Chapter 2 Project: Measuring Habitat of Florida Lakes

Name_____ Name _____

    The purpose of this project is to learn how to quantify lake habitat, and to work with measurements, units, and percents. We will use part of the Winter Haven, Florida, topographic map. When working on the project, be sure to use metric rulers. Also note the following abbreviations: mm = millimeter, cm = centimeter, m = meter, and km = kilometer. Here are some common metric conversions: 10 mm = 1 cm, 100 cm = 1 m, and 1000 m = 1 km.

Introduction
    Senator Blowsmoke and Representative Foghorn are each proposing their own bill in the Senate and House (respectively) to conserve lake habitat in southern Florida, in an area near the town of Winter Haven. Blowsmoke's bill is called the Big Lakes Bill ("The Bigger, The Better"). In her bill the 5 biggest lakes, measured by *area*, will be preserved in an undeveloped state, while the smaller lakes will be permitted for development. Foghorn's bill is called the Many Lakes Bill ("A Lake For Every Child"). In his bill, the 5 biggest lakes, measured by *perimeter*, will be permitted for development, while the small lakes will be preserved in an undeveloped state.

    Both politicians claim that their bill will "preserve over 50% of lake habitat in Florida." Both claim that the other's bill "conserves less habitat." Blowsmoke has put out a press release that says "Big Lakes = Big Conservation. It's a No-Brainer." Foghorn calls a press conference and says "More Lakes, More Conservation. Do the Math." The public and the press are confused. As the Environmental Mathematician, you are called in to straighten out the mess.

1. Collecting Data
    You need to collect data on lake areas and perimeters before you can assess the two habitat bills. The region in dispute is presented on the attached map; take a look at this map now. The lakes under consideration for development or preservation are numbered 1 through 35. These **sinkhole lakes** are formed when caves in the limestone bedrock collapse. Limestone is a rock that is easily dissolved in weak acids; over time, large underground caverns form that are partially filled with groundwater. The roofs of these caverns eventually collapse, creating sinkhole lakes.

    One method to determine the area and perimeter of each lake is to assume that the lakes are **elliptical** in shape. The advantage of this approach is that the area of an ellipse can be determined from its length and width, and the perimeter can be approximated using the length and width. A hypothetical elliptical lake is shown below with the length (long dimension) bolded and the width (short dimension) dashed. The length and width are at right angles to each other.
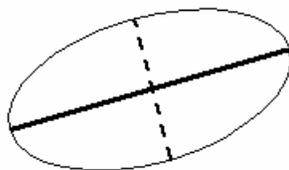
By measuring the length and width of each lake on the map, you'll be able to estimate the actual length and width of each lake in reality. From the actual measurements, you'll determine area and perimeter.

So get started! Measure the length and width for each lake on the map to the nearest 0.1 centimeter. Work in pairs. One person can measure length and width, the other can record data on the forms provided (see end of exercise). Record data in the proper columns. Each lake is numbered, and the lake numbers are given on the data sheet. There are 35 lakes total.

Note that some lakes are irregular in shape—not very elliptical or circular. Do your best to approximate the dimensions of these "blobby" lakes. Some error is introduced, but this error should be a **random error** (equal chance of being overmeasured or undermeasured), rather than a **systematic error** (always over-estimating, for example).

2. Converting map distance to real distance:
The *map scale* relates the **distance on the map** to the **distance in reality**. The scale for this particular map is given on the map legend.

a) What is the scale of this map? _____

b) The scale means: 1 centimeter on the map = _____ centimeters in reality

c) which means: 1 centimeter on the map = _____ meters in reality

d) For each lake, convert map length and map width in centimeters into real length and real width in meters. You should be able to do this in one step using the last equation above. Record results in the proper columns on the data sheet.

3. Determining Lake Area and Perimeter
Now you'll need to compute the area for each lake. Recall that the area of a circle is

$A = \pi r^2$ where r is the radius. For an ellipse, the area formula is $A = \pi r_1 r_2$ where r_1 is half

the length and r_2 is half the width. See below.
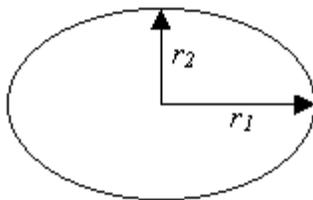
Because $r_1 = \dfrac{\text{length}}{2}$ and $r_2 = \dfrac{\text{width}}{2}$, the area formula for an ellipse can be rewritten as:

$$A = \pi \left(\frac{\text{length}}{2}\right)\left(\frac{\text{width}}{2}\right)$$

$$\boxed{A = \left(\frac{\pi}{4}\right)(\text{length})(\text{width})}$$

a) Start by using the area formula to compute the real area for Lake Haines (#3), in units of square meters. Show work below, include units at each step.

b) Determining the real areas for the rest of the lakes is a big task, so let's put the power of the online applet StatCrunch to work. Not only will this save time, but it will avoid simple computational mistakes. Go to www.statcrunch.com now and log into your account. If this is your first time using StatCrunch, you will need to register. Once in StatCrunch, follow the instructions below.

