Examples of Field Studies for Field Ecology

Field Study 1-Seed Dispersal Field Problem

Background

Most plant species have adaptations for dispersing their seeds away from the parent plant. In this way the germinating seedlings are not as likely to encounter as much competition for nutrients, water, and light as they would if they remained under the parent competing with other young plants. In addition, seed predators (e.g., mice, squirrels) and pathogens (bacteria, viruses, fungi) may be more successful in locating and destroying seeds if they occur in large clumps under the parent plant.

The seeds of fleshy fruits, such as those of cherries and blueberries, are tasty to many animals and are well adapted for passing through an animal gut intact. Thus, they can be carried long distances by frugivores. Other fruits have hooks, spines, hairs, or sticky surfaces and adhere to the feathers or fur of animals that brush against them; thus, they are eventually transported to new locations.

A common means for dispersal used by Pennsylvania trees is wind dispersal. Wind dispersal is also a common means of seed dispersal among herbaceous plants.

Maples, pines, birches, and ashes are common trees in our area that have wind-dispersed seeds. A maple fruit, for example, has wing-like extensions. When the fruit drops, its wings cause it to spin sideways. This increases the amount of time the fruit can remain in the air before hitting the ground and thus allows wind to transport the seed away from the parent plant. If we carefully examine the architecture of maple fruits and those of other wing-fruited species, many questions might come to mind. Many of these questions are not trivial. Indeed, some might be *life and death* questions. . . . for the maple.

Procedure

General approach: The objective of today's lab is to gain practice in asking focused question, designing experiments, and analyzing data.

In small groups (3-4 /group) begin by making a list of all of the things that might influence seed dispersal distance. All your ideas in this list are essentially hypotheses. For example, you might hypothesize that wind speed influences dispersal distance or ….. or ….. or …. Come up with at least six hypotheses! Next, with your hypotheses in mind (and written out), perform the following two tasks.

Task 1: Comparing dispersal distance and/or hang time: To investigate the extent to which different discrete factors (treatments) may influence the dispersal distance (and/or hang time) of winged seed, your group should come up with an experiment to test one of your above hypotheses. For example, you might examine differences among different species (each species being a treatment) in seed dispersal distance (or hang time) or you might determine the dispersal distance/hang time for fruits of just one maple species subjected to different alterations (treatments).

Once you have a clearly articulated questions, take time to figure out how you might test it. **DON'T RUSH THIS STEP. IT IS THE MOST IMPORTANT OF ALL. REALLY GIVE THIS SOME THOUGHT.**

When your group is ready, present your question and methods to me for approval.

Task 2--Regression analysis of one or more predictor (independent) variables on a response (dependent) variable: The type of comparison explained above (Task 1) is appropriate if you want to see whether one species has better dispersal ability than another species (in this case, each species is regarded as a "treatment") OR whether there is a difference in dispersal ability when the seeds of a single species are subjected to two or more discrete treatments.

Another way to explore factors that may affect seed dispersal capability is to explore the extent to which variation of a particular variable (e.g., seed weight, wing surface area, etc) might affect seed dispersal difference and/or hang time.

Regression analysis is a statistical procedure that is often used to judge how well one variable might be able to predict the response of another variable. For example, one could measure the weight of 30 individuals, ask them to eat as much pizza as they could in 30 minutes measuring their pizza intake, slice by slice, and then use regression analysis to judge how well knowing someone's weight predicted their pizza intake.

Specific Task: Working in your group, discuss ideas for testing how a variable related to fruit morphology or weight might be related to seed dispersal distance or hang time or something else. You should again come up with a question that can be expressed as a testable hypothesis as well as the method that your group will use to test this hypothesis. Present your experimental design to me before beginning.

When your group has its plan for Task 1 and Task 2 clearly laid out, go outside with your seeds and appropriate equipment to carry out the test(s). Take at least 20 measurements (samples) from each of your treatments (Task 1); and at least 30 measurements for each of your regression variables (Task 2).

NOTE: Before beginning, develop a clearly labeled sheet for recording your data.

Task 1 Statistical Analysis--Comparing dispersal distance and/or hang time:

1) When you have access to a computer, bring up the statistics software program MINITAB. Open a "worksheet" and have it fill the screen1. Label the columns from left to right. Label Column 1 "TRT 1" and Column 2 "TRT 2" (i.e., the two treatments in TASK 1). Label Column 3 "PREDICTOR" and Column 4 "RESPONSE" (i.e., your two data columns in Task 2). Note: It is fine to have 3 treatments in Task 1 and more than one "predictor variable" in Task 2.

