to engage students in developing a base farm map that will be used throughout the rest of this semester. Students will create maps in different geospatial software and identify different software operational procedures.

Lab Goals

In this lab, students will:

1. Create a base farm map in ArcGIS software
2. Select and clip basemap datasets
3. Export data to a file geodatabase and set map document properties

Scoring Rubric

(50 Points)

1. Answer Sheet: Student completed the answer sheet (0 to 35 points)
2. Screen Shot: Student produced ArcGIS map (0 to 15 points)

Submission Instructions: For this exercise, submit an answer sheet containing all the answers from the text. Insert the maps into the answer sheet in .jpg format.

Chapter 4 Overview

Chapter 4 is a lengthy exercise that will instruct users on how to create basemaps for farm operations. Focusing on a single field in Bolivar County, download free geospatial datasets from a Mississippi State sponsored data clearing house. Using a provided field boundary shapefile, reduce datasets from the county-wide scale to the local field scale. An important lesson in this chapter is managing data in an Esri Geodatabase®. Although not universally used in all agricultural software, the Esri geodatabase is becoming the standard for spatial data management.

Once the ArcMap basemap exercise is completed, repeat some of the same steps in Trimble's Ag® software. Both maps will be used in later chapters for cropping decisions.

Trimble Ag software does not contain a file data browser like that of Esri's ArcCatalog. Therefore, begin this, and every, exercise by examining the data used for the map production by previewing the data in ArcCatalog.

Crop Mapping in ArcGIS

Review Data in ArcCatalog

1. Always begin a mapping exercise with a review of our data. Open ArcCatalog and verify the TOC is connected to the DRIVE:\ArcProjects folder.
2. Locate and navigate to the CH04_Basemap\SHPFFiles\ folder. There are two subfolders named by their coordinate systems.
3. Recall, WGS84 is the datum used by GPS/GNSS satellite systems to collect data. Also recall that the UTM15N system is used to project a 3-D dataset into a 2-D map.
4. Navigate to the CH04_Basemap\XLSFiles folder. Examine each of the tables in the folder by expanding the file name and selecting the Database in Table view.

Viewing the MS Excel database file within ArcCatalog.

Note the po44_soilattributes table has sampled data regarding sand_perc, silt_perc, and clay_perc. Add this layer to the next map and compare the sampled results to the percentages derived from the SSURGO relational database.

5. The data in the XLSFiles folder was collected using GPS technology. The data is likely to have which geographic coordinate system attached to it:
 - a. NAD 1927?
 - b. NAD 1983?
 - c. WGS 1983?
 - d. WGS 1984?
6. Rename the XLSFiles folder by adding an underscore and the GCS system used to create the data (see previous image for an example).
7. Minimize the XLSFiles_WGS84 folder and expand the \SHPFiles\WGS84_UTM15N and \WGS84 folders in CH04_Basemap.
8. Right-click each shapefile in this folder → Properties → XY Coordinate System tab. Take time here and note the coordinate systems of each file name:

Table 3 Shapefile attributes and coordinate systems

Shapefile Name	Purpose of File	GCS	PCS
po44_2013_soiltest			
po44_bndry			
po44_CORN_2013_Harvest			
po44_soilEC			

In the following exercise, the *_bndry file will clip the larger Bolivar County soils and other datasets down to field level. Compare the other files to results derived from the soils mapping experience. Before creating the map, download the county data from the MARIS website.

The Mississippi Automated Resource Information System

MARIS @ <http://www.maris.state.ms.us/>

The MARIS mission is to provide Mississippians with a systematic arrangement of digital natural and cultural resource information. MARIS encourages compatibility of Geographic Information Systems (GIS) and data distribution within state government. Users can search and retrieve GIS datasets from the MARIS website.

Download Bolivar County Data

1. Open a new internet browser window and go to the Maris website at: <http://www.maris.state.ms.us/>.

2. Locate the Download Data sidebar and note the different downloadable datasets. Select the County Data option and locate the “bolivar.zip” file link in the Standard County MSTM Shapefile column.
3. Click the “bolivar.zip” link and open the file with an extraction software. When prompted to Extract the files, navigate to the DRIVE:\CH04_Basemap\SHPFiles folder and extract the dataset to the SHPFiles folder. Close the internet browser when finished.
4. When finished extracting, open ArcCatalog and locate the bolivar folder. Rename the folder: “MARIS_NAD83MSTM”.
5. In ArcCatalog, navigate to the MARIS_NAD83MSTM folder. Right-click on any file and choose Properties → XY Coordinate System tab. What is the coordinate system for this dataset?
 - a.

The MARIS organization has chosen a custom coordinate system for this data that will not match our mapping dataset. Be aware that users will be asked to change, or transform, the data before using it in a map. This is very common.

6. Note the different types of vector files contained in this dataset. Which files might be helpful in determining landuse?
 - a.

Close ArcCatalog and proceed to the mapping exercise.

Create a Basemap in ArcGIS

A basemap is a document filled with rudimentary files that can be used in multiple mapping exercises. Whether making maps on-the-job or for school assignments, a basemap can shorten mapping efforts by providing a general dataset that is ready-to-use.

1. Open a new, blank ArcMap document. Save the map in the folder called DRIVE:\ArcProjects\CH04_Basemap. Name the document: CH04_Basemap.
2. Right-click on the Layers name in the Table of Contents (TOC) → Properties → Coordinate System tab. What is the coordinate system of this map?
 - a.
3. Click the Add Data button and navigate to DRIVE:\ArcProjects\CH04_Basemap\XLSFiles_WGS84.
4. Double-click the po44_soilattributes.xlsx file name and locate the Database table. Select this table and click Add.
5. When the table loads in the TOC, right-click its name and choose Open.
6. Scroll to the right and note the field names. Which fields will help map that data in a geographic data space?
 - a.

7. Are the fields numerical or alphabetical (Hint: numerical fields justify to the right while text fields justify to the left)?
 - a.
8. Close the table and save the map. Right-click the Layers name in the TOC and open the Properties → Coordinate System tab. What is the coordinate system of this map now?
 - a.

Although tabular data can be collected under a geographic coordinate system, the table does not possess a projection file that defines the GCS. In the next exercise, convert the table to an X,Y Event layer and export it to a real shapefile.

Convert XY Geographic Coordinates to Points

1. Right-click the Database layer name in the TOC → Display X,Y Data.
2. The Display XY Data wizard automatically recognizes which fields hold geographic coordinates but it does not know what GCS to apply.
3. Click the Edit... button.
4. Expand the Geographic Coordinates folder and locate the World folder. Expand the World folder and scroll to the bottom of the list. Select the WGS 1984 system and click OK.

Displaying X,Y Data.

5. The Description box is loaded with the GCS_WGS_1984 geographic coordinate system. Click OK.
6. Read the Table Does Not Have Object-ID Field box.

The Object-ID Field message.

This dialog mentions that without an Object-ID column in the data, the point file is only temporary. To remedy this, export the Database Events and create a shapefile.

7. Click OK when finished reading the Table Does Not...box.
8. Before exporting, right-click the Layers name in the TOC → Properties → Coordinate Systems tab.
9. What geographic coordinate system is the Lab4_Basemap.mxd now defined in?
 - a.
10. From this point on, all data entering the map must be reconciled, or transformed, to the WGS84 system if it wasn't previously. Click OK to close the Data Frame Properties wizard.
11. Save the map.

Export a Database Events Layer

The database events layer is not permanent. Users must export it to a permanent shapefile in order to query data or perform analysis on the layer.

1. In the TOC, verify the Layers are in List by Drawing Order.

List By Drawing Order button.

2. Right-click the Database Events layer in the TOC and choose: Data → Export Data...
3. In the Export Data wizard, choose to:
 - a. Export: All features
 - b. Use the same coordinate system as: this layer's source data
 - c. Output feature class: DRIVE:\ArcProjects
 \CH04_Basemap\SHPPFiles\WGS84\po44_soilattributes.shp
4. Answer Yes to add the exported data to the map.
5. Right-click and remove the Database Events and the Database table layers from the TOC. Save the map.
6. Open the po44_soilattributes attribute table and examine the contents of the shapefile.
7. Close the attribute table and open the Layers Data Frame Properties → Coordinate System tab wizard again.
8. What is the current map geographic coordinate system?
 - a.
9. Save the map.

Create a Local SSURGO Soils Map

To reduce data in a local map, the SSURGO county data must be clipped to the field boundary. Employ an ArcToolbox Clip tool to cut the county-level data down to a local scale.

1. Click Add Data and navigate to E:\ArcProjects\
 PAILabs\Lab2_Soils\SHPPFiles\Soils_WGS84\MS011\spatial\soilmu_a_ms011.shp.
2. Load soils data shapefile and save the map.
3. Click Zoom to Full Extent on the Tools toolbar. Right-click the soilmu_a_ms011 layer in the TOC and choose Properties → Source. What geographic coordinate system is this data defined as?
 - a.

The SSURGO soil data and the po44_soilattributes data are both defined by WGS84. We're now going to add new layers that may or may not conflict with this system.

4. Click OK and close the Properties dialog box.
5. Right-click the po44_soilattributes layer and Zoom to Layer.
6. Click Add data and navigate to the DRIVE:\ArcProjects\
\CH04_Basemap\SHPFiles\WGS84_UTM15N folder and add the
po44_bndry.shp shapefile.
7. Right-click the boundary file and Zoom to Layer. Open the boundary
file layer Properties box and select the Source tab. What coordinate
system is this data defined in?
 - a.

This boundary layer was created in the WGS84 GCS and projected into the UTM_Zone_15N system. There's no conflict with the datum so users ARE NOT required to transform this data.

8. Click OK and save the map.
9. Below the po44_bndry name, click one time on the Symbology box to
launch the Symbology wizard.
10. Choose to make the boundary layer Hollow with a 2pt Black border.
Click OK and save the map.
11. Right-click and Open Attribute Table for the po44_bndry shapefile.
Scroll to the right. How many acres is this field (Hint: see Area_Acre
field).
 - a.
12. Remember this field size for use in a later exercise.

Working with MARIS Files

The MARIS datasets are constructed under a unique coordinate system that must be transformed to match the current mapping coordinate system. Use the Coordinate System tools to match differently projected datasets in a single map.

1. Click Add Data and navigate to the SHPFiles\MARIS_NAD83MSTM
Bolivar folder. Choose to add the pls_11.shp file.

The Geographic Coordinate Systems Warning box tells users that they MUST transform data because of a conflicting GCS. Recall that the MARIS data was defined in a custom Transverse Mercator system that did not identify a GCS we were familiar with.

Transforming the geographic coordinate system.

2. Click the Transformations...button. Complete the dialog box as follows:
 - a. Accept the defaults for Convert from:
GCS_North_American_1983
 - b. Accept the default for Into: GCS_WGS_1984
 - c. Click the Using (choices are sorted by suitability for the layer's extent): dropdown and choose the first menu item.
3. Click OK and then click Close to apply the transformation. The data lines up in the map quite nicely now.
4. In the TOC, move the po44_bndry layer above the pls_11 layer name. Save the map.
5. Right-click the po44_bndry and Zoom to Layer.
6. Pick up the Identify tool and click the polygon to the east of the field (most of this field falls into the eastern polygon).
7. Note here the section, township and range of this polygon:
 - a. Section = _____
 - b. Range = _____
 - c. Township = _____
8. Close the Identify box and pick up the Select Elements tool again.

9. Remove the pls_11 layer from the map and save the project.
10. Once again, Add data from the MARISFiles folder (Hint: hold the Control key and select each file name):
 - a. desig_hwys_11.shp,
 - b. NHDArea16_11.shp,
 - c. NHDflowline16_11.shp,
 - d. NHDWaterbody16_11.shp,
 - e. railrds_11.shp, and
 - f. transm_11.shp
11. Follow any transformation instructions, if required. When the data loads, save the map.