1. In StatCrunch you will see columns labeled var1, var2, var3, etc., and rows marked 1, 2, 3, and so on. Enter the (real) length data into column **var1**. Press **ENTER** after you enter each value. Enter the (real) width data into column **var2**. When finished, make sure that there are 35 entries in each column, and scan for possible typing mistakes.

2. Re-label the column headers. Click on var1, then backspace to erase. Then type in **length**. Similarly, re-label var2 as **width**.

3. Select **Data** > **Save data** and enter a file name such as "Florida lakes." Check the box "overwrite existing file" (if this box is active) and set the delimiter to "space." Click on **Save**. *(You should repeat this step often, to save any updated work!)*

4. To compute the area of each lake and store the results under column var3, select **Data** > **Transform Data**.   In the upper box labeled transformation, enter the

expression **3.14159/4*length*width** . Ignore the other menus. Finally, press the **Transform** button at the bottom of the screen. See below.
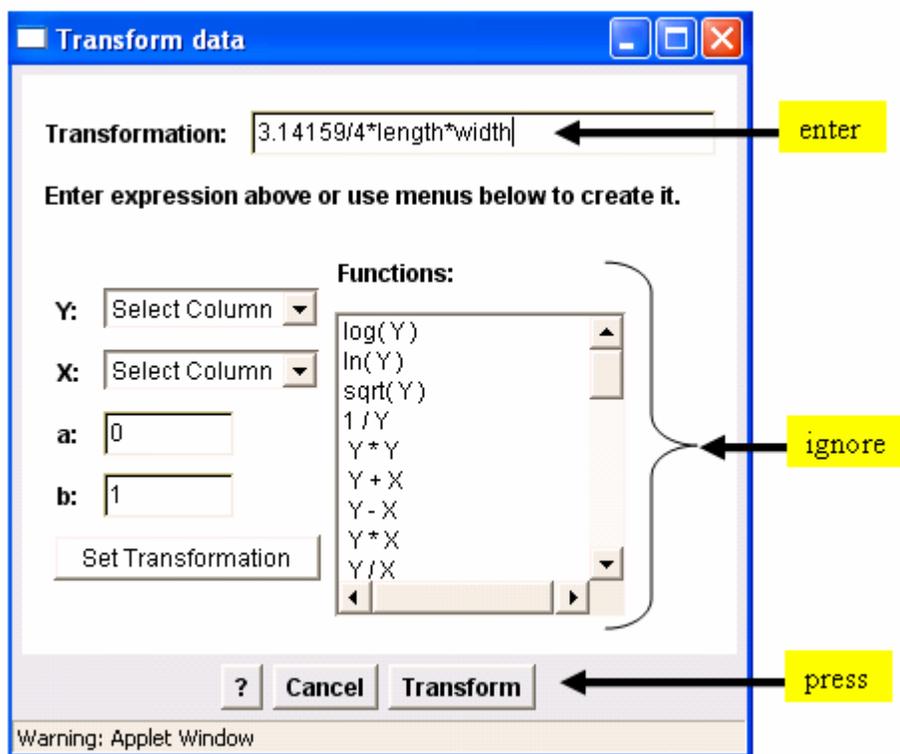
5. StatCrunch will produce a small warning window that says "Transform Data" on the top. Close this small window by clicking on the red X in the upper right hand corner.

6. The third column should now contain all the lake areas (in square meters). Check that the area of Lake Haines (#3) matches what you computed before. Save your work (see step #3). Re-label the column header to **area**.

7. Record lake areas in the proper column on the data sheet. Round answers to the nearest whole unit.

c) Now you'll need to compute the perimeter for each lake. The perimeter of an ellipse can be approximated with the formula $P = \pi\sqrt{0.5L^2 + 0.5W^2}$, where L = length and W = width. Use this formula to approximate the real perimeter of Lake Haines (#3). Show work below. Include units.