2-Enter all the data from your "field" data sheet into the appropriate columns on the minitab spread sheet.

3-Click STAT on the menu bar, then select BASIC STATISTICS, then DISPLAY DESCRIPTIVE STATISTICS.

4-Double-click TRT 1 so it shows up in the variable box. Next check GRAPHS and make sure GRAPHICAL SUMMARY is selected. Click OK to close both boxes.

5-The read-out in the session window will show you a histogram (frequency distribution of your data) overlaid by the closest fitting normal curve ("bell" curve).

6-Since data analysis involving the mean and standard deviation rely on the assumption that the data are normally distributed, first note the two values given under the Anderson-Darling Normality Test. If the P-Value is greater than or equal to 0.05, you can proceed under the assumption that your data are more or less normally distributed. The lower the A-squared value, the better your data set conforms to a normal distribution.

7-Create a DATA SUMMARY SHEET and write the Normality Test P-value down on this sheet.

8-Repeat this procedure for TRT 2.

9-To get all statistical parameters for your Task 1 treatments, again click on STAT, then BASIC STATISTICS, then DESCRIPTIVE STATISTICS. Double click on TRT 1 and then double click on TRT 2. This will cause TRT 1 and TRT 2 to show up in the variables box. Then click on GRAPHS and **unselect** GRAPHICAL SUMMARY. Click OK and this should give you a kind of table.

10-The table will give all the variables by name, sample size (N), Mean, Median, STDev (Standard Deviation), etc. Copy the values for Mean, Median, StDev onto your **data summary sheet**.

11-If you had a *high* enough P-values in the Normality test *(p-value > 0.05)*, you may compare sets of data with a t-test .

12-Click on STAT, then BASIC STATISTICS, then 2-SAMPLE T. Check SAMPLES in different columns. In FIRST select TRT-1, in SECOND highlight TRT-2. *The t-test determines if the means from sample 1 and sample 2 are significantly different. Your null hypothesis is that the means are not significantly different. In the case of your seed experiments, you don't have prior knowledge or expectation that one treatment will yield a greater or lesser effect, so you want to choose the alternate hypothesis to test as* ***"not equal."*** *Note that in the t-test dialog box, "not equal" is the default for the alternate hypothesis. When you are finished, click OK.*

13-In the session window read-out, note the P-value and record this on your **data summary sheet**. If this P-value is less than or equal to 0.05, there is a significant difference between the two means you are comparing. If this P-value is less than or equal to 0.01, there is a highly significant difference between the two means you are comparing.

14-If you have more than two treatments as part of Task 1, repeat this t-test procedure to compare you different treatments (e.g., TRT 1 vs. TRT 2, TRT 1 vs. TRT 3, etc).

15-If your Task 1 data failed to pass the normality test (p-value of the Anderson-Darling test was less than 0.05), you can try comparing your variables with a NON-Parametric statistical procedure. These procedures do not rely on the assumption that data are normally distributed.

(Note: you can use non-parametric methods even if your data are normally distributed.)

16-Click on STAT, then NONPARAMETRICS, then Mann Whitney. Enter variables to be compared under FIRST SAMPLE and SECOND SAMPLE (e.g., TRT-1, TRT-2) in the same manner you did for the 2-SAMPLE T TEST. *The Mann-Whitney Test determines if the medians from TRT 1 and TRT 2 are significantly different. If your null hypothesis is that medians are equal, then the alternative hypothesis, of course, is that they are not equal, and you can indicate this in the dialog box (Alternative: "not equal"). Note that the "not equal" option is the default option in Minitab. When you are finished with the dialog box,* click OK.

17-The session window read-out will once again have a significance value. If this value is less than or equal to 0.05, there is a significant difference between the Median values of the two variables you are comparing.

Task 2 Analysis: Regression analysis of one or more predictor variables on a response variable

1-Click STAT, then REGRESSION, then FITTED LINE PLOT.