With the exception to the po44_soilattributes and po44_bndry layers, the TOC shapefiles represent the county-wide scale of data. For future mapping exercises, this textbook only requires data at the field level. The ArcGIS Clip tool allows users to reduce data layers by using the boundary layer as a cookie cutter. In this exercise, determine which layers are worth keeping in the basemap, and then reduce larger-scale datasets to the extent of the boundary layer.

Before reducing the data to boundary size, create a geodatabase for the final datasets to be projected into.

Create a Geodatabase with Feature Dataset

A **File Geodatabase** folder (looks like a can) is designed to store spatial data and improve the versatility and usability of shapefiles and rasters. The File Geodatabase use is limited to ArcGIS software applications at this writing but they are expected to be universally adopted by other software companies in the future. Storing data in a geodatabase compresses the large file size and indexes data for easy searching.

1. Open ArcCatalog and navigate to the DRIVE:\ArcProjects\CH04_Basemap folder.
2. In the viewing window, right-click in the blank space and choose New → File Geodatabase.

A New File Geodatabase.

3. Rename the geodatabase: "PALabs.gdb".

A **Feature Dataset** is a sub-folder within a geodatabase that assigns a projected coordinate system (PCS) to all data that is imported into it. For this exercise, first create a File Geodatabase AND then create a Feature Dataset projected into UTM15N_WGS84.

4. Right-click the PALabs.gdb file name and choose New ➔ Feature Dataset...
5. In the New Feature Dataset wizard, type in the name: UTM15N_WGS84 and click Next >.

A New Feature Dataset.

6. Navigate into the Projected Coordinate Systems folder → UTM → WGS 1984 → Northern Hemisphere → WGS 1984 UTM Zone 15N. Select this projection to load it into the Current coordinate system: window. Click Next >.

Setting the Feature Dataset coordinate system.

7. Accept the defaults for Vertical Coordinate Systems and click Next >.
8. In the XY Tolerance window, accept the defaults and click Finish.
9. Preview the PAILabs.gdb in the ArcCatalog TOC and note that it is currently empty. In the next exercise, export data layers into the .gdb for future use.
10. Close ArcCatalog.

Clip the Data Layers

Clipping shapefiles reduces them from very large formats to only the area a map operator needs. ArcMap creates a new, smaller file from a larger file when clipping. Use a pre-defined study area to clip the datasets down to a useful size.

1. In the ArcMap CH04_Basemap document, add the StudyArea_poly shapefile from the N:\ArcProjects\CH04_Basemap\SHPFFiles\WGS84 folder. Save the map.
2. Open the StudyArea_poly properties dialog box (right-click → Properties) and choose the Symbology tab. Click the Symbol selector (the colored rectangle).
3. Make the StudyArea_poly shapefile Hollow with 2 points black outline. Close the Layer Properties dialog and save the map.
4. Move the StudyArea_poly to the top of the TOC and move the po44_soilattributes layer to the bottom of the TOC. Save the map.
5. There are no railroads or transmission lines in your study area, and the NHDAreas are minimal. Remove these three shapefiles from the TOC.
6. Save the map

Proceed to clip the larger files and create new smaller files. Each file will be exported and saved in the file geodatabase created in the earlier exercise. When the new, smaller shapefile adds to the map, remove the original larger parent file.

Locate the Clip tool in ArcToolbox.

1. On the Standard toolbar, click the ArcToolbox icon to launch the toolbox service.
2. Float the ArcToolbox over the center-right arrow in the viewing window to dock it on the right-hand side of the computer screen. Save the map.
3. Expand the Analysis Tools toolbox ➔ Extract drawer. Locate the Clip tool.
4. Double-click and launch the Clip tool.
5. Click the Show Help>>> button to expand the help menu.
6. Complete the Clip dialog as follows:
 - a. Input Features: `desig_hwys_11`
 - b. Clip Features: `StudyArea_poly`
 - c. Output Feature Class:
`DRIVE:\ArcProjects\CH04_Basemap\PALabs.gdb\UTM15N_WGS84`. Name the file Highways and click Save and OK.
7. The new Highways shapefile will add to the map. Remove the `desig_hwys_11` shapefile and save the map (see above image).
8. Continue clipping the remaining MARIS shapefiles until the dataset is complete. This includes:
 - a. `NHDFlowline`: name it Flowlines
 - b. `NHDWaterbody`: name it Waterbodies.

Now, it's time to add a soils map and clip it too but clip it only to the field boundary layer (`po44_bndry`) and not the study area.

1. Add the Bolivar County Soil map to your current map (Hint: `ArcProjects\CH02_Soils\SHPFiles\MS011\spatial\soilmu_a_ms011`)
2. Clip this file to only the `po44_bndry` shapefile.
 - a. Save the clipped soils file in the geodatabase naming it: `po44_soils`. Add it to the map.
3. Remove the original `soilmu_a_ms011` shapefile from the TOC and float the `po44_soilattributes` layer to the top of the TOC.
4. Right-click the `po44_bndry` layer and Zoom to Layer. Use the Zoom Out tool and zoom out about 25% more.
5. Verify all layers in the TOC are turned on and save the map.

The study area basemap.

Add Other Data to Basemap

ArcMap software has a live image system available when computers are connected to the internet. To add imagery to your map follow these instructions:

1. Save the map. Click the Add Data dropdown and choose Add Basemap.

Adding a Basemap imagery dataset.

2. Select Imagery and add it to the map. When the imagery loads, save the map.
3. Shut off the Waterbodies layer. According to the imagery, are the fishponds still in existence to the southeast of po44_bndry?
4. Save the map.

Fishponds previously in the study area.

Chapter 4 Review

In this chapter, you created basemaps in both ArcGIS and Trimble Ag software. The maps contained boundary, soils, and some harvest data. The Bolivar County field, named po44, possesses wide-ranging soil variability. Expect crop results to be as varied as the soils. In future exercises, employ these base maps to make farm planning decisions.

From this exercise, users learned how to access MARIS datasets for all Mississippi counties. In converting X,Y geographic coordinates to shapefile points, users loaded datasets from a 3-D space to a 2-D mapping plane. By creating a geodatabase with a projected (UTM 15N) feature dataset, users exported the WGS layers clipped to shapefiles with a local boundary.

CHAPTER V

Navigation and Telemetry

Purpose

The purpose of this lab is to aid students in developing an appreciation for farm geolocational technologies.

Lab Goals

In this lab, students will:

1. Review GNSS principles
2. Create XY data points and convert to permanent shapefile
3. Edit the shapefile points and delineate a field boundary.

Scoring Rubric

(50 Points)

1. Answer Sheet: Student completed the answer sheet (0 to 35 points)
2. Screen Shot: Student produced ArcGIS map (0 to 15 points)

Submission Instructions: For this exercise, submit an answer sheet containing all the elements of your work. Insert the maps into the answer sheet in .jpg format.

Chapter 5 Overview

In this chapter, students will review basic telemetry and navigational systems used in agriculture production. This chapter guides students to create field boundaries through two common methods: directly through GPS data collection and indirectly from a digitized harvest map. A brief overview of **Navigation Systems** and **Telemetry** are included at the beginning of this chapter.

Increasing farm efficiency requires a producer's complete attention to minute details and dynamic processes. Farmers outline field boundaries, or delineate boundaries, prior to planting and to aid in building prescription maps. Field boundaries are derived from several sources including GPS navigation, on-the-fly. Field preparation operations may also produce useable datasets for

creating field boundaries. Once created, a field boundary provides a template for groundwork, planting, treatment, and harvesting activities.

Navigation Systems and Telemetry

GNSS: Global Navigation Satellite System is used to geolocate an end-users position relative to a receiver transmitting signals to the constellation of navigation satellites. Heading and location information is derived from tracking movement while transmitting and receiving GPS signals on the fly. GPS satellites orbit in a constellation located just over 22,000 miles above the Earth (about 1/10th of the way to the Moon).

The number of satellites in a constellation over a receiver

Wikipedia: [Satellite Constellations in Active View](#)

Global positioning receiver signal is dependent upon the availability of multiple satellites being in view over the observer.

Precise time references are made through synchronized GNSS time systems. Acting as a reference clock, GNSS has time code generators that radio broadcast times and time corrections. Crystal oscillators reduce errors that occur in the receiver clock (jitters). The clock correction, or recover, is called a timing jitter. Without accurate time synchronicity, GPS navigation would be essentially useless.

GNSS components and GPS receivers

"Geolocation" by [Eric Chassaing](#) is licensed under [CC BY 3.0](#).

Telemetry: The automated measuring of physical parameters from a remote location. A telemetry system processes information through programming (instructions) and data sensed from an external source. Data transfer mechanisms in a telemetry system can be wireless, radio, ultrasonic, and even light driven.

A telemeter is a complex sensor system programmed to remotely detect a quantity of substance under consideration. A transducer is a sensor that detects an analog signal (i.e. light, heat, sound) and converts it to a digital signal. A data logger stores and transfers the digital signal for transfer to another microcontroller. The telemeter data-transmission path, data display, logging, and numerical control are pre-programmed by manufacturers but may be altered to meet customer specifications. Radio waves are an example of analog data that occurs naturally in the environment. GPS uses similar radio waves to broadcast and receive data. Incoming solar irradiance (light from the sun) is also a form of analog data. It must be converted to digital data before becoming useful in computational activities.

The electro (E) – magnetic (B) wave (z = time elapsed)

“Electromagnetic Wave” by [P.wormer](#) is licensed under [CC BY 3.0](#).

Telemetry systems might monitor temperature, humidity, precipitation, soil moisture, photosynthetically active radiation (PAR), and wind speed. The data outputs might be used to predict plant stress and water requirements. A new agricultural-telemetric application is unmanned aerial systems (UAS) technology. Autonomous flight of UAS aircraft is guided by multiple inputs, computer programming, and feedback systems. Autonomous UAS become airborne and achieve a mission all without manual-radio controlled steering.

Telemetry Systems: Agriculture and crop production telemetry systems are advancing towards autonomous systems. More recent advances have produced farm implements that adjust to terrain and vegetation on the fly. Coupled with vegetation sensors monitoring plant status, the adaptive implements (spray booms, combines, etc.) interact intelligently with the strata receiving treatments. These intelligent farm-telemetry systems include three major components:

- GPS data collected from built-in GPS receivers (location, time, speed, direction of movement)
- Analog sensors for fuel, temperature, pressure, idle time, flow-rate, yield monitoring
- Digital Control Area Network Vehicle Bus Controller Area Network Binary Units System (CAN bus) systems communicating without a host computer for speed, power, torque, load capacity and analog parameters

Telemetry and GPS navigational errors are common and are usually caused by the failure of on-board systems to register signals correctly. Changes in land (topography) and/or obstructions can interfere with signal reception and processing. Multipath errors occur when signals reflect off an object and shift the clock reception or transmission of a georegistered event.

Signal bounce error produced by nearby objects (direct waves in green, indirect in red)

"GPS Tracking Satellites" by [Javiersanp](#) is licensed under [CC BY 3.0](#).

Over time, become familiar with different onboard systems and components. In this lesson, users are introduced to the SMS Ag Leader Console used to guide tractor operations and gather data. The console accuracy depends on multiple complex digital interactions produced by the entire telemetry network. The most simple tractor operation involves georeferenced wireless communication for steering. More complex operations involve computer-based variable rate treatments that are based on prior knowledge.

Tractor and Implement BUS Systems

Tractors and farm implements operate in tandem by communication through the International Organization for Standardization (ISO) Computer using the CAN bus message-based protocol. The mapping and sensing activities on-farm are translated to and from device microcontrollers.

