FE 257. GIS and Forest Engineering Applications

Week 4

FE 257 Week 4 Topics

- Chapter 7
  - Buffering landscape features
- Chapter 3
  - Acquiring, creating, and editing GIS databases and examining errors
- Data input (GPS and other technologies)
  - Chapter 1
- Final project discussion
- Next week:
  - Chapter 11
  - Chapter 8

Geographic Information Systems

Applications in Natural Resource Management

Chapter 7

Buffering Landscape Features

Chapter 7 Objectives

- Objectives:
- What buffering spatial landscape features accomplishes
- How different buffering techniques can be applied to point, line, or polygon features
- How buffering can be used to assess alternative management policies and to assist in making natural resource management decisions

Buffering

- The creation of a boundary around selected landscape features
- Why?
  - Establish leave areas or curtailing management activities within a specific distance of streams, roads, trails, or housing areas
  - Delineating "home ranges" or "critical habitats" that capture the known nesting, roosting, or foraging sites of a wildland species
  - Determining the potential impacts of a flood
- Buffering is sometimes called a proximity process

How a buffer process works

- Buffer processes use mathematics and coordinate systems to identify the space around ______________________
- Features are selected for buffering
  - Through a variety of selection processes
- A buffer distance is specified
  - Can be directly input, from an attribute, or other table
- A line is drawn in all directions around the features until a solid polygon has been formed
- A new database containing the buffer results is created

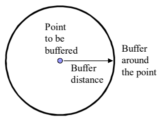


Figure 7. 1a. Developing a buffer around a point using an assumed buffer distance.

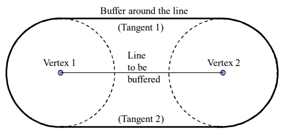


Figure 7.1b. Developing a buffer around a line using an assumed buffer distance around the line's vertices, and tangents bridging the vertices' buffers.

Buffer choices for polygons

- Users may select whether a buffer is created that represents
  - Only the area outside of the polygon that is being buffered
  - The area outside of the polygon plus the entire area of the polygon
  - The buffer area that is created both inside and outside of the polygon boundary

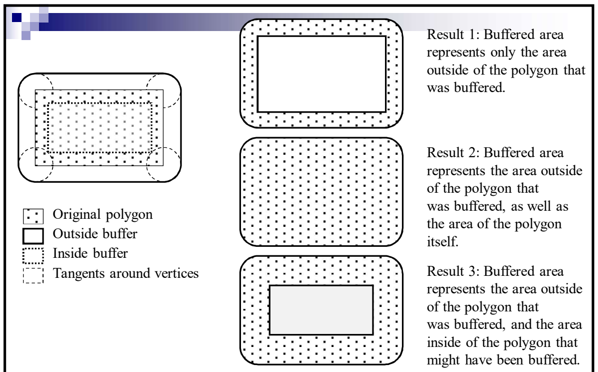


Figure 7.1c. Developing a buffer around a polygon using an assumed buffer distance around the polygon's vertices, and tangents bridging the vertices' buffers.

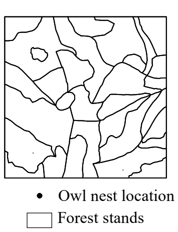
Vector and raster buffering

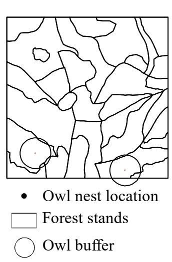
- Vector buffer
  - CPU intensive as complex geometrical processing is often necessary
  - Output shapes must often be merged
- Raster buffer
  - ____________________________
  - Involves the counting of pixels away from selected or specified pixels

Buffer distances and output

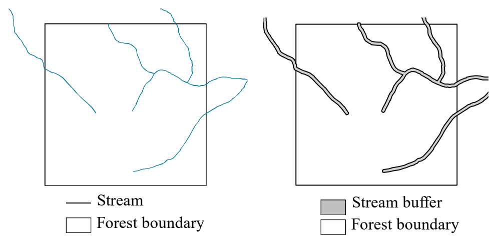
- Can be constant around all features
- Can be specific for each feature based on an attribute value
- Polygon output can be:
  - A single polygon (contiguous)
  - Individual polygons for all features (uncontiguous or noncontiguous)
    - This allows you to specifically assess buffer results
    - May potentially lead to overlapping buffers
- Most GIS packages allow you choose among these options

Buffering owl nests (fixed width)





Buffering streams (fixed width)



