EXPERIMENTAL DESIGN AND GEOGRAPHIC POSITION SYSTEMS
BI 311
Laboratory 01 and Homework 01

## Introduction:

For this lab we will distinguish between the different types of experimental studies, practice mapping/geographic locations, and practice techniques for estimating sample sizes.

## Skills:

1. Learn to use map, compass and GPS to define geographic locations.
2. Learn how to use a performance curve to estimate the number of samples needed.
3. Learn to distinguish between fundamental types of experimental studies.

## Materials:

1. Access to maps, compass and GPS units
2. 1 $m^2$ sampling plot
3. Access to EXCEL
4. PDF files of example studies located on the shares drive

---

### EXERCISE 1- HOW TO USE MAP, COMPASS AND GPS

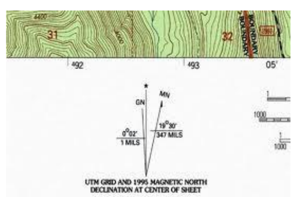
## Background:

The naturalists of the 19th century would have envied the maps, compasses and especially the satellite assisted GPS systems we have today. The temptation for students is to go immediately to GPS but, the system has its weaknesses. First, because it relies on signals received from satellites, the satellites must be in view. Dense tree canopy, buildings or slot canyons can scatter, distort or obscure signals from satellites and lead to errors in positioning. Second, GPS units rely on batteries. Once the batteries die, the unit is worthless. Third, many agencies still require reporting of the Land Office Grid System and GPS can't provide the necessary information. Thus, map and compass skills are still mandatory for a field biologist.

## Field Procedure:

*Finding your location on a map using a compass:*

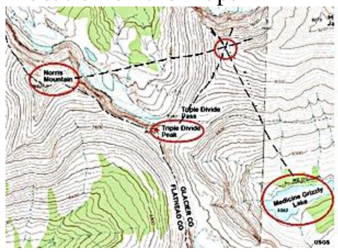
1. Set the declination on your compass for magnetic north to match the declination on the map. Now the travel arrow will point to true north instead of magnetic north.




2. Orient the map to true north using the compass bearing for true north and by placing the compass along any north/south oriented line on the map. Rotate the map until the magnetic needle aligns with the declination arrow and now the travel arrow and the map are oriented toward true north.

3. Locate a prominent feature on the landscape that you can also find on the map.

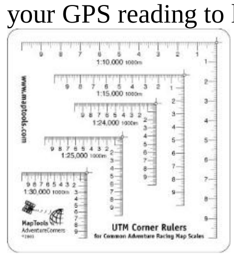
4. Take a compass bearing toward the landscape feature and then, holding the compass on the map to match the compass bearing, “draw” a line from the feature back toward your position on the map. (Instead of physically drawing a line on the map, which will ruin the map, use the straight edge of a piece of paper to mark your line).
5. Repeat steps 3 and 4 with another prominent landscape feature that has a bearing at least 30 degrees different than the first feature. Where the two lines cross should be your location on the map.



*Finding your location on a map using a GPS* (directions are for etrex and etrex 20 units)*:*

1. Turn on the GPS unit and allow it to track satellites until either a map (etrex) or menu (etrex 20) appears.


2. Select the menu (*Enter*) button until the menu window appears (etrex units only).
3. Scroll down and select *Setup* and then *Units* (etrex units) or *Position Format* (etrext 20 units).
4. Be certain the *Position Format* is set on *UTM/UPS* and the ***Map Datum*** is set on *NAD 27 – CONUS*. If not, enter each selection by selecting *OK* and toggle through the menu options to correct the settings. This step only has to be done once but it is important!
5. Select the *enter* button to return to the menu and then select *mark*. Copy the UTM coordinate information in your field notebook. For example, 12T, 0421684E, 5164620N. You can also save the coordinates as a *waypoint* by selecting the *OK* button, but then you must retrieve the same unit to be able to recall your data.
6. Use the UTM grid on you map to locate the closest 1000 m intersection to your GPS position reading. Then, place the compass UTM scale within the 1000 by 1000 m square and use your GPS reading to locate your position on the map.