Through these protocols, a producer can make a prescription map on a desktop computer. The data is served to the tractor control systems and jobs are parsed and assigned based on the control network.

Graphic: Fox, 2016

The following terms and definitions describe the communication system:

- FMIS – Farm Management Information System: the desktop application used to create prescriptions
- File Server – methods to transfer data from the FMIS to the tractor systems
- TECU – Tractor Engine Control Unit: manages engine, transmission, and hydraulic functions
- GPS – Global Positioning Satellite System used to control steering and map inputs/outputs
- TC – Task Controller: manages tasks defined by FMIS; implements setpoints for actions; setpoints may be minimum, maximum, and/or exact
- IFC – In-Field Controller: supervises and controls in-field activities; receives signal from TC after task selection and receives current position, then sends setpoints to the implement controller
- VT – Virtual Terminal: may be the same as the IFC or a separate device
- IC – Implement Controller: receives setpoints and takes action
- OLS-P and OLS-S - Online Sensors: provide information and receive information (both source and sink)

In tandem, the ISOBUS system extends the tractor implement CANBUS to the implement. This results in the implement and the tractor communication over the same CANBUS system.

Accuracy, Precision, and Scale

The terms “Accuracy” and “Precision” are used to describe measurement. Accuracy and Precision are very important in scientific research and most economic enterprises.

ACCURACY refers to the degree of “correctness”, like hitting a Bulls-eye in darts. PRECISION, on the other hand, refers to the repeatability of an event. You might throw a dart once and accurately hit a Bulls-eye but, unless you hit it every time a throw is made, the throws may not be very precise, or dependable.

Graphic by Fox, AAA.

Ideally, in a farm production scenario, the GPS data collected will be both accurate and precise. However, many objects interfere with accurate GPS sampling. Trees, buildings, and loss of GPS link can all be sources of interference.

Geographic software also uses terms that can be confused with Accuracy and Precision. When creating an Attribute Table field for coordinates, users may be asked to designate the field **Type, Precision, and Scale**.

Shapefile attribute tables fields holding coordinates are normally FLOAT types. A floating-point format is a numeric value with fractional values between -3.438 to 1.238.

The screenshot shows the 'Add Field' dialog box with the following details:

- Name:** NewCoordinateField
- Type:** Float
- Field Properties:**

Precision	10
Scale	6
- Buttons:** OK, Cancel

The PRECISION refers to the maximum LENGTH of an attribute field. For example, we typically present longitude/latitude coordinates in decimal degrees (-88.123456). Since decimal degrees can range up to 180 degrees, we need 10 placeholders for our coordinate (3 whole integers, the decimal, and 6 numbers below the decimal).

SCALE refers to the numbers to the right of the decimal point. In the example above, there are 6 place units to the right of the decimal.

When working with coordinate attribute fields, keep in mind the difference between syntax used to describe accuracy, precision, and scale.

Create X,Y Events

1. Open a new empty ArcMap document. Click Add Data and navigate to the CH05_NaviTele\XLSFiles folder.
2. Double-click on the BolivarFields_GPS.xlsx file and add the Database file to the map. In List by Source mode in the TOC, right-click the Database file and Open the attribute table.

3. How many points are contained in this file?
 - a.
4. Which fields can be used to draw the points in ArcMap?
 - a.
5. Close the attribute table and right-click its Database name again.
Choose: Display XY Data...
6. Verify the Lon and Lat attributes populate the X Field and Y Field, respectively.

The data was collected with GPS and, therefore, is referenced by the WGS84 Geographic Coordinate System.

7. Click the Coordinate System of Input Coordinates Edit... button.
8. Under Geographic Coordinate Systems, locate the World → WGS 1984 reference. Click OK and OK again when finished.

Display X,Y Data.

9. Answer OK to the Table Does Not Have Object-ID Field warning. This warning reminds users the XY Events layer is not permanent. To make it permanent, export it to a shapefile.
10. Right-click the Database Events layer and Open the attribute table.
How many points make up this file?
 - a.
11. Does the Database Events layer have an Object-ID field?
 - a.

You must export the temporary Database Events file to create a permanent shapefile with Object-ID data.

12. Close the attribute table and right-click the Database Events layer once more. Choose: Data → Export Data....
13. Choose to Export: All features
 - a. Use the same coordinate system as: this layer's source data.
 - b. For the output feature class, navigate to the CH05_NaviTele folder. Create a SHPFiles folder. Save the database events in the SHPFiles folder naming it: BolivarFields_GPS.shp.
 - c. Choose the Save as type: dropdown and change it to: Shapefile. Click Save and OK to launch the Export Data wizard. Allow the shapefile to add to the map.

Saving the exported dataset as a shapefile.

Save Map for Editing

1. Remove the Database and Database Events from the TOC, and choose to List by Drawing Order.
2. Save the map as: CH05_NaviTele\CH05_GPS.
3. Right-click the Layers name in the TOC. Choose: Properties → Coordinate System tab.
4. What is the current coordinate system?
 - a.

The WGS84 coordinate system was adopted by the first dataset added to the map. When adding data with a different geographic coordinate system in the following exercise, transform the added datasets.

5. Close the Data Frame Properties dialog and open the BolivarFields_GPS attribute table.
6. How many points make up this file?
 - a.
7. Are there extraneous waypoints created by the GPS travel on the ATV?
 - a.
8. Close the attribute table and save the project.

Cleaning Waypoints in ArcEditor

Data cleaning is a common activity when working with agricultural data captured on-the-fly. Users can “clean” points by deleting them in ArcGIS Desktop Editor mode. Select extraneous points and delete them from the attribute table. It’s important to save the editing work often in ArcEditor.

1. Park the BolivarFields_GPS attribute table below the TOC. Expand the table so that the fields are in view.
2. Zoom to the South fields.
3. Right-click the gray, empty toolbar area above the viewing window and choose: Editor. Park the Editor toolbar above the viewing window. Save the project.

Points requiring editing.

Before entering an active editing session, export the original shapefile and create a second copy in order to maintain the original dataset. This way, users have a backup copy in case they are forced to start over.

4. Right-click the BolivarFields_GPS layer in the TOC. Choose: Data → Export Data...
5. Save the new shapefile in the original folder adding the suffix: _Edits.
6. Remove the original shapefile and save the map.
7. Open the attribute table of the _Edits file.
8. Zoom into the two fields in the south. Examine the points that don't belong to the field boundaries in the South.

To remove unwanted points, users must:

- Turn on the Editor toolbar,
- Select the unwanted points,
- Show them in the attribute table, and
- Delete the points.

1. Choose the Editor dropdown menu and select: Start Editing.
2. Locate the Selection tool on the Tools toolbar and choose: Select by Rectangle.
3. Draw a rectangle that selects only the points that are to be deleted.
4. In the Attribute table, click the Show Selected Records button.
5. With the unwanted points highlighted in the attribute table and map, right-click the attribute table records and choose: Delete Selected.

Selected points for removal.

6. Immediately save the edits to maintain them. Save the edits by choosing the Editor dropdown and Save Edits.
7. Clear any selected features and verify there are two field boundaries made up of waypoints.
8. Zoom to the BolivarFields_GPS_Edits layer and then zoom to the North fields with the interactive zoom tool.

Deleting Unwanted GPS Points

Removing these extra points will be a bit more difficult. Users need to use the “Lasso” to select smaller sets of points, deleting them more often and ensuring they are not deleting points they wish to keep.

1. Pick up the Selection tool → Select by Lasso tool.
2. Carefully select a few points at a time and delete them.
3. If satisfied with your work, chose Editor → Save Edits.
4. If too many points are accidentally selected, simply clear the selection.
5. If you accidentally delete points you want to keep, choose: Editor → Stop Editing and DO NOT save the edits.
6. Begin editing again and complete the dataset by creating field waypoints you wish to keep.

When finished, note the presence of three points that are shifted slightly to the east. While in editing mode, pick up the Editor select tool and move them a short distance west (don't overlap the most western points).

7. Pick up the Editor Selector tool and hold down the Control key. Select each of the three shifted points.
8. Once selected, move them slightly west without overlapping the more western points.
9. Save the Edits and stop editing.

Three points to be selected for removal.

10. Clear the selected features when done editing. Zoom to the BolivarFields_GPS layer and save the map.

Finalize the Field Boundaries

Completing field boundaries requires three separate steps:

- First, select the points within a single field and create a Selectable Layer.
- Next, use the Points to Line tool to create polygon features from the Selectable Layer.
- Finally, use the Feature to Polygon tool to create a polygon shapefile.

Step #1- Create Selectable Layer

By selecting the points of individual fields and creating a selectable layer, users can output single field polygons from the closed points.

1. Open the BolivarFields_GPS_Edits attribute table. How many points are in this current, edited file?
 - a.
2. Close the attribute table in the TOC and shrink the TOC space creating more viewing area. Zoom to the BolivarFields_GPS layer and then zoom to the southern fields.

- Pick up the Selection → Select by Rectangle tool and select the points in either field but not both. Right-click the BolivarFields_GPS_Edits layer and choose: Selection → Create Layer from Selected Features.

Selecting points for conversion to line.

- Clear the selection and shut off the original BolivarFields_GPS_Edits layer in the TOC.

Create an output field boundary based on this selection only. The names of each field are presented in the maps below.

Step #2 – Convert Points to Line

1. Open ArcToolbox.
2. In ArcToolbox → Data Management tools, open the Features → Points to Line tool.
3. Complete the Points to Line wizard as follows:
 - a. Input = BolivarFields_GPS_Edits Selection
 - b. Output Feature Class = FIELDNAME_line (refer to graphic above for field names and save these files in the CH05_NaviTele\SHPPFiles folder)
 - c. Leave the Line Field and Sort Field blank
 - d. Select the **Close Line checkbox** and click OK. Wait while the data processes.

Points to Line close line function.

Step #3 – Convert Line to Polygon

1. Add the new feature class back to the map and save the map.
2. Launch the Data Management Tools → Feature → Feature to Polygon tool.
3. Complete the Feature to Polygon as follows:
 - a. Input Feature = current FIELDNAME_line layer.
 - b. Output Feature Class = "FIELDNAME_bndry" in the Lab4_Navigation\SHPPFiles\WGS84 folder.
 - c. Check the Preserve attributes box and click OK.

Converting the line feature to polygon feature.

4. When completed, verify the polygon shapefile appears as expected.

Remove three completed shapefiles from the TOC and begin the process again for the remaining five fields.

5. Remove BolivarFields_GPS_selection, FIELDNAME_polygon, and FIELDNAME_bndry, and save the map.

Follow the steps above to finalize this project. Be certain to only select points you wish to use in creating a selectable layer. The steps are:

- Zoom in closely to each field waypoint boundary and use the selection tool to highlight points that represent the field boundary.
 - Create a Selectable Layer
 - Use the Points to Line tool to create a polygon outline.
 - Use the Feature to Polygon tool to create a finished polygon.
6. Add the individual polygon shapefiles back to the original map and keep the BolivarFields_GPS_Edits layer in the map. Save the project.
 7. Zoom into both the North and South fields to create images of the local shapefiles.

Insert a .jpg image of the six polygon shapefiles created in this exercise into the answer sheet.

End Exercise _____

CHAPTER VI

Trimble Ag Farm Works

Purpose

The purpose of this lab is to create a production scenario to calculate fixed and variable production costs in Trimble Ag software.

Lab Goals

In this chapter, students will:

1. Restore a backup of farm records and review a farm report
2. Enter planting, field spraying and harvest records
3. Calculate net income from operations
4. Import soil test data and create a simple lime prescription map

Scoring Rubric

(50 Points)

1. Answer Sheet: Student completed the answer sheet (0 to 20 points).
2. Screenshot: Student created lime prescription map (0 or 10 points).
3. Upload: Student uploaded four separate crop production reports (0 to 20).