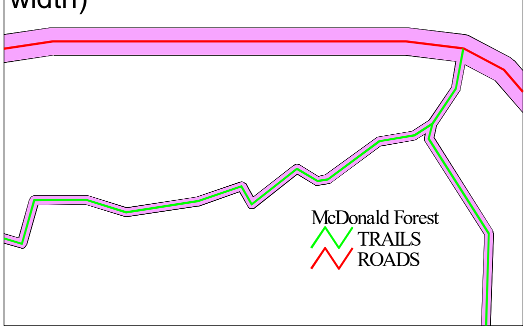
Variable width buffers

Table 7.3. State of Oregon riparian management area policy (Oregon State Legislature 2001)

	Riparian management area width (feet)	
	Domestic water use or fish-bearing	Non-domestic water use and non-fish-bearing
Large[a]	100	70
Medium[b]	70	50
Small[c]	50	20

[a] Average annual flow of ≥ 10 cubic feet per second.
[b] Average annual flow of ≥ 2 cubic feet per second and < 10 cubic feet per second.
[c] Average annual flow of < 2 cubic feet per second, or drainage area ≤ 200 acres.

Buffering trails and roads (variable width)



Other buffer applications

- Buffering trail systems or roads to delineate areas of visual sensitivity within which logging operations may be limited
- Buffering research areas to minimize disturbance
- Buffering stream systems to delineate the distance herbicide operations must stay away from water systems.
  - Local buildings (particularly houses), roads, agricultural fields, and orchards may also require buffering

Problems with buffers

- Wrong buffer units
- Sub-selected features buffered instead of the entire file
- Wrong sub-selected features processed
- Contiguous and noncontiguous results mixed

Geographic Information Systems

Applications in Natural Resource Management

Chapter 3
Acquiring, Creating, and Editing GIS Databases

Chapter 3 Objectives

- Methods to acquire GIS databases, particularly via the Internet
- Methods to create new GIS databases
- Processes to edit existing GIS databases
- Types and sources of error potentially associated with GIS databases

Four general cases of GIS databases at most organizations

- The data necessary for project work
  - Don’t exist
  - Do exist but were created for other general uses and may not be completely suitable for your project
  - Do exist but were created for other specific uses and may not be completely suitable for your project
  - The data are in place and in good order for your project!

Typically, you’ll have to acquire data

- Download data from the Internet
- Use a GPS or other device to create data
- Hire a contractor to create or edit GIS data
- Buy data from another organization

Internet acquisition

- Many federal and state organizations make spatial data available
  - The U.S. Government is the largest producer of spatial data in the world
  - Manual of Federal Geographic Data Products
- Freedom of information act allows the public some access to data created by public agencies
- Use these data to save time

Oregon Data Sources

- https://www.oregon.gov/GEO/Pages/index.aspx
- https://www.oregon.gov/geo/Pages/mapsites.aspx
- Google search for GIS data of an area of interest (AOI)
  - <AOI>, GIS, spatial, map…

Creating GIS databases

- We will cover these during our next presentation:
  - Digitizing
  - Scanning
  - Remote Sensing
    - Color
    - Infrared
    - Thermal
    - LIDAR
  - Laser range finder
  - Total station
  - GPS

Editing and updating GIS data

- Spatial and/or attribute updates
- In natural resources, updates may occur often to keep pace with change
  - Growth, disturbance, harvesting, habitat encouragement, policy change
- Other reasons for editing
  - Changing a spatial projection
  - Edge matching GIS databases to other databases
  - Converting GIS database to a specific format or resolution

Editing and updating processes

- Time consuming and error-prone
- Verification protocols can help
  - Assure that data variables are reasonable or meet some standard
  - Should be in place for spatial and attribute characteristics
  - Protocols can help…

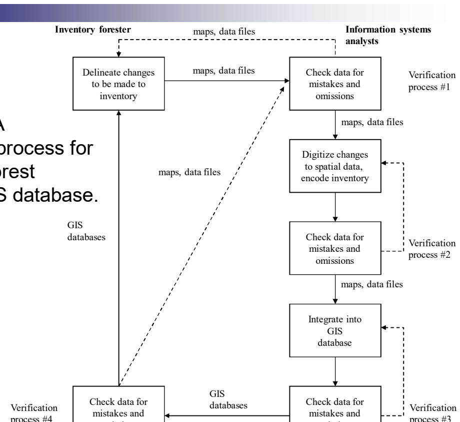


Figure 3.4. A generalized process for updating a forest inventory GIS database.