2- In the RESPONSE (Y) box, type in or click on the measure you used to test the seed dispersal performance (e.g., column 4 of data sheet). In the PREDICTOR (X) box, type in or click on the predictor variable (e.g., column 3) you measured to evaluate dispersal performance. Use defaults for other settings. Click OK

3-The read-out will produce a Regression Plot that graphs the points of the predictor and response being compared. The figure also presents a line generated by the regression equation (also shown) which has a y-intercept and slope that minimizes the distance between all the points and that line. *To determine how well the data fit the regression equation model, check the R^2 value. This is called the coefficient of determination, and itt measures how much of the total variation in your response variable (y) is explained by variation in your predictor variable (x). An R^2 value of 1.0 (100%) indicates that all of the variation in y is explained by variation in x, though it is highly unlikely that a functional relationship between predictor and response variables in nature are perfectly described by a mathematical model. For example, p*lotting height vs. weight for a group of adolescent males would *yield* a high but not perfect R2 value. Notice the extent to which your dots are clustered around or spread apart from the fitted line on your graph. Write down the R-Sq value on your **summary data sheet**.

4- Click STAT, then REGRESSION, then REGRESSION.

5-Again fill in the dispersal performance variable in the RESPONSE box by typing or clicking on it in the list of variables. Fill in the variable to be compared to the Response variable in PREDICTORS by typing the relevant column name or selecting it. Click OK

6- The session window read out will contain various outputs regarding this regression. Copy the R-Sq value (in % form) onto you data summary sheet. In the output section described as "Analysis of Variance," you will find a P value given on the far right. Copy this P-value onto you data sheet. P-values that are less than or equal to 0.05 indicate that there is a significant correspondence between the two variables being compared *(formally, the p-value in regression analysis indicates the probability that the slope of the regression line = 0, so a low p-value means* *that the slope of the line likely does not equal 0, and that the regression model is significant).*

7-If you have a second predictor variable repeat this procedure.

8-Please keep in mind that *a functional relationship between predictor and response variables* does not necessarily imply there is a cause and effect relationship between them.

Report

1-Write a concise statement of the objective of each of your two study TASKS consisting of one paragraph for Task 1 and one paragraph for Task 2. Be sure to include a clear statement of the question being asked in each task and the ecological relevance of each question.

2-Analyze your data following the mini-tab guidelines provided in this class handout.

3-For Task 1 summarize your mini-tab findings using one figure and one table; for Task 2 summarize your minitab findings using a single Figure. Note: Your Task 1 table should NOT simply be "raw" mini-tab output; however, the two figures can be mini-tab provided that they are exported to "Word" so that you can attach captions.

IMPORTANT: Please be sure that your table and two figures have concise and informative captions (use Gross and Werner as a model). As a "caption" test, be sure that your table and each of your figures, standing alone, provides an answer to one or the other of your two task-questions.

4-Describe your results in narrative form referring to your table and two figures in one type-written page. In this text summary include a description of the data (mean, standard deviation, etc.) as well as the results of any statistical analyses.

Field Study 2-A Historical Perspective on Homo sapiens

BACKGROUND

The most important survival issue facing any animal involves eating enough to meet its energy demands. Given the high potential energetic costs of finding and processing food items, optimal foraging theory predicts that natural selection will favor the development of food gathering strategies that maximize net energy intake (i.e., the total energy present in food consumed minus the energy required to obtain and process that food).

Throughout the vast majority of our evolutionary history humans have met their energy needs by hunting and foraging in natural ecosystems. In Central Pennsylvania, nuts (e.g., acorns, hickory nuts, black walnuts), seeds of annuals (e.g., lambs quarter, amaranthus), and wild fruits (e.g., grapes, blueberries, blackberries) would have been important food sources for native peoples. The abundance of these wild foods defined the amount of foraging area a given population would have needed to meet food needs. Viewed in another way, the abundance of sources of wild foods could have, in large part, determined the human carrying capacity of this region.

THE PROBLEM

The year is 500 BC. We are members of a clan of Woodland people--45 of us all together. Our clan is composed of 5 children (too small to forage), 5 elders who remain in camp at all times, 5 adults who remain in camp engaged in child rearing and camp chores, 5 adults who are "full-time" hunters and who supply 20% of our nutritional needs and, 25 of us who forage for the plant foods that make up 80% of our clan's diet.

The "problem" we will address is whether, through foraging for the available forest nuts our clan will be able to survive the upcoming winter? We have only these two months (mid-October to mid-December) to gather enough food to carry us through the winter (January, February, March) . By the mid-December the land will be covered with snow and foraging will no longer be worth the effort.

