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Software: Microsoft Excel, ArcGIS 9.3.1

Lesson 3: How to Extrapolate Biomass for Tamarisk

Background

This tutorial will walk you through the process of calculating Tamarisk biomass by using height and percent cover values. For this tutorial, we will be utilizing both *Microsoft Excel* and *ArcMap* in order to transfer and analyze the data. As in previous tutorials the *ArcGIS version 9.3.1* will be used and some small details may not hold true for other versions. The dataset I will be using for this example is a statewide collection of Colorado tamarisk data which consists of thousands of polygons.

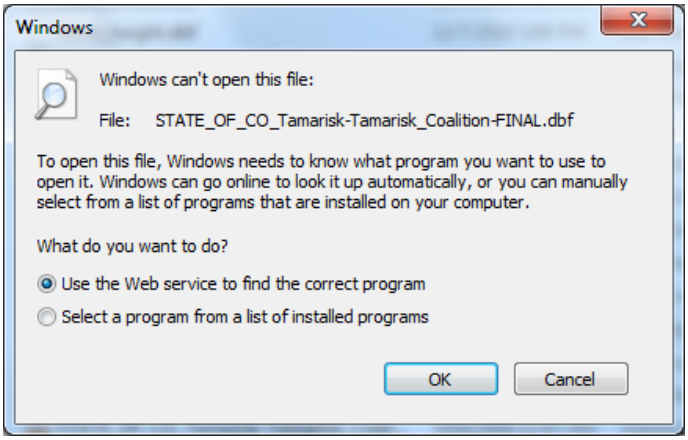
The biomass calculations being performed are used in Evangelista 2007, "Modeling aboveground biomass of *Tamarix ramosissima* in the Arkansas River basin of Southeastern Colorado, USA." Below is a list of some constants being used as well as helpful conversions and the equation to arrive at biomass:

1 acre = 4046.8564 sq meters
Biomass model:
Log_{10} (biomass) = C + [α Log_{10} (canopy area)] + [β (ave height)] + [γ (ave height)^2]
C = - 1.1993
α = 1.109
β = 0.8595
γ = - 0.0927
Correction Factor: 1.17
Biomass = (correction factor) * 10 $^{Log10\ (biomass)}$