Editing and updating spatial position

- As the locations or shapes of spatial features change, their coordinates will need to be changed within the GIS database
- Editing procedures for this purpose vary widely among software products
  - Typically, a database is first made “editable”
  - The user then makes edits
    - Points, lines, and/or polygons moved, copied, created, or deleted
  - The edits are saved
  - Often time-consuming

Consistency in spatial position

- When updating or creating new data, inconsistencies may result as the data are incorporated into existing databases

Figure 3.5. A timber stand drawn more precisely (top) and less precisely (bottom). Note that the lines on the south and eastern portion of the figures are different.

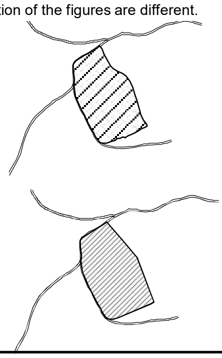
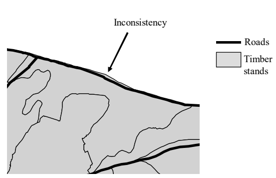


Figure 3.6. Spatial inconsistency between a timber stand GIS database and a roads GIS database.



Editing and updating attributes

- Attributes are the values used to describe landscape features in a GIS database
  - Fields, variables, columns, data, etc.
- Attributes may need to be updated overtime
  - Vegetation type, basal area, age, volume (mbf)
- Easy to make mistakes, particularly with major updates
- Verification processes can check whether values are in the appropriate range

Error in GIS databases

- Errors are possible from creation and subsequent editing
- Three primary sources of error in GIS data
  - Systematic
  - Human
  - Random

Systematic errors

- Caused by problems in the processes and/or tools used to measure spatial locations or attribute data
- Sometimes called cumulative errors since they add up during data collection
- ______________________________
- Can be removed if identified and quantified

Human errors

- Sometimes called gross errors or blunders
- Human errors happen through carelessness or other inattention
- Verification processes can be used to control human errors
- Data collection and editing protocols can also assist in limiting human errors

Random errors

- An almost unavoidable by-product of measuring and describing landscape data
- There will almost always be some slight variance from the true measurement when humans are involved
- Random errors are errors that remain after systematic and human errors have been removed
- Frequently, and especially in forestry, we assume that random errors cancel each other out
  - Random errors are sometimes called *compensating* errors

Geographic Information Systems

Applications in Natural Resource Management

Chapter 1

Focus: Spatial Data Collection and Input Devices

Chapter 1 Objectives

- Why GIS use is prevalent in natural resource management
- Evolution of the development of GIS technology and key figures
- **Common spatial data collection techniques and input devices that are available**
- Common GIS output processes that are typical in natural resource management
- The broad types of GIS software that are available

Data collection processes & input devices

- Technology is constantly on the move
- Enhancements in digital technology for measurement applications are frequent
- A multitude of tools are available for spatial data capture but two important data considerations must always be taken into account regardless of the sophistication of the tool: accuracy and precision

Accuracy and precision: two different animals

- Accuracy
  - The ability of a measurement to describe a landscape feature's true location, size, or condition.
  - Accuracy is typically described in terms of a range or variance that details a threshold within which we would expect to find the likely value.
- Precision
  - Relates to the degree of specificity to which a measurement is described.
  - Can also describe the relative consistency among a set of measurements.

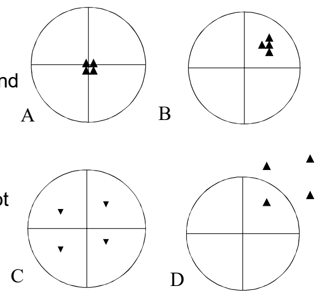
Figure 1.2. Examples of accuracy and precision.

Part A shows accurate and precise locations of data around the circle center;

Part B shows precise but not very accurate data;

Part C shows accurate, but not very precise data, and

Part D shows neither precise, nor accurate data around the circle center.