Chapter 6 Overview

This chapter engages users in developing production cost estimates for producing corn. Manually enter field records and create financial reports that estimate planting, spraying, and harvesting costs. The spraying report is also used for Environmental Protection Agency audit reports. With the cost reports and a yield estimate, calculate net income from your corn production.

Liming fields that have lower pH is an important consideration in corn production. Corn yields are highest when pH is between 6.0 and 7.0 because nutrients become more available within this range. Although multiple factors can

be incorporated into a lime recommendation, users will create a simple lime prescription based on field soil samples and their interpolated values.

Basemap Setup

As with the previous mapping exercises, first build a basemap for the data analysis. In Trimble software, you “Restore” or “Backup” projects rather than “Open” or “Save” projects. In this exercise, restore a previously constructed map file that contains only farm inputs. Then add the mapping files to create different farm production scenarios.

Restore a Trimble Ag Project

In Chapter 4, you created farm basemaps in ArcGIS and Trimble Farm Works. The Trimble map contained only field data. In order to complete this exercise, users will need background information such as tractors, planters, sprayers, and harvesters. Next, load the shapefiles from the Chapter 4 mapping exercise. Finally, enter the necessary production parameters to complete a field mapping project.

1. Double-click on the desktop icon to launch Trimble Ag software.
2. Answer Yes to the Windows User Account Control dialog and allow the software to load, if prompted.
3. Do not allow any updates to load, if prompted.
4. In the Project Selection wizard, click Restore Project.
5. Use the Browse button and navigate to the \ArcProjects\CG06_Trimble folder. Select the CH06_Basedata.zip file and click OK.
6. Type in the Project Name field: “Lesson 6 Farming” and click OK.

Restore the Lesson 7 backup file.

7. With the Lesson 6 Farming project highlighted in the Project Selection box, click OK.

Avoid hitting the Escape key until the project is restored to the active window frame. Hitting Escape before restoration will shut down the software launch.

8. Select the Inputs tab on the TOC.

Examine the inputs available to users for this project. No animals have been added to this project. Expand the Machines folder and note the different types of machines available to you. In this exercise, use planters, sprayers, and harvesters. The People folder contains names and contact information for farmers to contract with.

9. Expand the Supplies folder and right-click on any supply name and choose Properties. Note the extensive information provided with a single supply.

Add Clients and Farm Fields

1. Select the Clients / Farms / Fields tab on the TOC.
2. Right-click the < User Info > title in the TOC and choose Properties. You are the user. Place your name in the Full Name window.
3. State in the Care of window: Mississippi State University. Make your Job Title: Map Consultant
4. Choose the Address and Contact tabs. Fill them in with your personal contact information. Add a photo of yourself on the Logo tab. Click OK to close the User Information dialog box.
 - a. Ignore the < Unassigned Client > title in the TOC.
5. Right-click the New Client (Your Name) and choose New Farm...
6. In the Farm Properties wizard, make the Description: Bolivar County. Make the Client yourself. Click OK to close the Farm Properties dialog.
7. Right-click the Bolivar County Farm name → New Field...
 - a. Describe the field as: po44. Choose the Info tab.
 - b. Make the State: Mississippi and the County: Bolivar.
 - c. Make the Field#: 001 and the Land Class: Crop. Fill in the Section# (27), Township# (6), and Range# (24). Click OK to close the Field Properties dialog.
8. Right-click the po44 field name in the TOC → Import Boundaries.
9. Navigate to the CH06_Trimble\SHPPFiles\WGS84_UTM15N folder. Select the po44_bndry.shp file and click Open.
10. Verify in the Shapefile Import box the following:
 - a. Coordinate System = UTM
 - b. Datum = WGS84
 - c. Zone = 15 Northern Hemisphere

Importing a shapefile and projection.

11. Click OK when completed.
12. Select the Map tab in the viewing window and click Save and Close, if prompted.
13. Double-click the po44_bndry name in the TOC.

Create an Acreage Report

1. Right-click the po44 layer name in the TOC → Properties...
2. How many acres are listed in the Area section? (41.08, is the correct answer.)
3. Make the Legal and Tillable acres the same as Mapped acres. Click OK and close the Properties wizard.
4. Float the mouse over the Job/Resource Tools toolbar. Locate the Background Imagery button. Click it one time. Wait for the image to load.
5. In the text menu at the top of the program, choose: Reports → All Reports... option.
6. In the Reports wizard, expand the Field folder. Examine the numerous reports possible. Select the Acreage Report and click OK.
7. In the Field Acreage window, verify the Report Type is: "Acreage Report" and check the box next to the client name.
8. Select the Items to Print (your name) box. Click Preview.

Acreage Report

Client	Farm	Field	Mapped Area (ac)	Tillable Area (ac)	Legal Area (ac)
Student Name					
	Bolivar County				
		po44	41.08	41.08	41.08
		Total Bolivar County	41.08	41.08	41.08
		Total Student Name	41.08	41.08	41.08
		Total	41.08	41.08	41.08

The acreage report is drawn from the Properties summary. As a user increases the background data in the client profile, more reports will become available. Currently, only the acreage report can be populated.

9. Close the report and close the Field Acreage and Reports windows.

Exercise #1 Add SSURGO Soil Survey Data

1. Right-click on the po44 data layer → Import Background...
2. Navigate to the:
ArcProjects\CH02_Soils\SHFiles\MS011\spatialfolder and select "soilmu_a_ms011.shp".
3. Check the "Clip background to field boundary." Click OK.

Clipping an image to the field boundary function in Open.

4. Accept the defaults "Latitude/Longitude" for the coordinate system in the Shapefile Import wizard.
5. Verify the soilmu_a_ms011 layer is selected in the Displayed Layers window.
6. Locate the Views window in the center-bottom of the map. Scroll up and down and verify the attributes, especially, the MUSYM field, are present.
7. Select the MUSYM field and watch the legend populate different colors for each soil type.
8. In the Legend window, click the Legend... button. Select the "Range Count" box and click OK. The acreages per soil type are now displayed.
9. Characterize the soils based on the Soil Triangle below. The following averages apply:
 - a. Silt = 52.3%, Sand = 18.7%, Clay = 29%

10. What soil characterization is this soil rated as?
 - a.

Users have re-created your basemap in Trimble Farm Works. This new map has added information stored in the Inputs tab.

11. Backup the project one last time and choose to overwrite the last backup file.

The Production Scenario

During 2019, you planted, sprayed and harvested a corn crop at the Bolivar County po44 field. Planting and harvesting dates were 3/19/2019 and 9/29/2019, respectively. Spraying occurred in the third week after planting.

The “business” of production agriculture depends on management of multiple activity and enterprise records. Reducing input costs is key to increasing farm profitability, and record-keeping guides producers in understanding how inputs effect the financial bottom-line. The cost of production per acre is derived by totaling all inputs, and costs associated with them, over the entire field.

Planting records are important to growers because they establish costs associated with production and help in estimating final harvest time. Here, you’ll enter planting records from your first day’s activities.

Setting Up Costs

Set up the base costs in the Supplies list in order for them to be reflected in the production reports.

1. Click the Inputs tab on the TOC.
2. Expand the Machines → Tractor folders.
3. Right-click the Tracked Tractor → Properties.
4. Make the Costing Unit = hour and the Costing Rate = \$46.00. Click OK.
5. If prompted, change the Online Sync Type to <Do Not Sync>. Click OK to close the Machine Properties dialog.
6. Verify and/or modify all of the following properties in the Inputs list.

Table 4 Costing units for production equipment, services, and inputs

Category	Input	Costing Unit	Charging Unit
Machine → Tractors	Tracked Tractor	\$46.00	hour
Machine → Planting-Seeding	Corn Planter	\$10.50	acre
Supplies → Fuel	Diesel Fuel	\$3.50	gal
Supplies	Corn Seed 1	\$240.00	bag
Supplies → Fertilizer	10-34-0	\$645.00	ton
Supplies → Herbicide	Atrazine 4L	\$16.25	gallon
Machine Application	Spra-Coupe	\$10.50	acre
Machine → Harvesting	Combine, Corn Header, Grain Platform	\$165.00	hour (36 feet wide at 12 acres per hour). Charge unit conversion 1 acre: 0.08 hours.
Supplies → Fertilizer	Lime	\$46.00	ton-custom spread

Enter Planting Records – Day 1

Now that the production costs are associated with each input, move other inputs into the Working Group for Planting.

1. Expand the Machines → Tractors folder in the Inputs TOC. Double-click the Tracked Tractor to load it into the Working Group window below the TOC.
2. Double-click and load the following into the Working Group window:
 - a. Corn Planter (Machines → Planting-Seeding)
 - b. Corn Seed 1 (Supplies → Seed)
 - c. 10-34-0 Fertilizer (Supplies → Fertilizer)

If wrong input was moved into the Working Group window, select the green Up arrow to remove it from the Group.

The Working Group menu options

3. Once all inputs are selected, choose the Apply to Fields button. An Apply Working Group dialog will launch.
4. Verify the field containing Your Name in Bolivar County (po44) is active.
5. Select the Record Completed Jobs button.

Recording a completed job function.

6. The Farming dialog box appears. Select the Crop Enterprise from the drop-down list.
7. Make the Crop Enterprise = 2019 Corn.
8. Verify the Job Type is Planting-Seeding.
 - a. Enter the planting Start Date and Stop Date = 3/19/2019
 - b. Make the Start Time 08:00am and the Stop Time 10:30 am.
9. Use the tab key to move from entry to entry and watch the total Job Hours calculate.
10. Scroll down the Farming wizard and review the calculated totals for:
 - a. Corn Planter acres
 - b. Tractor Hours and Diesel Cost
 - c. Fertilizer and Cost
 - d. Corn Seed Actual Rate and Cost
11. Click OK when satisfied with the planting set up.
12. Select the Jobs tab in the Viewing window. If the new job does not show, click the Edit Filter button.
13. Right-click on the completed job. Choose Print

Job Report

Client Name, Your
 Farm Bolivar County
 Field po44
 Crop 2019 Corn
 Job Name po44 - Planting-Seeding
 Field Area 41.08 ac

Region 1		3/19/2019 8:00 AM - 3/19/2019 10:30 AM			
	Area (ac)	Rate (/ac)	Quantity	Unit Cost	Total
Equipment					
Corn Planter	41.08ac	1.00 ac	41.080 ac	\$10.50	\$431.34
Tracked Tractor	41.08ac	0.06 hr	2.500 hr	\$46.00	\$115.00
Supplies					
Diesel Fuel	41.08ac	0.55 gal	22.500 gal	\$3.10	\$69.75
10-34-0	41.08ac	5.00 gal	1.180 ton (l	\$285.00	\$336.30
Corn Seed 1	41.08ac	34,000 pop	17.460 bag	\$240.00	\$4,190.40
				Total:	\$5,142.79
Field and Weather Information					
Growth Stage:			Soil Condition:		
Application Method:			Soil Type:		
Sky Conditions:			Gusting Speed:		
Wind Direction:			Temperature:		
Wind Speed:			Humidity:		

14. Choose to Export the report in a PDF file format and save the report in the CH06_Trimble folder. Name the report: Planting.

The Export function for creating a PDF file.

15. Backup the project.

Enter Spraying Records – Day 21

In this exercise, enter restricted use pesticide applications and produce a report to meet Environmental Protection Agency (EPA) requirements. These reports protect producers in case of an audit. Producers should be familiar with state and federal requirements and restrictions on pesticide use. Weather information should be recorded at the time of spraying. The EPA number and chemical formulation is required on the reports, as well as who the licensed applicator was that performed the spraying service.