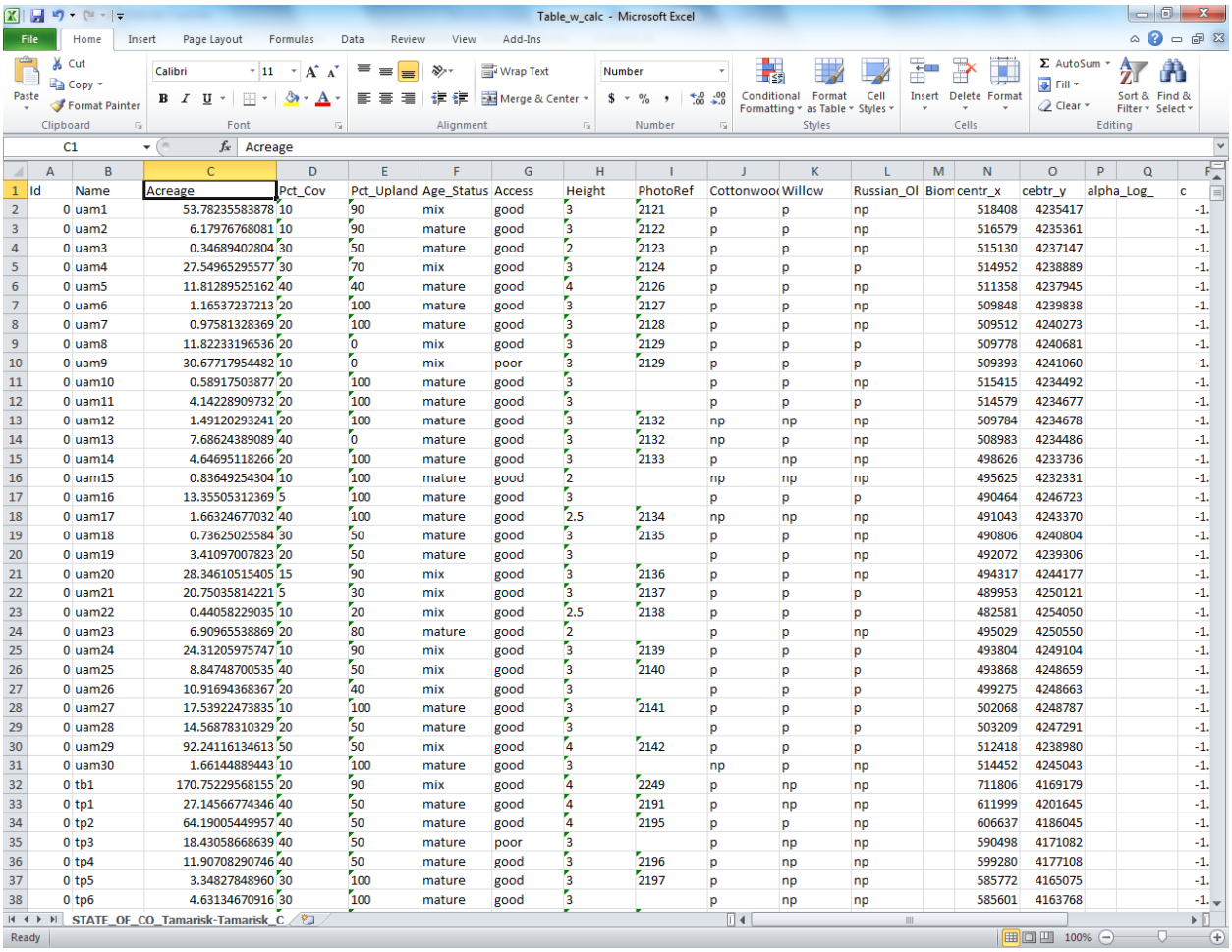
Getting familiar with the data

1. Before any analysis is performed, it would be best to familiarize yourself with the dataset you are using. This is only necessary if you were not the collector of the data and need to search for the values in order to arrive at "Canopy Area" (i.e. acerage/hectares, and percent cover).

2. If the file is within a .shp format then you will want to view only the .dbf file and navigate to open it with *Microsoft Excel* when presented with this prompt:

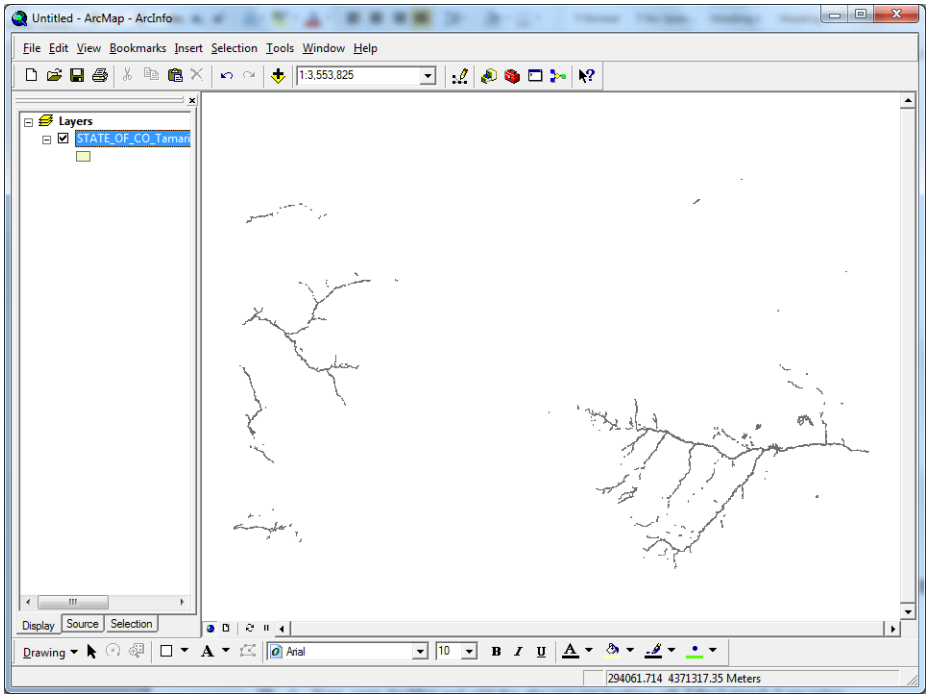


3. *Excel* should have no problem opening the .dbf file, but it cannot save a .dbf file so all calculations will be made in *Excel* as a reference to what will later be done with the field calculator within the attribute table of *ArcMap*. Below is what the tamarisk dataset looks like opened in *Excel*. Notice I do have a form of area available (Acreage), Percent Cover, and Height.