Sound weird? Contrived? Hardly. This has been the essence of life for most of our existence of a species. We used to be very good at it. We are "hard-wired" for it. Can we remember. . .

THE APPROACH

1. Calculate our clan's caloric needs (2:15-2:30). The first step in determining whether our clan will be able to gather enough food to survive the winter is to determine our caloric needs. Use the table below to estimate this. The table lists the number of people in our clan's subgroups (e.g., 5 children, 5 elders, etc.). To determine each subgroup's daily energy needs, use the following values from Clark and Haswell (1970):

--heavy work (e.g., foraging and hunting)	240 Kcal/hour
--light work (e.g., camp chores and food processing)	190 Kcal/hour
--sitting	80 Kcal/hour
--sleeping	65 Kcal/hour

Assume that children's caloric needs per hour are 60% those of adults for any give activity level (e.g., light work, sitting, sleeping) because of their smaller body size.

For each clan subgroup, we suggest that you first estimate the number of hours the subgroup will spend in each activity category (e.g., how many hours out of 24 do you suppose will be spent in heavy work, light work, sitting, sleeping). Then, multiply by the Kcal expended per hour for that activity (see values, above). When you have finished this, sum up the values for each activity for one individual in each clan subgroup and multiply by the number of people in each subgroup (provided in the table below). This will tell you the total caloric needs for each clan subgroup for one day. Add these up and the sum should be somewhere between 130,000 and 160,000 Kcal/day (depending on your assumptions) for the entire clan of 45 people. Finally, multiply your daily total by 150 (number of days in 5 months) and then multiply this number by 0.8 (the fraction of your food needs that must come from nut foraging). This number should be somewhere in the vicinity of 16,000,000-21,000,000 Kcal.

	Heavy work		Light work		Sitting		Sleeping			
Clan Subgroup:	hrs/day	kcal/day	hrs/day	kcal/day	hrs/day	kcal/day	hrs/day	kcal/day	No.People	Total kcal/day
Children									5	
Elders									5	
Camp Adults									5	
Hunters									5	
Gathers									25	
									GRAND TOTAL:	_______

Note: Although there is less "work" during the three months of winter , the temperatures are colder and, therefore, more Calories are burned to maintain body temperatures.

2. Developing foraging strategies for forest nuts (2:15--3:45). Our next task is to investigate the effectiveness of various foraging strategies. An effective foraging strategy will be one that maximizes energy return (in the form of gathered nuts) on energy effort (time spent foraging). Given our 20th century scientific orientation, we will approach this investigation as an experiment with **alternate foraging strategies** as "treatments". We will employ three "treatments".

Treatment One: The first treatment is straightforward. Call it the "objective" treatment. In groups of 3, we ask you to walk along a straight line (more or less) and to stop every 50 paces and then to forage at each stopping place for 2 minutes (8 stopping places total with 4 minutes for walking). TOTAL TIME = 20 minuets. Note: One clan member should forage right on the transect, a second just to left of the transect and the third, just to the right of the transect. Each forager should search in one contiguous area for the two minutes. MAKE SURE THAT ONE OF YOU KEEPS CAREFUL TRACK OF THE TIME. Combine all your acorns and hickory nuts into one bag—call it your "objective mind" bag.

Treatment Two: The second treatment we call "beginners mind." For this treatment, we ask you to again forage for acorns and hickory nuts but this time using your innate sense of how to find food. Forget the text books, forget the theory; use your intuition as an intelligent animal to forage for the food you will need to survive for the coming months. Decide among yourselves how you will do this (stay together, go off individually…). Although the day may be warm, winter is fast approaching, my friends; so, forage wisely. Again you have EXACTLY 20 minutes. Be sure that one of you keeps track of time . Combine all your nuts at the end of the 20 minutes in one bag---call it your "beginners mind" bag.

Treatment Three: This treatment we call "manager mind." In some cases, Native Americans "managed" forests where they lived creating "agroforests." Ground fires were an important management tool. Fires favored thick-barked nut producing species like walnuts, oaks and hickory, as well as berry plants like blueberries and huckleberries. In this treatment we ask that you go out to the oak trees growing in a park-like arrangement at Sunset Park and gather nuts for 20 minutes (Keep track of time!) and place all your nuts in bag 3—the management mind bag.