1. Begin by removing the items in the Working Group. Select the Remove All green up arrow.
2. Click the Inputs tab and add the following inputs:
 - a. Spra-Coupe (Machines → Application)
 - b. Atrazine 4L (Supplies → Herbicide)
3. Click the Apply to Fields button and make the po44 field the focus. Click Record Completed Jobs.
4. Verify the 2013 Corn in the Crop Enterprise.
 - a. Make the Start Date = 04/10/2019. Use the tab key to move through the fields.
 - b. Make the Start Time = 14:00 (2pm) and the Stop Time 14:45 (2:45pm).
 - c. Scroll down to Atrazine 4L and make the post-emergence rate 1 quart per acre.
 - d. Verify the Actual Rate and Cost.
 - e. Enter the Field Information.
5. Click the Growth Stage box and <Add / Edit> a growth stage. Name the stage: "V6" and click OK.

Selecting a growth stage.

6. When you return to the Farming wizard, make the Application Method = Post-emergence
7. Soil Condition = Dry
8. Soil Type = Clay Loam (add this characterization to the properties).
9. Scroll down to the Weather Information section.
 - a. Sky Conditions = Clear
 - b. Wind Direction = East-northeast
 - c. Wind Speed = 1
 - d. Gusting to = 3
 - e. Temperature = 71
 - f. Relative Humidity = 65.
10. Click OK to apply the changes.
11. Right-click the Application in the Jobs tab menu and print the report. Export the document as a PDF and save the report in the Reports folder for submission.

Exercise #2 Manage Harvest Information – Day 192

For this final scenario, add the farmer, corn combine, grain platform, and header to the Working Group and construct a report that reflects the cost of harvesting the field. Harvest time was approximately 3.5 hours. In fall of 2018, you had forward marketed the crop at \$3.63/bu. Average bu/ac were 150.

1. Remove the previous items from the Working Group window and add the following:
 - a. Tracked Tractor
 - b. Combine
2. Click Apply to Field and enter the Farming report window by clicking the Record Completed Jobs. The following applies:
 - a. Start/End Date = September 27, 2019

- b. Start/End Time = 11:30 – 14:30
 - c. bu/ac = 150
 - d. Unit Price = \$3.63
3. Create a report by clicking OK and export it to the Reports folder for submission. Name the report: Harvest.
4. Calculate net income based on the three reports:

Table 5 Simple net income calculation

Description	Total Price
Planting	
Application	
Harvesting	
Corn Grain Sales	
Net Income excluding land and fuel costs	

END Reports Exercise _____

Creating Variable Rate Prescription Maps

In this exercise, create variable rate prescription maps from soil test data found in the Lab 4 Basemap folder. Producers overlay the results of soils test in a basemap and convert the soil test sample points to a grid (or raster) that predicts nutrient values where soil samples were not taken. This type of analysis is referred to as: “Interpolation”.

Several interpolation methods exist but agriculture normally employs the Inverse Distance (weighted) method to fill in data gaps between soil sample points. Points nearer one another are weighted, or more influential, than points further away. The software will search for the nearest neighboring data points and calculate missing data values. The resultant map is a raster grid that estimates values across entire fields.

Interpolate Imported Soil Test Data

There are two ways to import soil test data. A shapefile can be added to the current map as well as “read” a *.csv and/or *.txt file into the map.

1. Select the Clients / Farms / Fields tab in the TOC and expand the YOUR NAME folder containing the po44 shapefile.
2. Select the Map tab in the viewing window.
3. Right-click the Your Name ➔ po44 layer in the Client/Farm/Fields menu and select: Import Background. Navigate to the CH04_Basemap\SHPPFiles\WGS84 folder. Select the po44_2013_soiltest.shp and allow it to be added to the map.

Verify the map appears as in the graphic below. The next objective is to launch wizards that will create a variable rate lime application map.

The Views menu in Trimble Farm Works.

1. In the View window, select the pH menu item by clicking it one time.

The pH menu item.

2. Locate the Add Views button in the Views menu (circled in red in previous image). Select the Add Views button.
3. Complete the New View wizard as follows:
 - a. Output = Grid.
 - b. Make the Cell Data Cell Size 50 feet.
 - c. Method = Inverse Distance Method.
 - d. Allow the Search radius to be 250 feet with 5 neighbors.
4. Check the Fill Blanks box and verify the Smoothing is set to 0%. Click OK

New View

Output

☒ Grid
☐ Contour
☐ Area

Area Options

Layer

☐ Grid then average base data
☐ Create new composite layer

Cell Data

Cell Size
 Method
 Search Radius
 Neighbors
☒ Fill Blanks
 Smoothing 0%
 None Max

Innermost Contour Rings

Minimum Area

Setting the New View wizard.

5. The pH default color range isn't very useful. Click the Legend... button and select the Colors tab.
6. Set the color ramp to: "Wide" and Invert the colors so Red indicates low pH and Blue indicates high pH.
7. Click Apply and OK. Click the green plus (+) sign in the range counter and make the number of divisions: "7" and click OK to close the Legend wizard.

Legend

Attribute: pH
Commodity:
Legend Type: Manual Breaks
Unit of Measure:

Ranges **Colors**

Color Scheme: < New > Delete
Description:

☐ Narrow
☒ Wide
☐ 3 Color
☐ Contrast

Invert Colors

Save Color Scheme Apply >>

☐ Range Count
☐ Histogram
☐ Range Descriptions
☐ Values & Descriptions

	From	To	
+	6.105000	+∞	Blue
-	5.980000	6.104999	Light Blue
-	5.915000	5.979999	Cyan
-	5.815000	5.914999	Green
-	5.790000	5.814999	Light Green
-	5.610000	5.789999	Yellow
-	0.000000	5.609999	Red
+	-∞	0.000000	Dark Blue

OK Cancel

Adjusting parameters on the Legend menu.

In this pH prediction grid, any color other than Dark Blue indicates a soil pH less than 6.1. Ideally, soil pH for corn should be between 6.0 and 7.0 pH. The pH ranges below 5.5 have a detrimental effect on corn harvest.

The circled stars representing soil sample points in the graphic below exhibit greater effect on the data interpolation where the Red grid indicates very low pH. The software calculates areas between points by searching 1) the point of interest and 2) detecting nearest neighboring points. Points further away have less impact on the total lime prediction.

Points neighbors for interpolation.

8. Print a map of the pH interpolation. Select the Printer (Map Report button) icon on the toolbar.
9. Choose Standard Layout and make the Map Area = Window.
10. Scale it to: "Best Fit" and title the map with the field name and pH Prediction.
11. Uncheck the Use Default Information box. In the Info: box, type YOUR NAME and the date. Click Print.
12. When visible, use the Zoom (magnifying glass) option to zoom to a viewable size. Use the Print Screen keyboard function and copy the map into a .jpg file format. Save the map in the Reports folder for submission.

Create a Prescription Map

Reducing input costs in field production is the best way to increase net profits. Variable rate prescription maps are created to apply only the nutrients that are needed on the most critical locations in a field.

1. Select the Inputs tab and remove all items from the working group.
2. Add the lime (custom spread at \$46/acre) to the Working Group window.
3. In the Views window, right-click the pH attribute and choose Create Simple Application.

Creating a simple application in Farm Works.

4. Rename the Job Type to: "Spreading"

5. Set the application date to 2 weeks prior to planting (March 5, 2019). Make the Start Time 10:30am and allow for 1 hour to unload the prescription.
6. Make Farmer, Robert L. the operator.
7. Verify the quantity used in the prescription and the costing rate. Click OK.

Farming

File Add Region

Job Name	po44 - Spreading
Region Name	
Field Name	po44
Crop Enterprise	2019 Corn
Job Type	Spreading
Console ID	
Area Farmed	41.08
Start Date	3/5/2019
Start Time	10:30 AM
Stop Date	3/5/2019
Stop Time	11:30 AM
Job Hours	1.000
Operator	Farmer, Robert L
Notes/Instructions	Notes
Lime	Delete
Variable Rate Application	☒
Machine	
Applied Area	41.08
Planned Rate (ton (US)/ac)	5.641
Qty. Used (ton (US))	231.711
Costing Rate (\$/ton (US))	46.00

The Enterprise menu.

8. When the new grid displays, verify the area covered, the amount used, and the total lime tonnage needed to correct the soil to nearly 7.0 pH.
9. The Default Rate given is 1.0 but a producer can reduce this rate to lower lime costs.
10. Click the Adjust button and reduce the lime tonnage by 43.440 ton. Note the reduction in cost of the total lime.

Default Rate:	<input type="text" value="1.00"/>	
	<input type="button" value="Adjust"/>	
Area:	<input type="text" value="41.08"/>	ac
Rate:	<input type="text" value="1.06"/>	ton /ac
Quantity:	<input type="text" value="43.392"/>	ton (US)
Cost:	<input type="text" value="\$1,996.03"/>	

Setting rates and adjusting default values.

11. Return the lime tonnage to the original figure. Click Save and Close on the toolbar.
12. Select the Jobs tab in the viewing window.
13. Right-click on the po44 Lime Application listing and choose Print → Plan Report.
14. Export the report to the Report folder. Name the pdf file: 2013_limeapplication. Backup the project.

Chapter 6 Review

In this chapter, users entered field records and created financial reports for estimating planting, spraying, and harvesting costs. Using an estimated yield per acre, users calculated net income after costs. After creating a prescription lime application, the financial recovery was calculated assuming there was a net increase in yield over a three year period.

Other factors, including soil cation exchange capacity (CEC), should be factored into a lime prescription map.

CHAPTER VII

Financial Management Scenario

Purpose

This lab introduces students to farm planning through the Mississippi State University Agriculture Economics budget services. In order to estimate farm income and plan for the next year's production cycles, farmers use specialized tools that calculate net return after estimated expenses across all the fields within the production scheme. At the end of this tutorial, you will possess basic farm mapping techniques and tools to make farm planning decisions.

Lab Goals

In this chapter, students will:

1. Download Mississippi State University Agriculture Economics Budgets,
2. Create a complex map output, and
3. Make farm production decisions based on possible planning scenarios.

Scoring Rubric

(50 Points)

1. Answer Sheet: Student completed the answer sheet with inserted *.jpg map (0 to 20 points)
2. Submitted: Student uploaded two spreadsheets (0 to 20 points).
3. Submitted: Student uploaded *.pdf formatted map (0 to 10 points).

Submission Instructions: For this exercise, you will submit an answer sheet containing all the elements of the work. Insert the maps into the answer sheet in .jpg format.

Chapter 7 Overview

In this final chapter, you will combine several tutorial learning experiences to make cropping decisions on 6 different fields in Bolivar County. After creating a field basemap, you will calculate net income using the Mississippi State University Agriculture Economics Budgets and Planning worksheets. You will estimate long-range weather conditions using the Climate Prediction Center

maps, and you will preview Growing Guides made available to producers through the University Extension Service.

In the second half of this chapter, you'll learn how to download weather data for a Mississippi farm site, and you'll calculate growing degree days (GDDs) for two different crop types. The GDDs help producers estimate crop progress and harvest dates. In later chapters, you will plan the next-year's crop based on long-range weather predictions and the GDD estimates related to yield.

Build basemap with two data frames

Producers grow crops on lands that are often disconnected or away from a central farm locale. A map of detached parcels can be created using multiple mapping layouts, also called Data Frames in ArcGIS software. In this exercise, you will create two mapping layout views in order to produce a single map of several parcels.

Setting Data Frames

1. Open a new empty ArcMap document. Switch to Layout View.
2. Dock the Layout toolbar above the map.
3. Right-click the blank white space and choose: Page and Print Setup...
4. In the Page and Print Setup wizard, make the Orientation: Landscape and leave all other settings as default (see image below). Click OK.

The Page and Print Setup menu.