*Reporting your map location for publications:*

1. For the **Land Office Grid System** report the Township, Range, Section and Section description using the following format: T10N, R3W, S30, NWNW.
2. For the GPS UTM System report the datum, zone, and UTM coordinates using the following format: NAD27-CONUS, 12T, 420510E, 5161015N.

## Homework Procedure:

Using your newfound geographic skills, locate the water fountain outside of the CUBE using the Land Office Grid System and you map. Then, use the GPS and the UTM System to record the coordinates of the fountain (this will require a visit to the fountain).

## EXERCISE 2- ESTIMATING THE APPROPRIATE SAMPLE SIZE

### Background:

Most ecological systems (e.g. individuals, populations, communities, or ecosystems) are large and complex enough that it is impractical to measure all of the subjects of the study. We must sample the system by measuring a subset of subjects and then infer back to the system as a whole. To make proper inferences, the sample must be unbiased and representative of the system. If we were to sample just one subject from a population (or group) of subjects, we may question how well the one subject represents the group. If two samples are better than one, why not 4, 8, or 16 samples? Statisticians call each sample a **replicate**. How do we determine how many replicates are necessary to legitimately represent our group? This is often a difficult question, the answer depending on the variable being measured, the cost of measuring/counting, and the time available for the study.

One way to address the sample size question is to perform a preliminary study that estimates the appropriate sample size. Statisticians have designed several methods to estimate an appropriate sample size. One simple method is the construction of a performance curve. A **performance curve** examines the association between the **cumulative mean value** of a measurement/count and the number of samples taken. When the cumulative mean remains the same even after the addition of more samples, your sample size is probably large enough. For example, say we want to estimate the average body size for scrub lizards but don't know how many samples we need to get an accurate estimate. Figure 1 shows the association between the cumulative mean size (snout to vent length) for male scrub lizards for samples of different size. The cumulative mean fluctuates when going from one to 2 lizards and even from 14 to 15, but eventually (after about 15 lizards) the cumulative mean doesn't change much. In other words, the addition of more samples doesn't change the cumulative mean and the sample size is probably large enough.

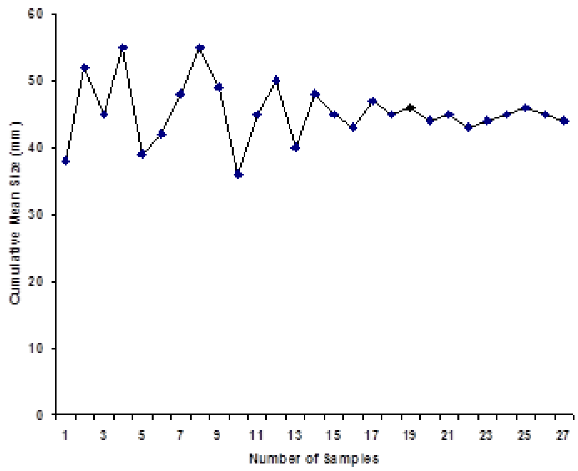



Figure 1. Cumulative mean body size versus number of samples for male scrub lizards.

### Field Procedure:

You have been provided with a 1 $m^2$ rectangle made of PVC. You will use the apparatus and a random number table to define plots across a playing field/lawn containing weeds (to be demonstrated). Ultimately, you would like to answer the question: what is the average number of weeds per $m^2$? However, you first need to know how many samples are needed to provide you with a viable estimate of the mean. Use the 1 $m^2$ plot and a random number table to record the number of weeds in at least 20 plots (more if time allows).

### Homework Procedure:

Create a performance curve using the weed data collected in the field. Open an EXCEL file and complete the following.