The goal for all three treatments will be to determine the food ***energy return on foraging effort****. In other words, we want to determine, fore each treatment, the return in energy (Kcal) per hour of work (Kcal). After weighing your harvest at the "weight station," please use the conversion factors below to determine the energy expended (Kcal) in your foraging along with the food-energy return (Kcal). In other words, how much return in food kcal do you receive for your energy investment in nut gathering. Assume that the energy expenditure in foraging is 240 kcal/hour/person or 80 kcal for one person for 20 minutes (i.e., 240 kcal when we multiply by 3 (the number of foragers in your group that foraged for 20 minutes each)).*

What is the ratio for ***Energy Harvested: Energy Invested*** *for TRT 1: ________; for TRT. 2 _________; for TRT. 3 __________?*

To convert from acorn and/or hickory fresh weight (i.e., whole nuts with shells) to dry weight (i.e., usable acorn and hickory meal), multiply by 0.25 (i.e., 25% of the total weight is rendered nut meal). Pay careful attention to units. If you weight is in kilograms, multiply by 1000 to get grams. Then, to calculate the actual energy (Kcal) available in acorn and hickory meal multiply by 3.5 Kcal (the energy per gram of dry meal).

Example: Using these conversion factors, 50 g of raw acorns would yield 12.5 grams of acorn meal that contained a total of 44 Kcal (3.5 kcal/g x 12.5 g).

Calculate how many kcal of nuts one person could harvest per hour and per seven-hour foraging day using each of the three approaches (treatments). Then go further and calculate how many kcal your clan with 25 foragers could harvest in the 60 days you have available to you before winter sets in.

	TRT 1 **(Objective Mind)**	**TRT 2** **(Beginner's Mind)**	**TRT 2** **(Management Mind)**
Kcal harvested per person per hour	________	________	_________
Kcal per person per seven-hour day	________	________	_________
Kcal per 25 foragers per day	________	________	_________
Kcal per 25 foragers over 60 days	________	________	_________

Would you be able to harvest enough energy in 60 days to satisfy the Kcal needs for your entire clan of 45 people for the 150-day winter (See Table 1 for total energy needs)?

3. **Calculate your clan's land requirements (4:00-5:00).**

The final objective of this exploration is to calculate the forest area needed to provide the caloric needs of our 45-person clan during the winter (the toughest survival time). The approach we will take is inspired by Rosenthal (1995). It involves inventorying the diameters of the oak and hickory trees in a known area and estimating per tree acorn/hickory nut production from diameter at breast height based on the following equation:

Acorn/hickory nut fresh weight (kg) = -3.8 + 0.2 x tree dbh (cm).

Note: This is a regression equation; tree diameter is the predictor variable; acorn fresh weight is the response variable.

Thus, an oak tree with a dbh (diameter at breast height) of 30 cm would yield 2.2 kg of acorns nuts. This method assumes constant year-to-year acorn production and complete capture of all acorns by the foragers. Based on what you have done so far today, you can see how generous those assumptions are. For the sake of realism, we will assume that 75% of the acorn/hickory crop will be lost to mammals, insects, and fungi, leaving 25% for us to harvest.

Procedure

1. Establish two 50 m transects and measure the diameter of all oak and hickory trees within 2.5 m (2.5 paces) of the tape along each transect. Determine the starting point and direction of each transect randomly. Note: Your total sample area is 5 m x 100 m or 0.05 hectares). In other words, it would take 20 such plots to make one hectare (100 x 100 m). Only measure trees > 20 cm dbh; smaller trees are non-yielding.

2. Plug your diameter values (in cm) into the above equation to determine fresh weight nut yield in kilograms.

3. Multiply by 0.25 to get actual harvest (recall 0.75 lost to other organisms)

4. Next, convert kg fresh weight of harvested “whole” nuts to **nut meal** by multiplying by 0.25; then multiply by 1000 to convert kilograms to grams; finally multiply by 3.5 to convert grams to Kcal.

5. Next, multiple by 20 to get an estimate of Kcal of nut meal produced per hectare.

6. Divide this estimate of Kcal of nut meal per hectare into the total caloric needs for your clan for the 150-day winter (i.e., the big number in Table 1) to estimate the hectares of natural forest your clan would need to support itself through the winter. Express the result on a per capita basis by dividing population (45) into forest area needed. This is the amount of hectares needed to support one human. The inverse of this (population divided **by** forest area) is the human **carrying capacity** of the land (the amount of people supported by one hectare). .