Now use StatCrunch to approximate the real perimeter for all the lakes. Select **Data > Transform**. In the box labeled transformation, type in the expression **3.14159*sqrt(.5*length^2+.5*width^2)** and then press **Transform**. See below.
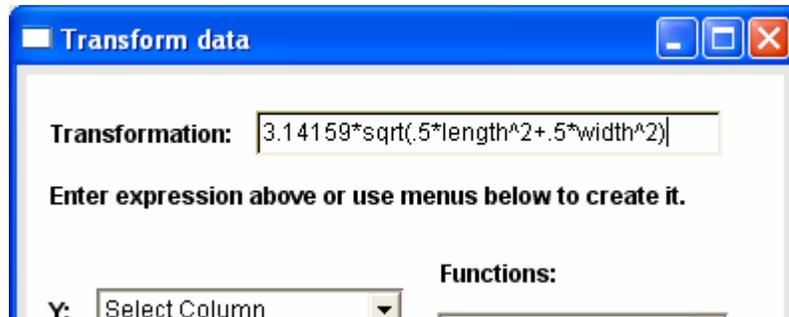
d) Confirm that the perimeters have been stored in the 4th column, and check that the perimeter of Lake Haines matches your previous calculation. Re-label column 4 to **perimeter**, and then *save your work*. Record lake perimeters in the proper column on the data sheet. Round answers to the nearest whole unit.

4. Finding the total area and perimeter

Before you analyze the two habitat conservation bills, you will need the total area and total perimeter of all 35 lakes. StatCrunch can do the work for you again, but through a slightly round-about process. Select **Stat > Summary Stats > Columns** and then click on **area** and **perimeter**, so that those columns are selected and displayed in the right hand box. See below.
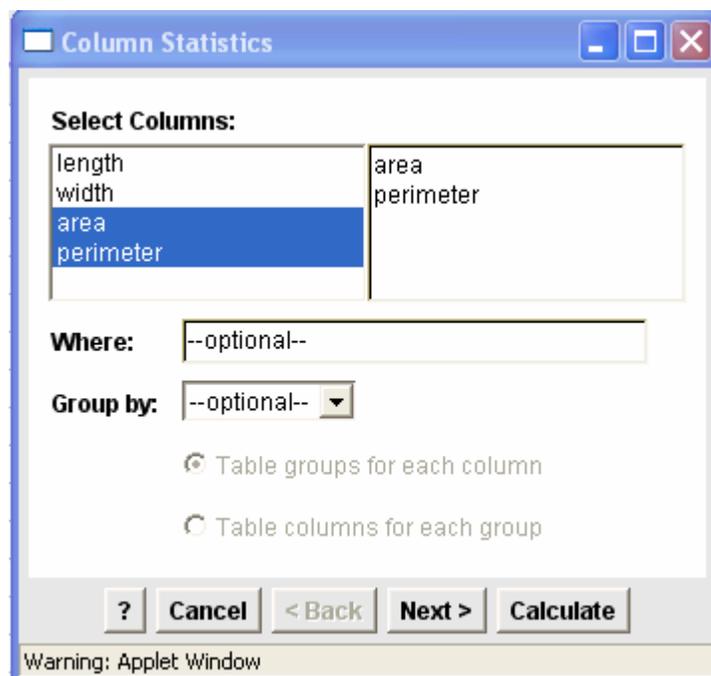
Now press **Calculate**. StatCrunch will produce a new window listing what are called summary statistics (more on these in Chapter 11). For now, just read the table and record the **mean area** and **mean perimeter** below.

mean area = _____

mean perimeter = _____

The mean is what you might commonly think of as the "average value." For example, the mean area is the sum of all areas, divided by the number of areas (which is 35):

$$\text{mean area} = \frac{\text{sum of areas}}{35}$$

By multiplying each side of the equation above, we find that the sum of the all lake areas is simply the average value (the mean) multiplied by the number of lakes (35):

$$\text{sum of areas} = 35 \times \text{mean area}$$

Use a calculator and the formula above to find the sum of the lake areas. Record below. Repeat to find the sum of the lake perimeters.

sum of areas = _____

sum of perimeters = _____

Record both values at the bottom of your data sheet under "total."