Digitizing

- Many sizes from laptop to desk-sized ($200 - $1500)
- Board has sensors that record instructions from a "puck"
- Typically digitize from a hard-copy medium
- Need at least four points of known locations
- These are transferred to board as a series of "tics" or registration points (Quad example)
- Puck is used to record points, lines, or polygons

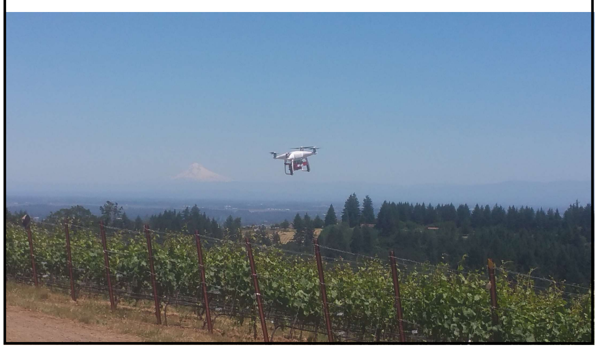
Digitizer

Figure 1.3. Modern digitizing table.

Scanning of images

Figure 1.4. Small format scanner.

Aerial photography



Aerial photography

Composite image

Light detection and ranging (LiDAR)

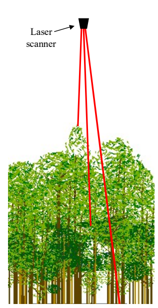
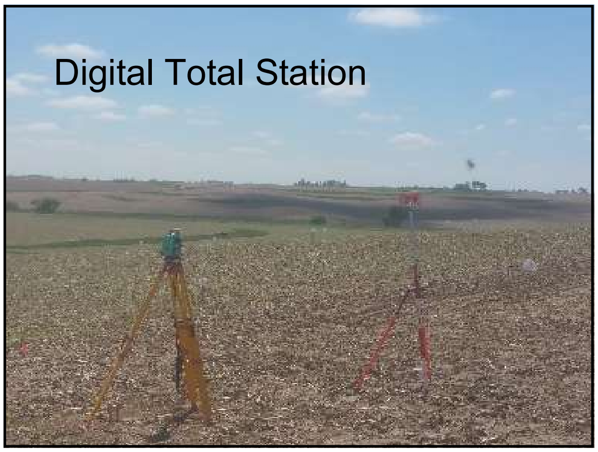


Figure 1.11. Laser range finder.

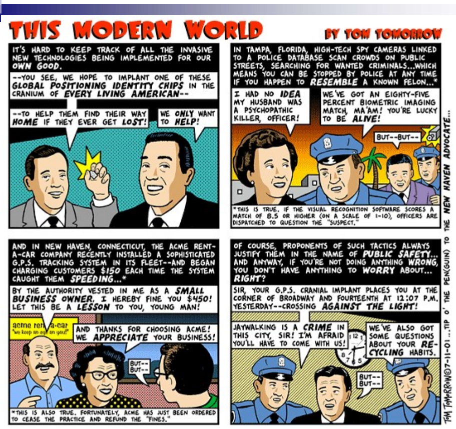
Digital Total Station



Handheld Data Collector

Global Positioning Systems…

- A collection of hardware and software that allows users to access satellite signals and determine locations on or near the earth's surface
- Typically, most people interact with GPS through a receiver (hardware) and use a mapping program (hardware & software) to view results



GPS mechanics

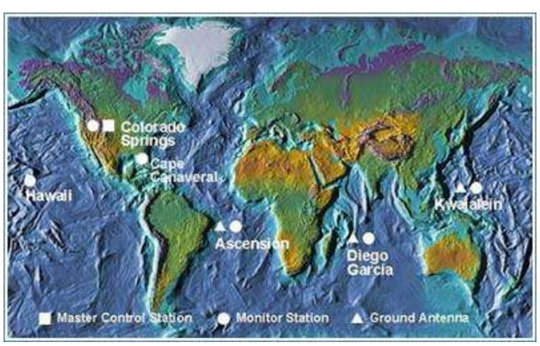
- A navigation system funded and controlled by the U. S. Department of Defense (DoD)
  - Called NAVSTAR (Navigation System w/ Time and Ranging)- operational in 1995
- 24 operational satellites (31)
  - orbit the earth in 12 hours
  - ____________________
  - transmit microwave signals towards the earth
- GPS receivers on the ground receive the signals
  - Base positions by computing the difference between time signal transmitted and received
  - Three satellites for X and Y, four for X, Y, and Z