GENERAL DISCUSSION QUESTIONS

1. Will your clan be able to survive for the next five months given the various situations posed? Provide the results and calculations to support your answer. If you will survive, how much time (hours per day) will your group of 25 foragers need to spend foraging over the next two months to meet your clan’s winter energy needs?

2. Which of your foraging methods (treatments) yielded the highest net energy gain? What was the energy input/output ratio for that treatment? In other words, what was the energy yield in harvested nuts compared to the amount of energy you spent foraging?

3. On an individual basis how many adult oak trees (50 cm dbh) would be necessary just to support one person for the 5-month winter?

4. A squirrel requires about 150 kcal/day. How many squirrels could one adult oak tree (50 cm dbh) tree support through the 150-day winter?

5. What are the key assumptions that have gone into your calculations and how might errors in your assumptions affect your conclusions?

6. What gender differences in foraging effectiveness, if any, did you observe?

7. In contemporary agriculture, the ratio between FOOD ENERGY OUT (i.e., kcal contained in the food you and I consume) compared to the sum of all the energy that goes into producing our food (e.g., fossil fuels necessary to grow, transport, process and package our food)—i.e., THE ENERGY IN) is, 1:10. In other words we put ten times more energy into our food (mostly in the form of fossil fuels) than our food actually contains in kilocalories. How does our contemporary situation compare with the pre-modern one that you explored today?

8. Your calculations on the number of hectares necessary to supply the nut needs of one person are, in a sense, the "ecological footprint" of a Native American living in 500 BC. How do you suppose your estimated footprint compares to the footprint of modern humans?

Field Study 3. *Ecological Footprint* of a PSU Football Game

Introduction

A Canadian researcher, Dr. Mathis Wackernagel, is greatly concerned about our failure to understand our dependency on the natural world and he is doing something about it. Wackernagel has developed an accounting tool aimed at expressing all human consumption-related activities in terms of the area of productive land required to support them in a sustainable fashion. Wackernagel refers to this land area as our "Ecological Footprint." Think of it this way: our economy has a metabolism; it is like a cow in a field--consuming resources and emitting waste products. Just as a responsible farmer knows how much pasture is necessary to support a cow, we, too, should know how much pasture (i.e., bio-productive land and sea) is necessary to sustainably support each of us. Part of our ecological footprint is in the land our homes, factories, commercial outlets, and roads occupy; part is in the land/sea needed to provide our food and fiber, and so forth.

Wackernagel has found that each U.S. citizen would need about 25 acres of land in production--year in and year out--to provide all his/her needs in a SUSTAINABLE fashion.

An interesting thing happened when Wackernagel divided the total productive land on the planet (i.e., the 35 billion acres of land that can be used for farming, grazing, forestry, etc.) by our planetary population of 6.5 billion. He discovered that a "fair earth share"--what each of us would receive if this productive land were shared equitably--was approximately 5 acres/person. This means that we would need more than five earths to sustainably support our current population at the level of U.S. consumption [25 acres (U.S. requirement)/5 acres (Fair Earth Share) = 5 earths].

A powerful feature of Wackernagel's analysis is that it offers solutions. For example, it allows us to compare the ecological footprints of different lifestyle choices. Take the case of a person who decides to sell his car and instead commutes 3 miles back and forth to work by bicycle. According to Wackernagel's calculations, the footprint for bike commuting is 133 square yards. This is the amount of land that would need to be permanently set aside to provide the food (biker body fuel), raw materials and energy (for bike construction), and space (bike paths) necessary to commute by bicycle. If this same person were to commute by bus, 327 square yards would have to be set aside on a permanent basis. Finally, if this citizen chose to commute in a single-occupancy car, the land area or "footprint" would be 1,668 square yards or 13 times more than the amount needed for commuting by bike.

The Field Study

Everything we humans do has an impact—a footprint. Measuring the footprint of various activities requires breaking them down into their component parts and then making a series of estimates. Often times a little common sense and some simple arithmetic is all that is needed to estimate a footprint.

In this three-hour lab we will estimate the ecological footprint of a single PSU football game. Before beginning, I ask that you simply make a guess at what you think the Ecological Footprint of a single Penn State football game would be? In other words, how much land, on average, needs to be set aside each year to sponsor a single PSU football game? What's your best guess (in acres) = __________?