5. Right-click the Layers box highlighted in Layout View. Choose: Properties... → Size and Position tab.
6. Make the Size Width 5.0 inches and the Height: 7.75 inches. Click OK when done.

Setting Data Frame Properties.

7. Float the Layer window to the left of the map surface in order to make room for a second map data frame.
8. Save the maps as: CH07_FinMang\CH07_Basemap.mxd.
9. In the TOC, right-click the top Layers name and choose: Properties... → General tab. Rename the top Layer: "North Plots".
10. Make the Map Units: Feet and set the Display: to Decimal Degrees. Click OK.

Data Frame Properties

Feature Cache | Annotation Groups | Extent Indicators | **Frame** | Size and Position

General | **Data Frame** | Coordinate System | Illumination | Grids

Name: North Plots

Description:

Credits:

Units

Map: Feet

Display: Decimal Degrees

Tip: See Customize > ArcMap Options > Data View tab for additional options for displaying coordinates in the status bar

Reference Scale: <None>

Rotation: 0

Label Engine: Standard Label Engine

☒ Simulate layer transparency in legends

☐ Allow assignment of unique numeric IDs for map service publishing

OK Cancel Apply

Data Frame Properties map and display units.

11. In the Insert text menu, choose Data Frame. This will insert a new data frame into the map.

Inserting a second data frame into a map.

12. Rename the New Data Frame: "South Plots".
13. Open the South Plots Properties ➔ Size and Position dialog. Again, make the Size Width 5.0 inches and the Height: 7.75 inches. Click OK when done.
14. Organize the map so it appears as follows:

Active and inactive layers in the TOC.

The blue grab handles on the Layers window indicates the highlight Layer is the active layer. Notice in the TOC that the second Layers name is bolded. This also indicates which layer is active.

In ArcMap Layout View, a user can view both datasets simultaneously but not in Data View. In this exercise, switch often between Data and Layout View. Be certain you are aware of which layer is active.

1. Before proceeding, save the project.
2. Left-click the right-hand South Plots layer one time in the Layout View to activate it. Verify the blue grab handles are present. This ensures the South Plots layer is active (as in the previous image).
3. Now, right-click the South Plots layer name in the TOC and choose: Add Data.
4. Navigate to the CH07_FinMang\SHFiles\WGS84_UTM15N\Fields\South folder and add two boundary shapefiles.
5. Create a bookmark for the South Plots where both plots at this zoom level. Name the Bookmark: "South Plots".

A designated bookmark.

6. Activate the North Plots layer by left-clicking the left layer pane. North Plots will be bold in the TOC if the layer is active.
7. Now, right-click the North Plots layer name in the TOC → Add Data.
8. Navigate to the CH07_FinMang\\SHPFiles\WGS84_UTM15N\Fields\North folder and add the four boundary shapefiles.
9. Make a new bookmark for the North Plots. Name it: North Plots.
10. Verify whether or not you can see the South Plots bookmark when the North Plots layer is active.

Bookmarks are unique to the active layer window. You must create separate bookmarks for each Data Frame

11. With the North Plots layer active, select the Add Data button and choose Add Basemap.... Select the Imagery option and allow the grid to add. If you do not have an internet connection, recall the NAIP file for this county is stored in the CH04_Basemap\RSTFiles folder.
12. Activate the South Plots layer by left-clicking the right map view pane and add Basemap imagery. Save the project.

Complete the Basemap

All maps should contain priority elements that lend to ease of reading and interpretation. In order of priority, create the map by adding the following:

- **The Map(s)** properly projected and symbolized (completed).
Make the field boundary: Hollow, 1 pt. 40% gray. Right-click the shapefile → select Label Features. Modify the label for individual fields: Right-click the shapefile name → Properties → Label tab. Verify the Label Field is: Name. Make the font 12 pt. Click Symbol → Edit Symbol → Mask tab. Select Halo and close.

- **Title:** in the text menu, choose Insert ➔ Title. Create a North Plots and South Plots Title: 24 bold font with background. Double-click the title to open the Properties box. Choose Change Symbol. In the Symbol Selector, choose Edit Symbol... Choose the Advanced Text tab and check the Text Background box. Click OK three separate times to return to the map.

Using ArcMap Symbol Selector Editor.

- **Legend:** Activate the South Plots layer. In the text menu, select Insert ➔ Legend. Remove all Legend items except the po44_boundary and World Imagery.

The ArcMap Legend Wizard items selection.

Click Next. Remove the word “Legend” from the legend, as it is redundant. Click Next. Place a 0.5” border around the legend and make the background the same color as the title background. Click Next, Next, and Finish. In the South Plots TOC layer, change the po44_bndry name to Field Plots. Float the legend between the two map layers.

- Scale Bar: Both the North Plots and South Plots layers need separate scale bars because they are mapped at different scales. In the text menu, click Insert ➔ Scale Bar. Make a scale bar in feet for both the South and North layers.
- North Arrow: Add one North arrow only to the right (South Plots) map and one legend only to the left (North Plots) map. Be certain to use a background or symbolize the arrow in White so that it contrasts with the imagery.
- Data Description Box: Student name, projection system, and date (in a contrasting font).

Exercise #1 Insert Maps

When finished, export the map in both .jpg and .pdf formats. Insert the .jpg map in the answer sheet and upload the .pdf version when submitting the exercise.

Exercise #2 Estimate Crop Yield per Acre

The map contains polygon shapefiles with acreage data in the attributes table. You are given 2016 yields from each field and can calculate yield per acre.

1. Make the North Plots layer active and save the map.
2. If you changed the name of a TOC layer to correct the map legend, and don't know what the crop or field name is, right-click the layer and choose Properties → Source tab. Scroll to the right in the Data Source window and find the name of the file. When finished, close the Layer Properties window by clicking OK.
3. Right-click the bu50_bndry shapefile name in the TOC and Open Attribute Table.
4. Note the number of acres in this field boundary.
5. Close the Attribute Table and enter the acres in the table below.

Table 6 Calculated yield per acre estimates

2016 Crop Yields					
Field	Crop	Total Yield	Acres	Yield / Acre	Units
bu50	Rice	6,513			bu (45 lb)
bu52	Soy	1,909			bu (60 lb)
bu58	Rice	8,235			bu
bu64	Rice	9,140			bu
po44	Cotton	40,689 L / 61,034 CS			lb
po71	Corn	9,320			bu (56 lb)

6. Retrieve the acres attributes for the remaining fields and record the data in the table above.
7. When finished, calculate the yield per acre by dividing yield by acres. Save the project and close ArcMap.

END Exercise Basemap_____

Estimating Financial Returns

Farm Enterprise Planning

The Mississippi State University Agriculture Economics Advanced Farm Management (AEC 4343/6343) course features training on techniques and procedures for decision making in farm business. These techniques and procedures help producers optimize their enterprise by choosing and planning the best combination of crops across a wide and varying farm landscape.

In this exercise, you will download MSU planning budgets and spreadsheets, and plan the next season's cropping scheme on six individual field plots.

Exercise #3 Download MSU Budgets

1. Navigate to the Mississippi State University Agriculture Economics department at: <http://www.agecon.msstate.edu/>.
2. Scroll down the website and locate the Decision Tools menu. Click Budgets.
3. In the Planning Budgets menu, download the most recent:
 - a. Corn,
 - b. Cotton,
 - c. Rice, and
 - d. Soybean budgets to the CH07_FinMang\Utility folder.
4. Feel free to download any other budgets that might interest you.
5. Locate the Budget Spreadsheets menu on the current or main MSU Agriculture Economics homepage.
6. Download and save the Corn, Cotton, Rice, and Soybean budget spreadsheets in the CH07_FinMang\XLSFiles folder.
7. Open the Rice 2016 Planning Budgets .pdf file in the Utility folder.
8. Which MSU department sponsored this budget?
 - a.
9. Scroll down to the budget forward. What is the purpose of the budget?
 - a.
10. A farm enterprise Planning Budget may be very helpful in determining credit needed to support the upcoming crop production system. Mississippi State University employed extension and research faculty to create a multidisciplinary approach in estimating inputs, the associated costs, and estimated returns.
11. How are the financial returns stated in this report?
 - a.

12. Are the land costs, management, and general farm overhead included in the Report?
 - a.
13. When making planning decisions beyond one year, which “return” should you base the decision on?
 - a.
14. Scroll down to the Table of Contents. The report is separated into three distinct sections.
15. Section I is Methods and Procedures, which explains how costs (direct, fixed, and irrigation) and returns are calculated. Section II, Enterprise Budgets, covers fields configured under varying treatments and irrigation schemes. Section III, Appendix, is a tabulation of different field factors.
16. Scroll through the report and review the sections. When finished, close the report and open the
Lab10_FinanceManagement\XLSFiles\Rice_Budget spreadsheet.

Complete Budget Spreadsheets

17. Save the spreadsheet as: “bu50_2017_rice” in the XLSFiles folder. Refer to the previous table for crop type and yield information used to calculate returns above specified expenses.
18. Note several tabs across the bottom of the rice spreadsheet. Each tab contains differently configured cropping schemes. Review the different options available.
19. For all scenarios, consider yourself the owner/landlord.
20. You will edit the “Quantity” column only by placing a “0” in the field to represent no cost factors.
21. Read the following scenario and complete the budget spreadsheet based on 2016 yield returns.

Exercise #4 2017 Rice Production (bu50, bu58, bu64)

Rice Scenario: You are considering planting rice, again, on the bu50, bu58, and bu64 fields in an upcoming production year. The estimates will be based on the 2016 returns. The field is prepped and requires no survey or marking of the levees. The plan includes, for the first time, planting the three fields in Clearfield® straight levee rice. As in years past, planting will be spaced on in a multi-inlet flood irrigated (23”) system using Clearfield CL 161 seed. A soil test indicated that phosphorus (DAP) is required. Nitrogen fertilizer will be applied aerially [(10 gal) Urea (46% N)]. Pre-plant weed burndown glyphosate and a post-emergence application of New Path® and Command® will be required. The young rice shoots are susceptible to sheath blight so a planned application of fungicide is necessary. Karate® will be used against insects with a surfactant.

1. Which spreadsheet will you use?
 - a.
2. Leave as default roll out pipe, hauling, drying, crop consultant, soil test, operator labor, irrigation labor, hand labor, diesel fuel, repair and maintenance, and all fixed costs.
3. Insert the estimated yield from the table above into the bu50_2017_rice spreadsheet.
4. Complete the worksheet by typing "0" into the QUANTITY field for factors not used in the production scheme.
5. Save the file and record the Returns Above Total Specified Expenses.
6. Re-save the file naming it: "bu58_2017_rice".

Table 7 North Plot estimated returns for rice

Field	Crop	Yield / Acre	Returns Above Direct Expenses Per Acre	Returns Above Total Specified Expenses Per Acre
bu50	Rice			
bu58	Rice			
bu64	Rice			

7. Edit only the quantity by typing in the Yield per acre estimates from the previous table.
8. Record again the Return Above Direct and Total Specified Expenses in the table above.

Exercise #5 2017 Corn Production (bu52)

You plan to rotate the bu52 soybean field into corn in hopes of capitalizing on the increased nitrogen from the previous soybean crop.

1. Open the corn_grain_sorghum_wheat_budgets.xlsx spreadsheet and save it as: bu52_2017_Corn.xls.

Corn Scenario: The crop scenario assumes you will achieve 210 bu/acre corn grain at harvest. Soil tests indicates zinc is needed and it will be applied pre-plant. Lime, custom applied, is required early season but potash is not required. At planting 10-34-0 will be banded with the Bt RoundUp Ready® furrow irrigated (13") corn planted 38 inches with a 12-row planter. Pre-plant burndown includes glyphosate (3lb) followed by a post-emergence atrazine 4L treatment and another round of glyphosate (3lb). Bifenthrin® will be used if needed for insects. Aerial application of fungicide is not considered necessary for this crop.