1. Create a column with successive sample numbers (e.g. 1, 2, 3, etc. See table 1 below as an example).

Table 1. Example data used for creating a performance curve.

| Sample Number | Dependent variable | Cumulative Sum | Cumulative mean |
|---|---|---|---|
| 1 | 52 | 52 | 52 |
| 2 | 92 | 144 | 72 |
| 3 | 82 | 226 | 75.33333 |

| | | | |
|---|---|---|---|
| 4 | 345 | 571 | 142.75 |
| 5 | 435 | 1006 | 201.2 |
| 6 | 991 | 1997 | 332.8333 |
| 7 | 76 | 2073 | 296.1429 |
| 8 | 112 | 2185 | 273.125 |
| 9 | 64 | 2249 | 249.8889 |
| 10 | 506 | 2755 | 275.5 |
| 11 | 474 | 3229 | 293.5455 |
| 12 | 133 | 3362 | 280.1667 |
| 13 | 11 | 3373 | 259.4615 |
| 14 | 30 | 3403 | 243.0714 |

2. Create a second column with the dependent variable of interest (in this case, weed abundance) next to each sample number.
3. Create a third column for the cumulative sum of the dependent variable. For the first row, copy the value of the dependent variable. For the second row, type out the formula that is equal to the neighboring cell in the previous column plus the neighboring cell in the previous row. For the example in table 1, that would be 92+52 which equals 144. Using EXCELs row and column format, the formula would be '=b3+c2'. Now drag and copy the formula down to the bottom of the column. The formula will automatically fill in the correct sum for each row.
4. Now calculate the cumulative mean for the first row by dividing the cumulative sum (in the third column) by the sample number in the first column. E.g. '=d2/a1'. Because this is sample one, the value should be 52/1 = 52. Now drag the formula down the column and EXCEL will automatically calculate the correct cumulative mean.
5. Plot the sample number against the cumulative mean to create your cumulative mean plot. At this point, you may plot the curve by hand by drawing an x versus y plot with sample number on the x axis and cumulative mean on the y axis. Alternatively, if you are familiar with EXCEL, you can create an x-y plot using EXCEL (Don't worry if you don't know how to do this. It is a procedure we will learn later in the course).
6. Answer the following: Does the cumulative mean (performance curve) level out at a certain number of replicates? If so, you have discovered the number of replicates needed for sampling an average number of weeds per $m^2$. If not, you need to add replicate samples until the mean cumulative levels out.

---

## EXERCISE 3- PRACTICE CATEGORIZING STUDIES

### Background:

It is often useful to categorized studies to better understand the design, analysis, limitations, and conclusions. There are many ways to categorized scientific studies. We have already categorized studies in this course into **field** versus **laboratory**. Field studies are most useful at describing the effects of independent variables (factors) in a natural context whereas laboratory studies are useful for controlling some factors to better study the effects of others.

Another way to categorize studies is in terms of whether or not they test a hypothesis. Some studies simply describe measurements about nature such as describing where a species is found, the habitat preferences of a species or even the molecular characteristics of a species. Such studies are often called **descriptive** studies and provide background information for other researchers but do not directly test a hypothesis.

Studies that test a hypothesis are referred to as **experiments**. Note that lay people often refer to any study as an experiment but scientific researchers should restrict their usage of the term to studies that test hypotheses.

In turn, experiments can further be categorized into **comparative**, **manipulative**, or **modeling** studies. In a comparative study, the authors do not directly manipulate the independent variables but rather compare data that differ in time or place. Because often the data differ with respect to hypothesized natural phenomenon (e.g. north versus south facing slopes) these studies are also known as natural experiments. Modeling studies can also test hypotheses but are conducted in "virtual" space/time with the use of computers, mathematical models or both.

### Laboratory Procedure:

On Moodle are four journal articles you should use to practice categorizing studies: Ernst et al 2004; Hokit and Blaustien 1994; Hokit and Branch 2003a; Hokit and Branch 2003b. First, describe each of the four papers as either field or laboratory studies. Then describe each of the studies as either descriptive or experimental and, if experimental, which type of experimental study. You shouldn't have to read the entire article to determine the study type. Reading the abstract and introduction section should give you enough information. Either the abstract or introduction should list the hypotheses being tested. If you are still unclear, skim the results section. A study that tests hypotheses will report p-values associated with inferential statistics.

## HOMEWORK SUBMISSION

Each person should create a WORD file named *Homework 1*, answer the following 3 questions, and submit their file to me via email.

1. Regarding Exercise 1: report the Land Office Grid System and GPS UTM system coordinates for the water fountain outside the cube.
2. Regarding Exercise 2: Did your performance curve level out? How many replicates did it take?
3. Regarding Exercise 3: Describe each of the four papers referred to in Exercise 1 as studies that are field or laboratory, descriptive or experimental, and if experimental, which type of experimental study.

