Summer Ventures – Mathematical Ecology
Using ImageJ

ImageJ is the cross-platform version of *NIH Image*, a free image processing and analysis program created by the National Institute of Health. ImageJ (the "J" if for Java) is freely available and can be found at http://rsb.info.nih.gov/ij/ and is another software you want to download and install on your computer in the lab (select the "bundled with Java 1.6.0_05 (21MB)" option for Windows).

We won't begin to push the boundaries of what ImageJ can do in terms of image processing and analysis, but we will use ImageJ to help us identify several characteristics of the leaves you collected on Monday, namely the length, diameter, area, and fractal dimension of each leaf.

1   Getting Your Image Ready for Analysis

ImageJ can open images saved as TIFF, GIF, JPEG, BMP, DICOM, FITS, and "raw" formats. We'll stick to the more common formats (TIFF, GIF, JPG, and BMP). In order to get an image you have stored on your computer ready for analysis, you'll want to follow these steps:

1. Import the Image:

   (a) Go to `File` → `Open` and maneuver around the folders to find the image you want to load.

2. Set the Measurement Scale:

   (a) Select the Straight Line Selections Tool from your ImageJ tool bar.

   (b) Holding down your left mouse button, draw a line between two measuring points on the ruler in your picture. When you are done drawing the line, release the left mouse button (the line should be highlighted).

   (c) Go to `Analyze` → `SetScale` menu from the ImageJ tool bar.

   (d) In the SetScale window, the length of the line you just drew is given, in pixels, in the top box. You are to fill in the known distance and units of measurement in the appropriate boxes and click OK. When you take any other measurements from now on, they will be shown in terms of this scale.

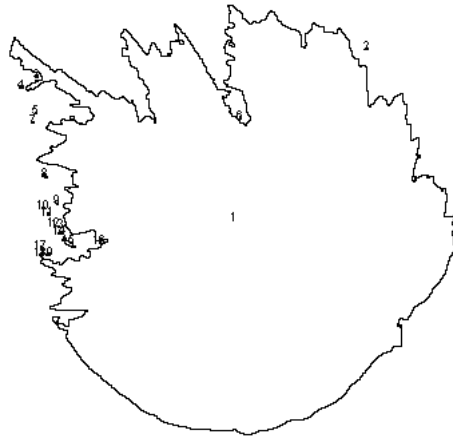## 2   Measuring Distance Between Two Points and Areas

Now you are set to measure the distance between points on your image as well as the area of your leaf.

1. Use the Straight Line Selections Tool to draw a line from the tip of your leaf to the base and consider this it's length. When you finish your line, it's length will be displayed at the base of the ImageJ tool bar as with the leaf pictured below.
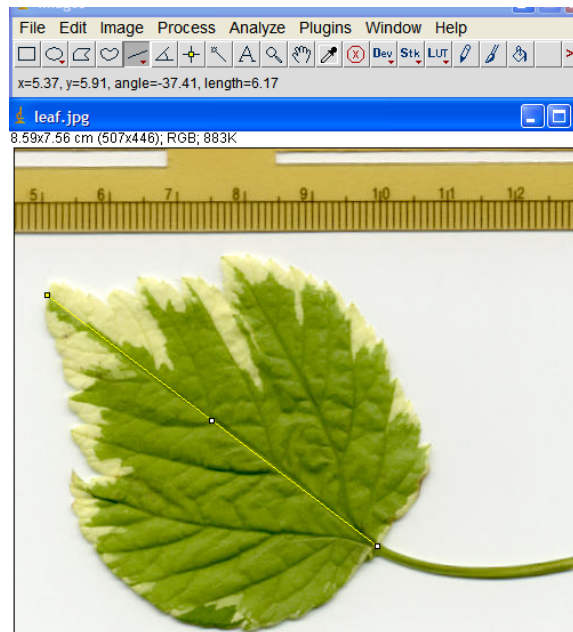
2. In this same manner, you can draw a line across the widest part of your leaf (from left side to right side of the leaf) to get the leaf diameter.

3. In order to calculate the area of the leaf, we first must make sure that our image is truly in black and white (i.e. convert it to a binary image).

   (a) First convert the image of the leaf to grayscale by the following menu options:
       `Image` → `Type` → `8-bit`

   (b) Now convert the image to binary by following these menu options:
       `Process` → `Binary` → `Make Binary`

   (c) If you have a stem on your leaf, you may want to remove that stem by surrounding it with a box using the Rectangular Selection Tool ▢ and then: `Edit` → `Clear`
       NOTE: You don't want to capture any of the body of your leaf in this box, as it will erase it too.

   (d) Now surround your leaf with a box

   (e) Go to `Analyze` → `Analyze Particles` and

       i. In the "Show" drop down menu, select "Outlines", and

       ii. Click "Display Results", then

       iii. Click OK

   You could get results that look like this:

Note that the main portion of the leaf has an area of 19.556 cm^2.

3   Calculating the Fractal Dimension of Your Leaf

The last bit of information we'll collect on our leaf is its fractal dimension. To do this we will need the binary image we used to get the area of our leaf ...

1. Starting with your binary image of your leaf,

2. Go to the following menus:
   `Analyze` → `Tools` → `Fractal Box Count...`
   this will bring up a pop-up box with options.

3. Select OK

This will bring up a graph of the line of best fit for the $\log(N)$ vs. $\log(r)$ data as well as a table of results and the fractal dimension itself:
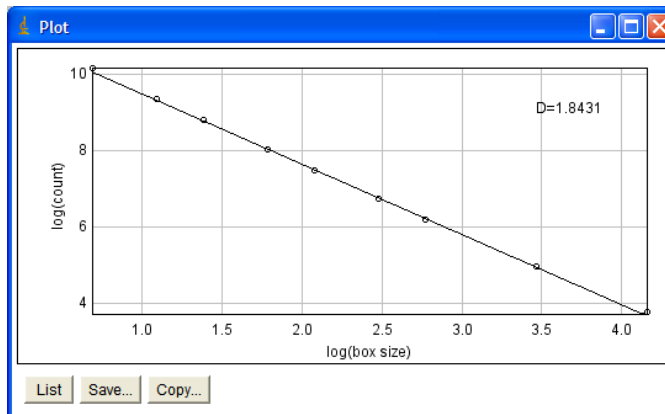
size	count
2	25922
3	11701
4	6695
6	3119
8	1827
12	864
16	492
32	146
64	44

D=1.8431