Three GPS segments

- Control
- Space
- User

Control segment

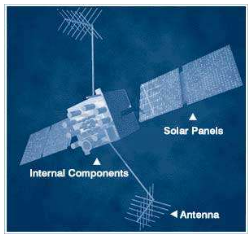
- One master control station
  - Falcon AFB (Colorado)
- Six monitor stations track the satellites
  - Ascension Island (South Atlantic Ocean)
  - Cape Canaveral
  - Diego Garcia (Indian Ocean)
  - Falcon AFB (Colorado)
  - Kwajalein Atoll (Pacific Ocean)
  - Hawaii
- Each satellite passes over at least one monitor station twice daily
  - An almanac of satellite position is created
- Three ground antennas
  - Track satellites and transmit correction information to satellites



http://www.faa.gov

Space segment

- Satellites have solar panels
- Each satellite has four atomic clocks
  - Accurate to a billionth of a second (nanosecond)



http://www.faa.gov

GPS Principles

- Distances, known as ranges, between the GPS receiver and the satellites are measured based on the speed of light
  - How long did it take the satellite signal to reach the GPS receiver?
- The location of the satellite at the exact instant it sent the signal must also be communicated
- Atmospheric conditions also accounted for
  - Satellite signals start in a vacuum (space)
  - Must then must travel through the atmosphere
  - Delay of GPS signal through atmosphere is measured

GPS Principles

- The GPS receiver must also be able to identify each satellite it receives signals from
- Three signals allows the GPS receiver to compute longitude and latitude
  - Through process of trilateration
- Four GPS satellite signals are needed to compute positions in three dimensions
- Signals are sometimes hard to get
  - Topography, cover
  - Satellite position
  - Atmospheric interference

User segment: GPS receivers

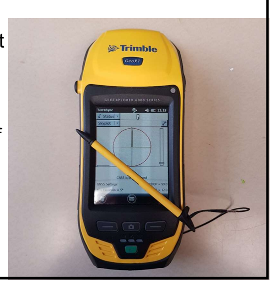
- Three broad categories
  - Consumer or recreation grade (5-20 m)
    - $50-750
  - Mapping or resource grade (1-5 m)
    - $1,500-10,000
  - Survey grade (< cm, potentially)
    - $10,000 and up

Consumer grade GPS receivers

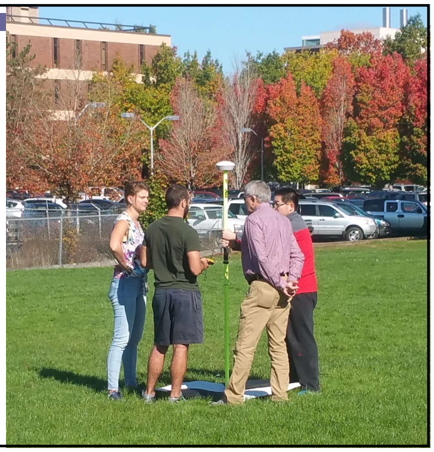
- Handheld and relatively inexpensive
- Coarse location measurements (5-20 m)
- Points can be saved and downloaded in some packages
- User unable to set minimum quality of signals
  - Allows forest measurements to be collected
- Garmin, Lowrance, Brunton, Deloreme, Magellan

Mapping grade GPS

- Sometimes called GIS or resource grade
- Handheld or backpack
- Moderate location measurement accuracy (1-5 m)
- Points can be saved and downloaded
- User can set minimum quality of signals
- Differential correction possible with many
- Trimble, Archer, SXBlue, CMT



Mapping grade GPS receiver and data collector in use



Survey grade GPS

- Most accurate (< cm) and expensive
- User can set minimum quality of signals
- Used for precise earth measurements, determining construction project measurements, property measurements, and other applications when precision and accuracy are essential
- Differential correction possible
- Topcon, Trimble, Leica, Thales ProMark, Ashtech

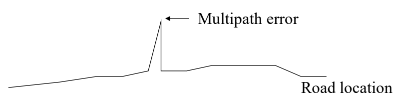
Summary: GPS Principles

- Control, space, and user segments
- Satellite signals carry:
  - Time, satellite position, atmospheric information, satellite ID
- Control segment monitors the space segment
- GPS receivers represent the user segment and allow position determination

GPS Error Sources

- ________________
  - GPS signals reflect off another surface before reaching GPS receiver
    - Buildings, structures, vehicles
    - Trees, water, vegetation
- Some GPS software can reduce, but not eliminate, multipath errors

Multipath error



GPS Error: Atmospheric, digital, and mechanical

- Troposphere/Ionosphere (< 4m)
  - Travel time of signal
- Receiver Error (< 2m)
  - Rounding, false position
- Ephemeris Error (< 1m)
- Clock Error (<1 m)