And, before we get started, here's a second question for you: What is the biggest part of football game footprint? Your best guess = ___________?

OK. Now, what would you need to know to figure out the footprint of a football game? Clearly people have to get to the game. So there is a travel footprint. Also, the stadium itself has a footprint as does the actual space put aside for parking. Then there is all the stuff people buy at a game that they would not otherwise be purchasing.

We will start our estimation process in the classroom by estimating the travel footprint for one PSU football game.

Travel Footprint:

Working in groups of four begin coming up with your best *guesstimates* for the following:

-Number of people driving to game = ________

-average people/vehicle = ______

-average distance traveled (roundtrip) = ________

-average fuel mileage = ________

Next, using the following "givens" (available in the literature), estimate the Travel Footprint.

-30,000 kcal/gallon of gas or ethanol
-1 acre will produce 10,000,000 kcal of ethanol/year
-43,560 square feet in one acre

Note: All footprinting calculations are grounded in absolute requirement for sustainable approaches to living. Thus, the cars used to transport people to and from the football game have to be powered by current-day sunlight (e.g., biofuels like ethanol), not fossil fuels which are in dwindling supply.

Travel Footprint Calculations: **Travel footprint (acres) for one game =** ___________________

Stadium Construction Footprint

Next, we will walk over to the Beaver Stadium with the goal of estimating the footprint of the stadium itself. Upon arrival, you will soon see that the stadium is constructed of steel, concrete and aluminum. Your task is to estimate, working in groups of four, as best as you are able, the volume of steel, aluminum and concrete in the stadium and then to use the "givens" below to transform your volume measurements into footprint estimates. In addition, you will need to guesstimate the square footage of the press box and luxury suites, as well as the construction cost of the stadium, the lifetime of the stadium and the number of games/season.

Your best guesstimates:

-Cubic feet of steel in stadium = ________
-Cubic feet of concrete in stadium = _______
-Cubic feet of aluminum (for seats) in stadium = ________
-Square feet of built environment (press box + luxury suites) in stadium = ________
-Cost to build stadium = ____________

-Lifetime of stadium = _________
-Games per season =_________

Given:

-one cubic foot of steal weighs 130 pounds; one cubic foot of cement weighs 80 pounds; one cubic foot of aluminum ore weighs 70 pounds
-embodied energy in steel = 3,400 kcal per pound
-embodied energy in concrete = 500 kcal per pound
-embodied energy in aluminum ore = 12,000 kcal per pound
-1 acre will produce 10,000,000 kcal of ethanol/year
-dollar to footprint conversion for construction: one dollar = 2 square feet of 'footprint'
-43,560 square feet in one acre

Stadium Construction Footprint Calculations:

Materials footprint :

Construction footprint:

Total materials/construction footprint (acres) for <u>one</u> game: __________________

Consumption of Stuff During one Game Footprint

Assumptions:

-Number of attendees: ___________
-Average expenditure on non-food 'stuff' per person: ___________

Given:

-Footprint/dollar spent = 3 square feet
-43,560 square feet in one acre

Stuff Consumption Footprint:

Total stuff footprint (acres) per game = _________

Stadium + Space for Parking Footprint for One Game

Next, based on your observations, offer guesstimates for the following

-Acres occupied by stadium itself = __________

-Acres devoted to parking = __________

-Lifetime of stadium = __________

-Number of games/season = ________

Total land area devoted to stadium + parking footprint calculation:

Total land (acres) footprint/game = __________

Footprint per Game	**<u>ACRES</u>**
Travel	________
Stadium construction	________
Stuff	________
Stadium land & Parking	________
TOTAL	________

This exercise makes what before was invisible—namely the impact of football entertainment—suddenly visible. This is important because once an individual realizes the size of the footprint of a certain activity, she has more information available to decide if she wants to continue to engage in that activity… or not?

Indeed, individuals can, if they choose, dramatically reduce their footprint size by the decisions they make regarding entertainment (e.g., playing touch football in your backyard vs. going to a football game), housing (e.g., living in homes of modest size designed in ways that minimize the use of energy), food (e.g., eating whole foods produced close to home rather than highly processed, energy-intensive foods shipped from far away), and so on. There is good news here. We can measure our footprint and take creative steps to minimize it, if we so choose.