11.1: Biometrics Lab #1

Experiment 1

You are unhappy with the logging company you hired to thin a stand of red pine. You carefully laid out the skid trails leaving bumper trees to avoid excess damage to the remaining trees. In the contract, it is stated that the logging company would pay a penalty (3 times the stumpage rate) for trees damaged beyond the agreed amount of five or more damaged trees per acre. You want to estimate the number of damaged trees per acre to see if they exceeded this amount. You take 27 samples, from which you compute the sample mean, and then construct a 95% confidence interval about the mean number of damaged trees per acre.

2	4	0	3	5	0	0	1	3
2	7	4	8	10	0	2	1	1
5	3	5	6	4	9	5	3	6

Enter these data in the first column of the Minitab worksheet and label it "Trees." Now calculate the sample mean and sample standard deviation. **Stat**>**Basic Statistics**>**Display Descriptive Statistics**. Select the column with your data in the variable box.

a) sample mean: _____

sample standard deviation: _____

Examine the normal probability plot for this data set. Remember, for a sample size less than n = 30, we must verify the assumption of normality if we do not know that the random variable is normally distributed. Go to **GRAPH → PROBABILITY PLOT.** Enter the column with your data in the "**Graph variables**" box and click OK.

b) Would you say that this distribution is normal?

c) Calculate the 95% confidence interval by hand using $x \pm t_{\alpha/2}(\frac{s}{\sqrt{n}})$ and the t-table.

95% CI for the mean number of damaged trees:_____

Now find the 95% confidence interval for the mean using Minitab.

Go to **STAT> Basic Statistics> 1-sample t…**Enter data in **"Samples in columns."** You do not have to enter the standard deviation but select **OPTIONS** and set the confidence level (make sure it is for 95%) and select "**Alternative:not equal."**

d) 95% CI for the mean number of damaged trees: _____

e) Do you have enough statistical evidence to state that the logging company has exceeded the damage limit? Why?

Experiment 2

The amount of sewage and industrial pollution dumped into a body of water affects the health of the water by reducing the amount of dissolved oxygen available for aquatic life. If the population mean dissolved oxygen drops below five parts per million (ppm), a level some scientists think is marginal for supplying enough dissolved oxygen for fish, some remedial action will be attempted. Given the expense of remediation, a decision to take action will be made only if there is sufficient evidence to support the claim that the mean dissolved oxygen has DECREASED below 5 ppm. Below are weekly readings from the same location in a river over a two-month time period.

5.2, 4.9, 5.1, 4.2, 4.7, 4.5, 5.0, 5.2, 4.8, 4.6, 4.8

The population standard deviation is unknown and we have a small sample (n≤30). You must verify the assumption of normality. Go to **GRAPH→PROBABILITY PLOT**. Examine the normal probability plot. Does the distribution look normal?

Use DESCRIPTIVE STATISTICS (**Basic Statistics>Display Descriptive Statistics**) to get the mean and sample standard deviation.

Now test the claim that the mean dissolved oxygen is less than 5ppm using α = 0.05

a) First, state the null and alternative hypotheses

H0:_____

H1: _____

b) Compute the test statistic by hand $t = \frac{\bar{x}-\mu}{s/\sqrt{n}}$

c) Find the critical value from the t-table: _____

d) Do you reject the null hypothesis or fail to reject the null hypothesis?

Now use Minitab to do the hypothesis test. Go to **STAT > BASIC STAT > 1-SAMPLE t.** Check **PERFORM HYPOTHESIS TEST** and enter the hypothesized mean (5.00). Click **OPTIONS** and enter the confidence level (1-α) and select alternative hypothesis (H1). Click OK. Check to see that the null and alternative hypotheses shown in the session window are correct.

e) What is the p-value for this test?

f) Do you reject or fail to reject the null hypothesis?

g) State your conclusion:

Experiment 3

A forester believes that tent caterpillars are doing a significant amount of damage to the growth of the hardwood tree species in his stand. He has growth data from 21 plots before the infestation. Since then, he has re-measured those same plots and wants to know if there has been a significant reduction in the annual diameter growth.

Before	After
0.17	0.15
0.22	0.23
0.19	0.17
0.2	0.14
0.12	0.13
0.13	0.11
0.15	0.13
0.16	0.17
0.16	0.12
0.19	0.16
0.25	0.26
0.24	0.21
0.21	0.21
0.18	0.15
0.19	0.17
0.22	0.2
0.24	0.19
0.25	0.24
0.24	0.25
0.14	0.1
0.11	0.11

You need to compute the differences between the *before* values and the *after* values. To create a new variable (diff), type "diff" in the header of the column you want to use. Select **CALC>CALCULATOR**. In the "Expressions" box, type in the equation "**Before-After."** In the box "**Store results in variable**" type "diff." Click OK.

You now have a new data set of the *differences* with which you will complete your analyses. Compute basic descriptive statistics to get the sample mean $\bar{d}$ and sample standard deviation s_d of the differences. Use these statistics to test the claim that there has been a reduction in annual diameter growth. You can answer this question by using either a hypothesis test or confidence interval.

a) H0:_____

H1: _____

$t = \frac{\bar{d} - \mu_d}{s_d/\sqrt{n}}$ or $\bar{d} \pm t_{\alpha/2}\frac{s_d}{\sqrt{n}}$

Do you reject or fail to reject the null hypothesis?

Now let Minitab do the work for you. Select **STAT> Basic Statistics> Paired t…** Select **SAMPLES IN COLUMNS**. Enter the *before* as the **First** sample and *after* data as the **Second** sample. Select **OPTIONS** to set the confidence level and alternative hypothesis. Make sure the Test mean is set to 0.0. Click OK.

b) Write the test statistic and p-value

c) Write a complete conclusion that answers the question.

Experiment 4

Alternative energy is an important topic these days and a researcher is studying a solar electric system. Each day at the same time he collected voltage readings from a meter connected to the system and the data are given below. Is there a significant difference in the mean voltage readings for the different types of days? First do an F-test to test for equal variances and then test the means using the appropriate 2-sample t-test based on the results from the F-test. Please state a complete conclusion for this problem. α = 0.05.

Sunny – 13.5, 15.8, 13.2, 13.9, 13.8, 14.0, 15.2, 12.1, 12.9, 14.9

Cloudy – 12.7, 12.5, 12.6, 12.7, 13.0, 13.0, 12.1, 12.2, 12.9, 12.7

F-Test

a) Write the null and alternative hypotheses to test the claim that the variances are not equal.

H0:_____ H1: _____

Select **STAT>BASIC STAT>2 Variances**. In the **Data** box select "Samples in different columns" and enter Sunny in the **First** box and Cloudy in the **Second** box. Click **OPTIONS** and in **Hypothesized Ratio** box select **Variance1/Variance2**. Make sure the **Alternative** is set at "**Not equal**." Click OK. Look at the p-value for the F-test at the bottom of the output.

b) Do you reject for fail to reject the null hypothesis?

c) Can you assume equal variances?

Now conduct a 2-sample t-test (you should have rejected the null hypothesis in the F-test and assumed unequal variances). **STAT>BASIC STAT>2-Sample t**…Select the button for "**Samples in different columns**" and put Sunny in the **First** box and Cloudy in the **Second** box. Click **OPTIONS** and set the confidence level and select the correct alternative hypothesis. Set the **Test difference** at 0.0. Click OK.

d) What is the p-value for this test?

e) Do you reject or fail to reject the null hypothesis? State your conclusion.