2. Which spreadsheet will you use?
 - a.
3. Leave as default roll out pipe, hauling, drying, crop consultant, soil test, operator labor, irrigation labor, hand labor, diesel fuel, repair and maintenance, and all fixed costs.

Table 8 North Plot estimated returns for corn

Field	Crop	Yield / Acre	Returns Above Direct Expenses Per Acre	Returns Above Total Specified Expenses Per Acre
bu52	Corn	210		

2017 Crop Production (po44 & po71)

Before making the decision about crops for the po44 and po71 fields, consider two factors in production: Weather and Cultural Practices.

Field weather conditions may be out of the producers control and they can make or break an entire farm's economic returns. Previously, you learned to use the PRISM weather site to estimate growing degree days for past production years. Now, you will look at the long-range weather forecast and integrate these predictions into the crop planning scenario.

Exercise #6 Estimate Future Weather Patterns Ahead

1. In an internet browser, navigate to the NOAA Climate Prediction Center weather forecasting site at:
<http://www.cpc.ncep.noaa.gov/products/forecasts/>.

The mission of the Climate Prediction Center (CPC) is to deliver real-time weather information useful in predicting and describing climate variability for up to one year in advance. Farming is a climate-risk enterprise in that almost every facet of production is affected by climate change. The CPC is best known for forecasting climates based on the El Nino and La Nina conditions in the tropical Pacific Ocean.

2. Click on the "Seasonal" link in the main menu.
3. On the three months outlook page, locate the link to the upcoming planting year for April-May-June, if available.
4. Describe, in your own words, what the upcoming planting season outlook is for temperature and precipitation in Mississippi:
 - a.

5. Look ahead to June through August. Again, describe the Mississippi growing season during the summer:
 - a.
6. Finally, what is the weather outlook for September through November. Do you see any indication that harvesting might be difficult due to high precipitation predictions?
 - a.

Keep the CPC predictions in mind when considering the cropping schemes.

7. Describe the upcoming production year weather, predicted by the CPC, in this table using “above-average, average, or below-average” terms:

Table 9 Upcoming production year weather estimates

Period	Temperature	Precipitation
April through May		
June through August		
September through November		

Land Grant Colleges and Extension Service

A federal system of establishing colleges of agriculture was enacted through the Morrill Act in 1862 (7 U.S.C. 301) and of 1890 (26 Stat. 417). Publically donated lands and investments created a network of 70 institutions of higher learning that instruct students and active farm producers in modern farming techniques.

The Hatch Act of 1887 provided federal funds to establish experiment stations under the jurisdiction of the state’s respective land-grant college in hopes of improving farm production techniques through research. In 1914, the Smith-Lever Act expanded the land grant university mission by developing state-funded networks of county-level Extension Agents who act as a segue between agriculture researchers and farm producers.

A crop producer can access Extension publications for virtually every commodity crop grown regionally near their farm. Extension publications address important crop culture issues and provide producers with a wealth of cropping knowledge and experience at little or no cost to the producer.

Before making the final crop planning decision for the po44 and po71 fields, consider reviewing Extension bulletins for each crop to determine:

- Field preparation
- Varieties, planting, irrigation, and harvesting methods,
- Integrated pest management practices, and
- Best Management Practices.

You can find these crop guides by searching Google using the phrase: “CROPNAME Growing Guide”.

Review Crop Extension Publications

Below is a list of four crop growing guides to help you plan the po44 and po71 fields for the upcoming year. With the exception to the Soybean guide, you can also find these publications in the Lab10_FinancialManagement\Utility folder.

Soybeans – Arkansas Extension Service, in single chapters, at:

<http://www.uaex.edu/publications/mp-197.aspx>

Rice – Mississippi State University at:

<http://msucares.com/pubs/publications/p2255.pdf>

Cotton – Clemson University Extension at:

http://www.clemson.edu/extension/rowcrops/cotton/crop_resources/2015cottonproductionguide.pdf

Corn – University of Georgia Extension at:

<http://www.caes.uga.edu/commodities/fieldcrops/gagrains/documents/2015CornProductionGuide.pdf>

In 2016, po44 and po71 were cropped in irrigated cotton and dryland corn respectively. Choose to rotate in different crops for the 2017 budgets and calculate the returns using any of the MS Excel planning budget spreadsheets.

1. Complete the table below and submit two spreadsheets with the answer sheet.

Table 10 South Plot return estimates

Field	Crop	MS Excel Sheet #	Yield / Acre	Returns Above Direct Expenses Per Acre	Returns Above Total Specified Expenses Per Acre
po44					
po71					

END Financial Scenario Exercise _____

Calculating Growing Degree Days

Farmers and agriculture researchers use Growing Degree Days (GDD) to predict development rates of plants and animals. Calculating GDDs allows you to estimate when plants will bloom and reach maturity. Crop phenology (growth and development) is closely tied to the amount of solar insolation and heat units received during the normal growing season. Precipitation is also an important factor but secondary to GDDs.

Growing degree days (Reddy et al., 1996) are calculated differently for various crops. Cotton is sensitive to temperatures below 60 °F but relatively insensitive to temperatures greater than 86 °F as long as first flower development has passed. Corn, soy, and rice are more tolerant of cool temperatures as low as 50 °F but tend to cease growing above 86 °F. When exposed to prolong, hot temperatures, corn, soy, and rice divert much of their growing energy into respiration.

Therefore, we calculate growing degree days for cotton as the average temperature above 60 °F minus the base of 60 °F, with 60 degrees being the lowest base temperature allowed for growth. We refer to the lowest allowed temperature as Tmin, the maximum temperature as Tmax, and the base temperature as Tbase. Cotton and corn require 2,200 to 2,600 and 2,100 to 3,200 GDDs, respectively, from planting to harvest.

Cotton Tmin is 60 °F with no Tmax. The formula to calculate cotton GDDs is:

- $\text{CottonGDD} = (\text{Tmax} + \text{Tmin} > 60) / 2 - 60 \text{ (Tbase)}$

assuming Tmin is greater than 60 °F.

For example, on April 20th, 2012 the average Tmax is 74 °F and Tmin is 53 °F, so the GDD accumulated for that day is 63.5 °F. Soil in Mississippi is typically

too cold and wet for planting cotton in mid-April so the cotton growing season usually begins in May.

CottonGDD for April 20th, 2012 = $(74 + 60)/2 - 60 = 7$ GDDs.

Corn Tmin is 50 °F with a Tmax of 86 °F and Tbase of 50. Therefore, you can calculate corn/soy/rice GDDS as:

- Corn/Soy/RiceGDD = $[(T_{\text{max}} < 86) + (T_{\text{max}} > 50)]/2 - 50$
(Tbase)

For example, on June 18th, 2013, the average Tmax is 89 °F and Tmin is 68 °F. The Tmax was over 86 °F, so Tmax is set at 86 °F. Tmin was above 50 °F and, therefore, the Tmin value is accepted as is. However, the Tmax value exceeds the recommended temperature by 3 °F, and we'll use 86 °F as the Tmax instead.

Corn/Soy/RiceGDD for June 18th, 2013 = $(86 + 68)/2 - 50 = 27$ GDDs.

For this exercise, **you may work in groups of two** but you must individually submit the answer sheets. From two different weather services, you will download weather data from 2012 to 2013 and calculate corn and cotton GDDs in MS Excel. Also, you will accumulate the amount of precipitation for the growing season in Excel.

Scenario: In 2013, corn was grown on a site located at **-90.814, 33.903** decimal degrees near Hushpeckna, MS. Locate this site in Google maps and familiarize yourself with the area. The closest MSU Extension weather station is located in Cleveland, MS but the weather station often lacks data. How far is the farm site to Clarksdale, MS (Hint: use Google Maps Direction Feature)?

a.

The year previously, cotton was grown on the same site. Corn planting date was March 19, 2013 and harvested on September 29. Cotton planting date was May 15, 2012 and harvested on November 11. Fill in the table below with planting and harvest date information:

Table 11 Crop planting dates

Crop	Planting Date	Harvest Date
Cotton-2012		
Corn-2013		

Reddy, K.R., H.F. Hodges, W.H. McCarty, J.M. McKinion. 1996. Weather and Cotton Growth: Present and Future. MSU Cares Bulletin 1061.

Download Weather Data

MSUCares Weather Stations

~http://www.deltaweather.msstate.edu/ag_weather_products/ag_weather_products.htm (use the Cleveland weather station)

The Mississippi State University Extension (MSUCares) Delta Agricultural Weather Center is located in Stoneville, MS. It was established in 1998 and maps sites throughout the MS Delta region. Weather stations situated away from the Stoneville site may not have complete datasets. Therefore, you will download the MSUCares data and compare it to a second mathematically derived weather dataset.

1. Open a Firefox browser and navigate to the MSU Extension URL listed above.
2. Choose the DD50's & DD60's link.
3. Make the Station: Clarksdale
4. Set the date for data retrieval to:
 - a. Start Date: 05/15/2012
 - b. End Date: 11/11/12
5. Click View All Data.
6. When the data page completes, use the Control-A keys to select the data.
7. Use Control-C to copy all data in the record to the clipboard.
8. Open an empty MS Excel and use the Control-V keys to paste the data. Save the MS Excel worksheet in the E:\ArcProjects\PA1Labs\Lab3_ProjectionSystems\ folder in a new folder called: "XLSFiles".
9. Name the file: "ClarksdaleMS_MSUCares_2012Weather".
10. Delete rows 1-14 (the extraneous header information).
11. Click the MSU Extension banner and remove it by tapping the Delete key one time.
12. Scroll to the right and verify the DD50 and DD60 weather data is stored within this spreadsheet.
13. Delete the following columns:
 - a. Air Temp OB, Relative Humidity (Max, Min, OB)
 - b. Pan Evaporation, Wind Run, Solar Radiation, Soil Temp (Max, Min, 2 & 4 inch)
14. Save the .xlsx table and minimize it.
15. Repeat the exercise to collect the 2013 date.
16. When finished, fill in the following data table with the results:

Table 12 Accumulated precipitation and growing degree days

Year	Precipitation	Accum DD50	Accum Adj DD50	Accum DD60
2012				
2013				

Think about the production years as they relate to the weather data presented in this table. Imagine how crops might grow under limited precipitation or temperature. **Save this data for input later in the exercise.**

Oregon State University PRISM Weather

~ <http://www.prism.oregonstate.edu/recent/>

The Prism Climate Group at Oregon State University provides end-users with modeled, climatologically interpolated weather estimates across landscapes. The resolution is 4 km and created from data gathered at multiple weather station networks. The derived weather estimates arise from monthly estimates and may not match exactly weather taken from the site. Download the 2012 cotton and 2013 corn mean minimum, mean maximum and precipitation data for the growing site using the longitude and latitude.

1. Open a Firefox browser and navigate to the OSU-Prism URL above. Click the Explorer tab and type in the Coordinates: longitude and latitude stated in the scenario above **-90.814, 33.903**.
2. Click Zoom to location.
3. Choose Daily Values from May 15, 2012 to November 11, 2012.
4. Choose the units to be English and allow the Climate Variable: Precipitation to be added to the group.
5. Under Controls, click the Retrieve Time Series to launch a download.
6. Click Download Time Series to obtain a .CSV file.
7. Store the file in the E:\ArcProjects\PAILabs\Lab3_ProjectionSystems\CSVFiles folder. Save the file as: Huspeckna_MS_2012precip.csv. Answer Yes to keep the file in current format.
8. Exit MS Excel without saving in .XLSX format.
9. Repeat the exercise and obtain the 2013 precipitation dataset.
10. Repeat the exercise and obtain the 2012 and 2013 Minimum temp (Tmin) and Maximum (Tmax) temp records for this site as well.
11. Name the Maximum temp file: Hushpeckna_MS_YEARTmax and the Minimum temp file: Hushpeckna_MS_YEARTmin.