GPS Accuracy

- Position Dilution of Precision (PDOP)
  - General guideline: < 6
- Composed of:
  - Horizontal Dilution of Precision (HDOP)
  - Vertical Dilution of Precision (VDOP)

Differential Correction

- Not available to consumer grade receivers
  - Except real-time differential correction (WAAS)
- Can remove some of the error but does not address multipath errors
- Coordinates collected in the field are post-processed in the office
- Uses a base station at a known X, Y, and Z
  - Base station computes measurement error based on satellite signals
  - Rover (GPS receiver) communicates with base station to apply correction to measurements

Real-time Kinematic GPS

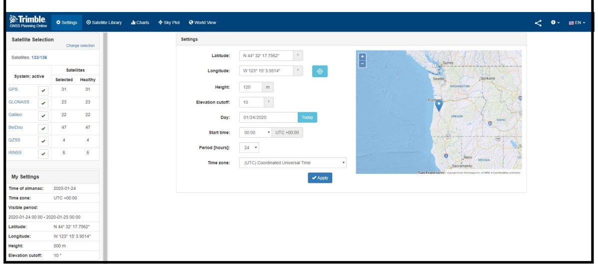
- A differential correction GPS method: the rover is continually moving or stopping only briefly
- Sometimes the rover and base station leap frog each other to increase ground coverage
  - If two mobile GPS receivers
- Corrections are communicated to the rover from the base station in real time using a radio or cellular connection
- Can collect points faster but usually offers trade-offs to accuracy

GPS challenges in natural resources

- Very efficient for data collection but:
  - Forest canopy and topography block lines of sight between satellites and receiver
  - Mission planning software can help
- Acquire and retain sufficient number of satellites and signal strength
- Multipath errors
  - Satellite signals which reflect off an object before reaching receiver
- Things are improving

GPS Mission Planning

- https://www.gnssplanning.com/#/settings



Final Project

Final project discussion

- 50 points (25% of grade)
  - Reports due last day of dead week

Project guidelines

- A spatial investigation, summary, or comparison that addresses a forest engineering or natural resources topic
- The result should be:
  - New knowledge or understanding of the topic
- Teams of two recommended
  - People may also work individually or in threes
  - Teams turn in one project

Project requirements

- Cover page
  - paper title, class number (FE 257), date, and author names
- 3-5 page, typed, double-spaced document that describes your project
  - Maps are not included in the 3-5 page limit

Report sections

- Introduction
  - Explains the relevance of the topic and provides a brief background.
  - Describe what you are intending to do and why it's important.
- Methods
  - Describe what tools (software) you used to accomplish your project.
  - What were the key steps in answering questions related to your project?
  - Where did your data come from?
  - Discuss the quality of your data (including discussion of the data scale or resolution)?

Report sections

- Results
  - Describe what you discovered including problems and/or successes with the methods you used.
  - Were there any unexpected or unanticipated results?
- Conclusion
  - This should contain a brief summary of the importance of your results.
- A minimum of two 8.5 x 11 inch maps in addition to your report
  - One of the maps should be show the location of your study area.
  - The other map(s) should show your project results.

How to get started

- Identify a topic:
  - Look through all of our labs.
  - Check out book chapter 12.
  - Browse spatial data WWW sites.
  - Consider your own interests in natural resources. Explore an issue or question(s) that interests you.
- See your TA or me for questions about your topic
- See your TA or me if you need help identifying a topic

Report grade sheet

Name(s):

PROJECT SCORES **FE 257**

REQUIRED PAPER SECTIONS

INTRODUCTION (10 points)
This explains the relevance of the topic and provides a brief background. This section should conclude with 1-3 paragraphs describing what you are intending to do and why it's important.

METHODS (10 points)
Describe what tools (software) you used to accomplish your project. What were the key steps in answering questions related to your project? Where did your data come from? What is the quality of your data (should include scale or resolution)?

RESULTS (10 points)
Describe what you discovered. This may include problems and/or successes with the methods you used. Were there any unexpected or unanticipated results?

CONCLUSION (10 points)
This should contain a brief summary of your results and the importance of your results.

MAPS/FIGURES (10 points)
Include a minimum of two 8.5 x 11 inch maps in addition to your report. One of the maps should be show the location of your study area. The other maps(s) should show your project results

Each of the two required maps:

Title	1
North Arrow	1
Scale Bar	1
Credits	1
Aesthetics	1

Final report

- Proof read
- Don't put in a plastic or other cover
- Turn in at: Snell 210A (FERM office)