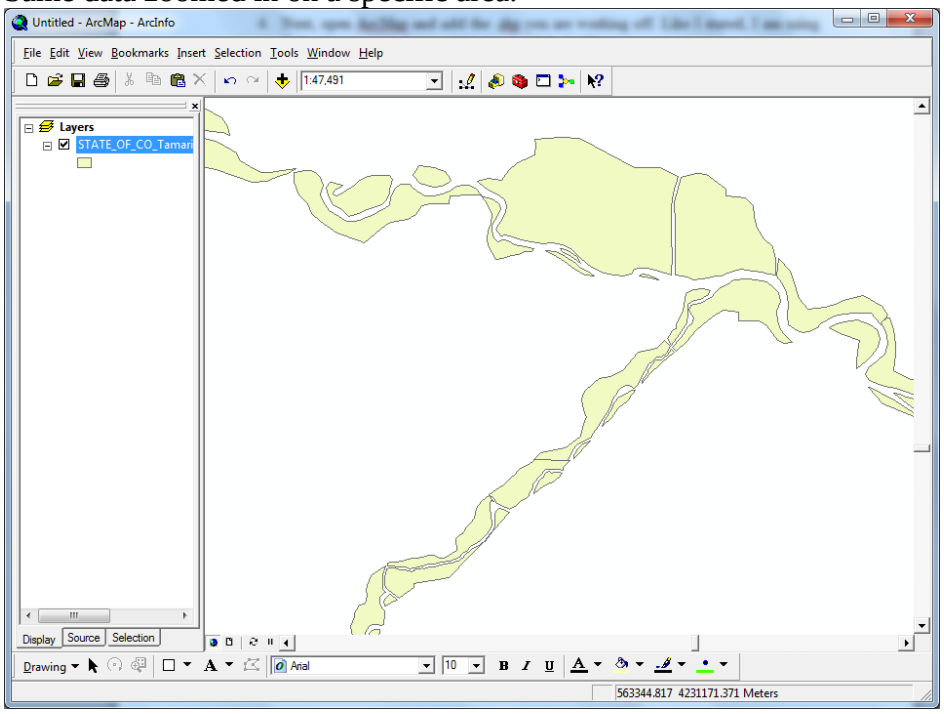


Id	Name	Acreage	Pct_Cov	Pct_Upland	Age_Status	Access	Height	PhotoRef	Cottonwoo	Willow	Russian_Ol	Biom	centr_x	cebtr_y	alpha_Log_	c
0	uam1	53.78235583878	10	90	mix	good	3	2121	p	p	np		518408	4235417		-1.
0	uam2	6.17976768081	10	90	mature	good	3	2122	p	p	np		516579	4235361		-1.
0	uam3	0.34689402804	30	50	mature	good	2	2123	p	p	np		515130	4237147		-1.
0	uam4	27.54965295577	30	70	mix	good	3	2124	p	p	p		514952	4238889		-1.
0	uam5	11.81289525162	40	40	mature	good	4	2126	p	p	np		511358	4237945		-1.
0	uam6	1.16537237213	20	100	mature	good	3	2127	p	p	np		509848	4239838		-1.
0	uam7	0.97581328369	20	100	mature	good	3	2128	p	p	np		509512	4240273		-1.
0	uam8	11.82233196536	20	0	mix	good	3	2129	p	p	p		509778	4240681		-1.
0	uam9	30.67717954482	10	0	mix	poor	3	2129	p	p	p		509393	4241060		-1.
0	uam10	0.58917503877	20	100	mature	good	3		p	p	np		515415	4234492		-1.
0	uam11	4.14228909732	20	100	mature	good	3		p	p	p		514579	4234677		-1.
0	uam12	1.49120293241	20	100	mature	good	3	2132	np	np	np		509784	4234678		-1.
0	uam13	7.68624389089	40	0	mature	good	3	2132	np	p	np		508983	4234486		-1.
0	uam14	4.64695118266	20	100	mature	good	3	2133	p	np	np		498626	4233736		-1.
0	uam15	0.83649254304	10	100	mature	good	2		np	np	np		495625	4232331		-1.
0	uam16	13.35505312369	5	100	mature	good	3		p	p	p		490464	4246723		-1.
0	uam17	1.66324677032	40	100	mature	good	2.5	2134	np	np	np		491043	4243370		-1.
0	uam18	0.73625025584	30	50	mature	good	3	2135	p	p	np		490806	4240804		-1.
0	uam19	3.41097007823	20	50	mature	good	3		p	p	np		492072	4239306		-1.
0	uam20	28.34610515405	15	90	mix	good	3	2136	p	p	np		494317	4244177		-1.
0	uam21	20.75035814221	5	30	mix	good	3	2137	p	p	p		489953	4250121		-1.
0	uam22	0.44058229035	10	20	mix	good	2.5	2138	p	p	p		482581	4254050		-1.
0	uam23	6.90965538869	20	80	mature	good	2		p	p	np		495029	4250550		-1.
0	uam24	24.31205975747	10	90	mix	good	3	2139	p	p	p		493804	4249104		-1.
0	uam25	8.84748700535	40	50	mix	good	3	2140	p	p	p		493868	4248659		-1.
0	uam26	10.91694368367	20	40	mix	good	3		p	p	p		499275	4248663		-1.