You'll need to organize the PRISM data in a single .XLSX spreadsheet and make it similar to the MSUCares worksheet. Take some time here and work

slowly through this process. Learning to manage spatial farm data requires slow and deliberate practice.

12. Close all .CSV files and open a new, empty MS Excel spreadsheet. Save the spreadsheet in the E:\ArcProjects\PAILabs\Lab3_ProjectionSystems\XLSFiles folder naming it: HushpecknaMS_PRISM_Weather.
13. In the Data text menu, choose Get External Data → From Text.
14. Navigate to the \Lab3_ProjectionSystems\CSVFiles folder.
15. Select the Hushpeckna_MS_2012Tmax and click the Import button.
16. In the Text Import Wizard, choose the Delimited radio button and click Next.
17. In the Delimiters window, choose Comma and uncheck Tab. Click Next.
18. Accept the defaults on Step 3 of 3 and click Finish.
19. In the Import Data wizard, allow the data to import to an Existing worksheet: in cell =\$A\$1. Click OK.
20. Save the HushpecknaMS_PRISM_Weather file.
21. With the mouse, select cell C1 in the spreadsheet.
22. Choose the Data menu → Get External Data → From Text.
23. Import the Hushpeckna_MS_2012Tmin data using a comma delimiter. Allow the data to import to the existing worksheet in cell = \$C\$1. Click OK.
24. Select cell E1 and import the precipitation data.
25. Save the MS Excel worksheet.
26. Change the name of the spreadsheet tab to: "2012DD60".
27. Delete rows 1-7 of this spreadsheet. Save the file.
28. Make a new spreadsheet tab called: "2013DD50". Import the .cvs files from 2013 into this new spreadsheet and save the file often.

Set up the spreadsheets in a uniform manner. Delete the "C" and "E" columns with extra date information. You will now calculate GDDs but keep in mind the following notes:

IMPORTANT NOTES:

- On days where the Tmin < 50, no growing degrees accumulate for both DD50 and DD60.
- There are no negative degree days. If a calculation is negative, set the value to "0".

In Excel, you'll use IF...THEN...ELSE statements to calculate the formulas. IF...THEN...ELSE (or ELSE-IF) statements execute a string of statements that are based on Boolean values of a condition. The condition results from comparison of two different values or a True/False statement. In the case of corn, you want to exclude temperatures less than 50 ° F and greater than

86 ° F. With cotton, we will accept the Tmin and Tmax values as is but set any negative GDD values to zero.

The following MS Excel formulas apply:

Table 13 Scripts for calculating growing degree days

Crop	MS Excel VBA Script
Cotton 2012	$=((T_{max})+(T_{min})/2)-60$
Corn/Soy/Rice 2013	$=(((IF(T_{max}>86,86,T_{max}))+ (IF(T_{min}<50,50,T_{min}))))/2)-50$

1. While in the 2012DD60 spreadsheet, select the first row and choose the View tab → Freeze Panes dropdown → Freeze Top Row.

MS Excel Freeze function.

2. Click the empty cell in column/row E1.
3. Name this field: "DD60".
4. Type in the formula to calculate cotton DD60 GDDs.
5. Copy and paste the formula into the rest of the spreadsheet or drag the selector to the bottom of the spreadsheet dates. Save the file.

	A	B	C	D	E	F	G
1	Date	tmax (degrees F)	tmin (degrees F)	ppt (inches)	DD60		
2	5/15/2012	81.6	59	0	$=((B2+C2)/2)-60$		
3	5/16/2012	82.6	59.2	0			
4	5/17/2012	85.9	61.4	0			
5	5/18/2012	88.4	62.1	0			

6. Select the DD60 field and choose the Data tab → Sort → Sort in Ascending Order.
7. Check again for values in the DD60 field that are < 0. Change these values to zero and total [=Sum(range)] the columns.
8. Resort the data on the Date column in Ascending Order.
9. Scroll to the bottom of the spreadsheet and sum the precipitation and DD60 fields.

The screenshot shows the Microsoft Excel interface with the 'DATA' tab selected. The ribbon includes 'Sort & Filter' and 'Data Tools' groups. The spreadsheet displays weather data for November 2012. The formula bar at the top shows the formula $=\text{sum}(D2:D182)$ being entered into cell D183.

	A	B	C	D	E	F	G
1	Date	tmax (degrees F)	tmin (degrees F)	ppt (inches)	DD60		
178	11/7/2012	56.6	39.7	0	0		
179	11/8/2012	61	33.4	0	0		
180	11/9/2012	62.2	36.1	0	0		
181	11/10/2012	72.1	47.3	0	0		
182	11/11/2012	75.4	50.2	0	2.8		
183				$=\text{sum}(D2:D182)$			
184							
185							

MS Excel mathematical functions: Sum script.

10. Repeat the calculations on the 2013DD50 spreadsheet using the formula given in the table above.

	A	B	C	D	E	F	G
1	Date	tmax (degrees F)	tmin (degrees F)	ppt (inches)	DD50		
2	3/19/2013	66.1	59	0.24	=(((IF(B2>86, 86, B2))+(IF(C2<50,50,C2)))/2)-50		
3	3/20/2013	62.6	59.2	0			
4	3/21/2013	60.5	61.4	0			
5	3/22/2013	49.4	62.1	0.45			
6	3/23/2013	49.4	65.4	0.66			

MS Excel IF mathematical function.

11. Sum the 2013DD50 data and save the file.

You've gathered general GDD data from two years and two different crops. Fill in the following table with Bolivar County weather data:

Table 14 Accumulated GDDs for MSUCares and PRISM

Year	GDD50 MSU Cares	Adj50 MSU Cares	GDD60 MSU Cares	Precip MSU Cares	GDD50 PRISM	GDD60 PRISM	Precip PRISM
2012							
2013							

Compare the MSUCares data to the PRISM data.

1. Are there adequate DD50s to grow corn in 2013 under both systems?
2. Are there adequate DD60s to grow cotton in 2012 under both systems?
3. Which system do you feel is most reliable and why?

The Postal Code closest to the Hushpeckna, MS field is: 38774

12. Navigate to the Potash[®] GDD calculator (<http://www.potashcorp-economics.com/tools-to-calculate-fertilizer-needs/calculators/gdd/>)
13. Complete the following table (GDD data does not exist for the period before 2008):

Table 15 Accumulated Potash[®] GDDs

Year	GDD Corn (3/19/YEAR – 09/29/YEAR)
2011	
2012	
2013	
2014	
2015	

14. Based on the figures gathered from the MSU Cares Weather Station, the PRISM Weather simulator, and the Potash GDD calculator, which weather service do you feel gives the most reliable GDD estimates? Explain your choice.
15. What might you do as a producer or researcher to assure you get the most accurate weather data?
 - a.
 - b.

END GDD Weather Exercise _____

Chapter 7 Review

Learning to calculate GDDs helps you make predictions about crop progress and potential harvest. Another excellent resource for long-range weather predictions is the NOAA Climate Prediction Center weather forecasting site at: <http://www.cpc.ncep.noaa.gov/products/forecasts/>. Choose to review the “Seasonal” maps for estimating long-range weather.

Textbook Resources

- **Google Earth Pro**
 - <https://www.google.com/earth/>
- **Google Maps**
 - <https://www.maps.google.com>
- **Mississippi Automated Resource Information System**
 - <http://www.maris.state.ms.us/>
- **MSUCares Weather Stations**
 - http://www.deltaweather.msstate.edu/ag_weather_products/ag_weather_products.htm
- **NRCS Soil Data View Extension for ArcGIS**
 - http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053614
- **Oregon State University PRISM Weather**
 - <http://www.prism.oregonstate.edu/recent/>
- **The National Geodetic Survey**
 - <http://www.ngs.noaa.gov/NGSDataExplorer/>
- **USDA Geospatial Data Gateway**
 - <https://gdg.sc.egov.usda.gov/>

Other Open Source Resources

- **QGIS Open Source Geographic Information System**
 - <http://www.qgis.org/en/site/>
- **FGIS Open Source Geographic Information System**
 - <http://www.forestpal.com/fgis.html>
- **Glovis Earth Resources Observation and Science Center**
 - <http://glovis.usgs.gov/>

APPENDIX A

SMS AG LEADER® COMPATIBLE FILE FORMATS

Ag Leader Technology® (Ag L)

EZ-Guide 250/500 (*.shp)
 EZ-Guide Plus (*.fld)
 Ag L Integra/InSight/Edge
 Boundary (*.iby)
 Ag L Integra/InSight/Edge
 Guidance (*.pat)
 Ag L Integra/InSight/Edge Log
 (*.ilf)
 Ag L Integra/InSight/Edge
 Prescription (*.irx)
 Ag L Integra/Versa/Compass
 (*.agdata)
 Ag L Integra/Versa/Compass
 (*.agsetup)
 PF 3000/PFAdv/YM2000 (*.yld)
 PF Boundary (*.bdy)
 PF Navigation (*.pfn)
 PFL – Cotton (*.pfl)
 TGT Prescription (*.tgt)

AGCO

FieldStar II/Falcon VT/Task C.
 (TaskData.xml)
 Falcon Log (*.rpt)
 Falcon Prescription (*.tif) *
 Fieldstar *

AutoFarm

A5 System (*.sqlite)
 A5 System (*.dbmain.db)

Case IH

AFS Harvest (*.yld)
 AFS Planting/Seeding (*.ens)
 Agri Check ADX Air (*.log)
 EZ-Guide Plus (*.fld)
 FM750/1000/FMD (*.shp)
 Remote Data Logger (*.shp)
 Universal Display (*.vyg)
 AFS200/300/Pro600/700 (*.vy1)

CLAAS

CEBIS (*.dat)
 CEBISII (TaskData.xml)

Flex-Coil

FlexControl System (*.log)

HARDI

HC 8500 & 9500 (*.iby, *.pat, *.ilf,
 *.irx, *.agdata, *.agsetup)

Hemisphere GPS

Air M3 & Outback 360/STS/S3
 (*.log, *.tmp)

ISO11783 Displays

(TaskData.xml) *

John Deere

Greenstar (*.gsd, *.gsy, *.ver)

Kinze

Vision (*.iby, *.pat, *.irx, *.ilf)

Mid-Tech

Boundary (*.bnd)
 Mapping (*.gmf)
 Guideline (*.gln)
 Record (*.rcd)
 Prescription (*.arm)

Agri-Check

Flex Control (*.tag)

New Holland
 EZ-Guide (*.fld, *.shp)
 FlexControl & Harvest (*.log)
 SP Planter (*.ens)
 Info/Intelliview (*.vyg, *.vy1)
 Yield (*.yld)

Precision Planting

20/20 Seed Sense (*.dat)

Trimble

AgGPS (*.shp)
 EZ-Guide (*.fld, *.shp)
 Yield Data (TaskData.xml)

3D Surfaces

Digital Elev. Mod. (*.dem)
 LiDAR (*.las)
 NED Elev. Mod. (*.bil)
 SDTS Elev. Mod. (*.ddf)

Imagery

(*.gif, *.jpg, *.jpeg, *.jpg2)
 (*.sid, *.png, *.tiff, *.tif)
 (*.bmp, *.wmf)

Google Spatial Files

KML (*.kml)
 KMZ (*.kmz)

Management Files

Comma delimited (*.csv)
 dBASE (*.dbf)
 Management Setup (*.msf)
 Tab delimited (*.txt)

MapINFO MID

MapInfo (*.mif)

TIGER Files

TIGER Line (*.rt1)
 TIGER County (*.rt7)

APPENDIX B
ILLUSTRATION REFERENCES

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