5. Analyzing the two habitat bills

a) Senator Blowsmoke's "Big Lakes Bill":
     Blowsmoke says that at least 50% of lake area can be preserved by *saving* just the top 5 lakes (area-wise) and developing the rest. Is she right or wrong? Show mathematical analysis, and write a concluding answer.

b) Representative Foghorn's "Many Lakes Bill"
     Foghorn says that at least 50% of lake shoreline can be preserved by *developing* only the top 5 lakes (perimeter-wise) and saving the rest. Is he right or wrong? Show mathematical analysis, and write a concluding answer.

c) Straightening out the mess: Which bill do you think is better? Explain in a few paragraphs so that the public and press understand more clearly.

6. Thought Questions

a) Why might the total *area* be important for habitat for plants and animals?   In other words, what kinds of organisms depend on the *areas* of lakes? Does the area of a lake have any special kind of function?

b) Why might the total *perimeter* be important for habitat? What kinds of organisms depend on the *shorelines* of lakes? Does the perimeter of a lake play any special role in the ecosystem?

c) Do the answers to these two questions affect your answer to "which bill is better?"

7. Assessing the Accuracy of the Ellipse Method

The organization People For Best Available Science, funded by real estate and construction companies, writes an article in the local paper titled "Our Lakes Are Not Equations!" The article questions your estimates for area and perimeter, saying that the values are "way off the mark."

a) Before you respond to the article, you need to estimate the error involved using the ellipse method for area and perimeter. One way to estimate the error is to compare the results with a different method. Displayed below is a copy of Lake Haines with a metric grid laid over the top. The scale is 1:30,000 and each square is 5 millimeters on a side. Determine the area of Lake Haines by using the grid. *You'll need to work out the details of doing this!* Summarize work below.

b) Now complete the following table for the area of Lake Haines. Include units where appropriate.

area by ellipse method	area using grid method	absolute error (ellipse area minus grid area)	relative error (absolute error/grid area. Express as a percentage)

9

c) Now consider assessing the error in finding the perimeter when using the ellipse method. You want to come up with a different method to find the perimeter, and again you'll work with Lake Haines. Below is a copy of Lake Haines, with a scale of 1:30,000. Use a metric ruler to measure directly the perimeter. *Again, you'll need to work out the details!* Summarize work below.
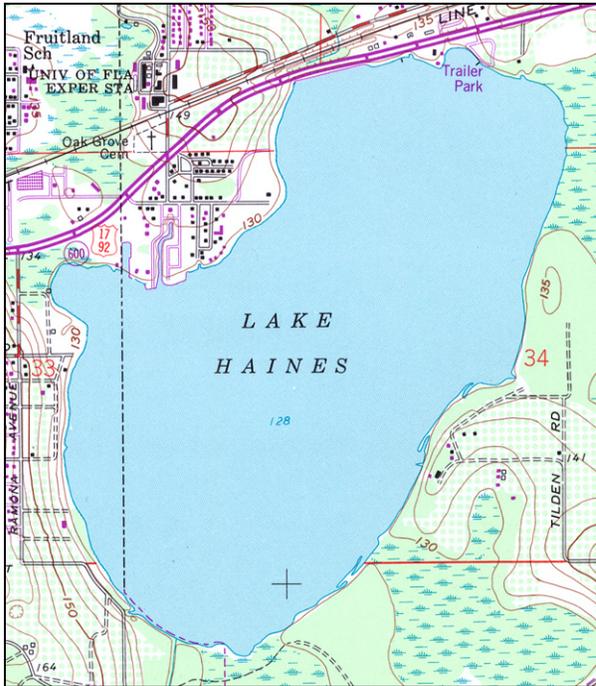
d) Now complete the following table for the perimeter of Lake Haines. Include units where appropriate.

perimeter by ellipse method	perimeter using direct measurement	absolute error (ellipse perimeter minus direct measure of perimeter)	relative error (absolute error/direct measure, expressed as a percentage)

e) **Conclusions:** The direct measurements for area and perimeter should provide fairly accurate values for the true area and perimeter of Lake Haines. What do the relative errors that you computed indicate about the ellipse method? Is the ellipse method very accurate, somewhat accurate, or not very accurate? Explain.

10

DATA SHEET

Lake Number	Length (map cm.)	Width (map cm.)	**var1** Length (real m.)	**var2** Width (real m.)	**var3** Area (real m^2)	**var4** Perimeter (real m.)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						

Lake Number	Length (map cm.)	Width (map cm.)	**var1** Length (real m.)	**var2** Width (real m.)	**var3** Area (real m^2)	**var4** Perimeter (real m.)
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
total						