0	uam27	17.53922473835	10	100	mature	good	3	2141	p	p	p		502068	4248787		-1.
0	uam28	14.56878310329	20	50	mature	good	3		p	p	p		503209	4247291		-1.
0	uam29	92.24116134613	50	50	mix	good	4	2142	p	p	p		512418	4238980		-1.
0	uam30	1.66144889443	10	100	mature	good	3		np	p	np		514452	4245043		-1.
0	tb1	170.75229568155	20	90	mix	good	4	2249	p	np	np		711806	4169179		-1.
0	tp1	27.14566774346	40	50	mature	good	4	2191	p	np	np		611999	4201645		-1.
0	tp2	64.19005449957	40	50	mature	good	4	2195	p	p	np		606637	4186045		-1.
0	tp3	18.43058668639	40	50	mature	poor	3		p	np	np		590498	4171082		-1.
0	tp4	11.90708290746	40	50	mature	good	3	2196	p	np	np		599280	4177108		-1.
0	tp5	3.34827848960	30	100	mature	good	3	2197	p	np	np		585772	4165075		-1.
0	tp6	4.63134670916	30	100	mature	good	3		p	np	np		585601	4163768		-1.

4. Next, open *ArcMap* and add the .shp you are working off. Like I stated, I am using Colorado tamarisk data and this is what it looks like:



Same data zoomed in on a specific area.



5. Right click on the layer and open the attribute table. This table should look almost identical to the one that you have opened in *Excel*.

Performing Biomass Calculation in *Excel*

Basics - A couple basic *Excel* processes need to be applied in order to make this process go much more smoothly. If you are familiar with *Excel*, you can skip this section of the tutorial.

1. When entering into a cell what equation you would like that cell to represent, make sure to put an "=" sign before entering the equation.

2. While entering an equation, you may need to use a value that is already in the table. When you get to the point in the equation where you need the value already in the table, simply click on that particular cell. Its column and row value will appear in blue within your equation cell. Now, when you drag down (step 4) the subsequent cell value will be entered automatically.

3. After entering an equation and hitting enter, a numerical value will appear in the cell. If you move the cursor across the cell to the bottom right hand corner of the cell the cursor will change form.