Random Number Table

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 82 | 5 | 48 | 25 | 66 | 10 | 64 | 75 | 91 | 63 | 87 | 78 | 4 | 76 |
| 50 | 51 | 85 | 49 | 60 | 41 | 54 | 31 | 49 | 64 | 34 | 94 | 62 | 81 |
| 52 | 53 | 91 | 74 | 91 | 11 | 40 | 16 | 51 | 89 | 60 | 29 | 52 | 66 |
| 5 | 9 | 73 | 30 | 66 | 9 | 8 | 89 | 9 | 95 | 91 | 37 | 99 | 41 |
| 28 | 3 | 50 | 43 | 75 | 38 | 87 | 80 | 13 | 89 | 82 | 89 | 25 | 31 |
| 64 | 98 | 21 | 96 | 52 | 37 | 94 | 8 | 6 | 39 | 33 | 80 | 96 | 87 |
| 60 | 41 | 89 | 81 | 49 | 77 | 22 | 84 | 8 | 66 | 88 | 27 | 14 | 21 |
| 14 | 10 | 62 | 94 | 60 | 8 | 61 | 38 | 55 | 76 | 66 | 75 | 99 | 48 |
| 13 | 82 | 19 | 48 | 87 | 54 | 90 | 57 | 58 | 84 | 41 | 81 | 80 | 97 |
| 36 | 11 | 85 | 15 | 18 | 40 | 62 | 75 | 23 | 6 | 50 | 46 | 39 | 29 |
| 14 | 63 | 16 | 10 | 72 | 83 | 90 | 92 | 66 | 96 | 87 | 96 | 77 | 30 |
| 41 | 2 | 16 | 87 | 97 | 91 | 98 | 65 | 94 | 80 | 58 | 98 | 88 | 8 |
| 2 | 26 | 89 | 75 | 42 | 65 | 71 | 71 | 22 | 66 | 31 | 71 | 5 | 9 |
| 35 | 46 | 63 | 22 | 49 | 17 | 25 | 93 | 13 | 17 | 10 | 3 | 52 | 57 |
| 87 | 35 | 8 | 57 | 4 | 92 | 95 | 28 | 92 | 17 | 31 | 92 | 93 | 11 |
| 80 | 95 | 45 | 49 | 59 | 56 | 50 | 38 | 66 | 78 | 99 | 40 | 65 | 33 |
| 52 | 66 | 32 | 95 | 63 | 84 | 99 | 85 | 29 | 87 | 22 | 36 | 40 | 80 |
| 73 | 36 | 66 | 44 | 19 | 79 | 43 | 73 | 77 | 53 | 97 | 50 | 61 | 43 |
| 85 | 53 | 99 | 17 | 63 | 94 | 84 | 89 | 67 | 20 | 95 | 82 | 41 | 2 |
| 77 | 5 | 52 | 97 | 85 | 33 | 71 | 99 | 33 | 15 | 81 | 9 | 7 | 34 |
| 30 | 87 | 75 | 85 | 35 | 19 | 2 | 34 | 25 | 57 | 43 | 95 | 78 | 53 |
| 75 | 57 | 29 | 11 | 75 | 35 | 10 | 65 | 52 | 8 | 18 | 77 | 28 | 46 |
| 7 | 45 | 25 | 23 | 2 | 89 | 47 | 21 | 24 | 74 | 48 | 22 | 96 | 90 |
| 85 | 56 | 6 | 31 | 43 | 91 | 91 | 84 | 32 | 81 | 97 | 65 | 93 | 40 |
| 72 | 97 | 3 | 20 | 29 | 58 | 59 | 49 | 26 | 92 | 31 | 71 | 52 | 69 |
| 44 | 62 | 40 | 17 | 41 | 56 | 84 | 46 | 75 | 82 | 66 | 69 | 3 | 16 |
| 68 | 66 | 17 | 63 | 3 | 11 | 9 | 22 | 8 | 12 | 27 | 74 | 64 | 9 |
| 33 | 21 | 30 | 42 | 29 | 43 | 79 | 58 | 87 | 59 | 67 | 49 | 71 | 43 |