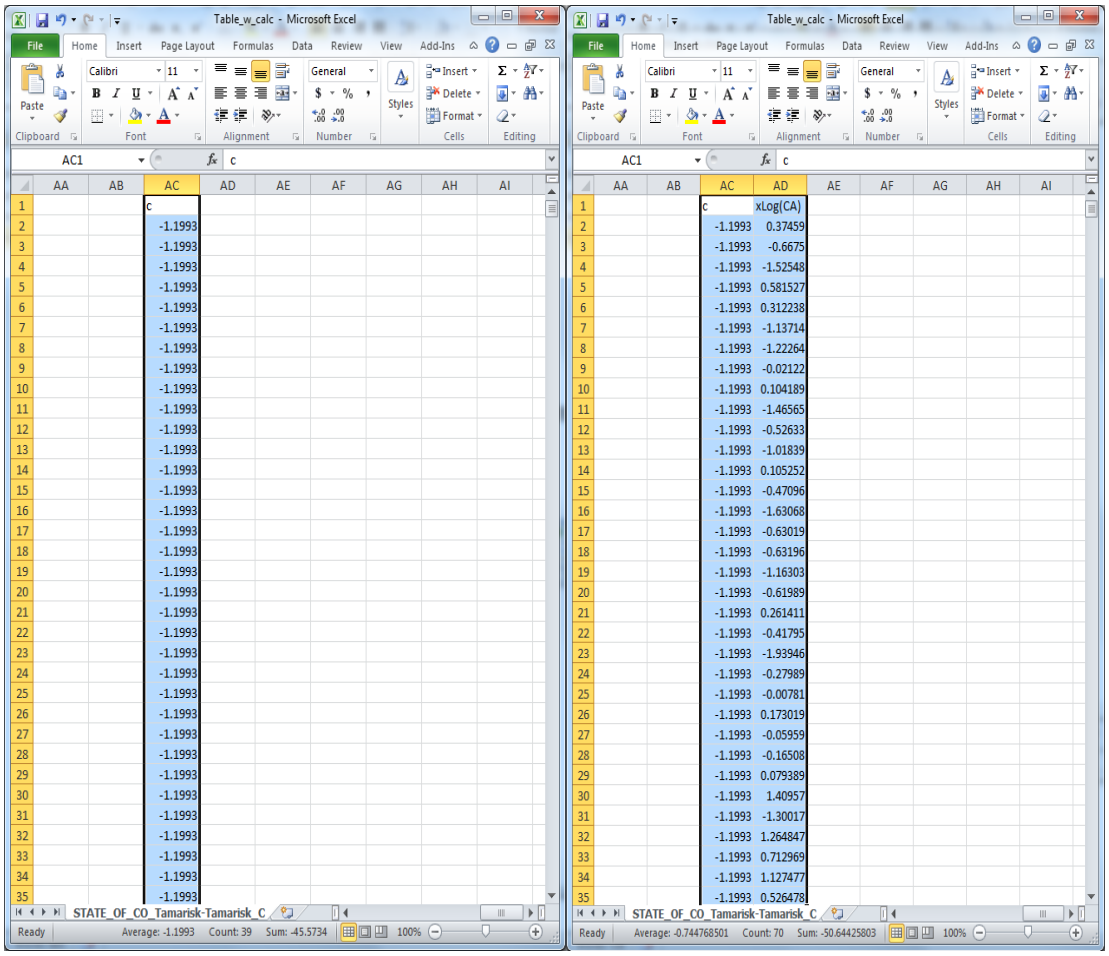
4. When a black cross appears you can left click and drag the cursor down selecting several cells. This action is dragging the equation you entered into the first and placing it in each subsequent cell you select. This is so that you do not have to enter the equation numerous times. For more than 1600 entries, this helps a lot.

Calculating – In order to prevent mistakes, it is best to break up the Biomass equation into its individual components before putting it all together. First we will put together the Log (biomass) equation referenced above by creating a column for each component.

1. Create a header for your new column. I usually use the variables of the equation I am representing within that specific column. My first column will simply consist of a single number (good practice in dragging down to select cells).

2. Insert the constant -*1.1993*. This is the constant "c" value. Drag the value down the length of your data within the single column. It should look something like the image below (left).

3. In order to get "canopy area," create an area column in *sq. meters* derived from the *acreage* column. Multiply this number in a new column by the *percent cover* value (make sure your percent cover values are less than 1, or if they are not divide it all by 100). The equation will look like this in *Excel* depending on what path and row the other values are in**: (AA2*D2) / 100** ; where AA2 is representing the cell with *area in sq. meters* and D2 is representing the cell with *percent cover*.



4. Next, move on to the next portion of the equation. This will be the ***αLog(CA)*** variable. Remember to enter the "=" before entering the arithmetic. "α" is the constant **1.109** and in order to insert a Log function you can do one of two things. First, you can search for it in the functions list by clicking on the **fx** icon near the top of the page or start typing in "LOG" and select it from the drop-down that appears.

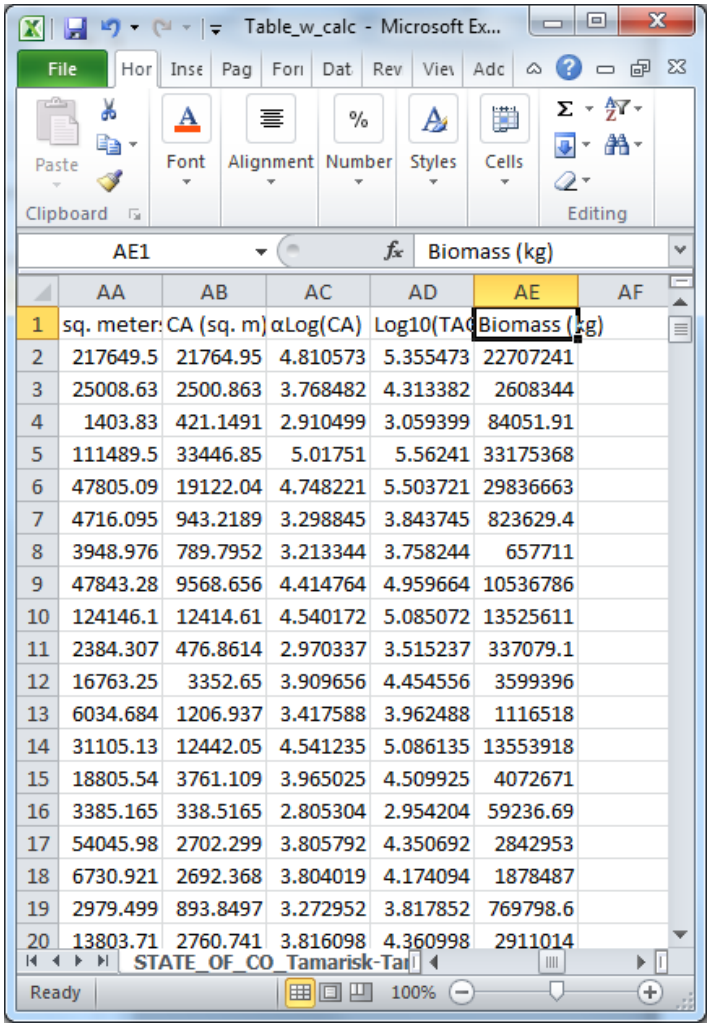
5. Once the equation is entered, drag down with the black + just like the "c" column. It will look like the image above (right).

6. Continue this process for the rest of the sections of the Log(biomass) equation. You will still need ***βHt.*** and ***γHt.***^{2}

7. Next, create a column that simply adds all of the components together. This is equal to the Log(biomass).

8. In order to get to biomass (kg), you need to inverse the Log still present. The Log is a base ten so the biomass equals 10 raised to the power of Log(biomass). Set the column equal to: 10 ^ (corresponding Log(biomass) cell). Then, multiply it by the correction factor of **1.17**.

9. The final table will look similar to this:



	AA	AB	AC	AD	AE	AF
1	sq. meter	CA (sq. m)	αLog(CA)	Log10(TA	Biomass (kg)	
2	217649.5	21764.95	4.810573	5.355473	22707241	
3	25008.63	2500.863	3.768482	4.313382	2608344	
4	1403.83	421.1491	2.910499	3.059399	84051.91	
5	111489.5	33446.85	5.01751	5.56241	33175368	
6	47805.09	19122.04	4.748221	5.503721	29836663	
7	4716.095	943.2189	3.298845	3.843745	823629.4	
8	3948.976	789.7952	3.213344	3.758244	657711	
9	47843.28	9568.656	4.414764	4.959664	10536786	
10	124146.1	12414.61	4.540172	5.085072	13525611	
11	2384.307	476.8614	2.970337	3.515237	337079.1	
12	16763.25	3352.65	3.909656	4.454556	3599396	
13	6034.684	1206.937	3.417588	3.962488	1116518	
14	31105.13	12442.05	4.541235	5.086135	13553918	
15	18805.54	3761.109	3.965025	4.509925	4072671	
16	3385.165	338.5165	2.805304	2.954204	59236.69	
17	54045.98	2702.299	3.805792	4.350692	2842953	
18	6730.921	2692.368	3.804019	4.174094	1878487	
19	2979.499	893.8497	3.272952	3.817852	769798.6	
20	13803.71	2760.741	3.816098	4.360998	2911014	

Calculating Biomass in *ArcMap*

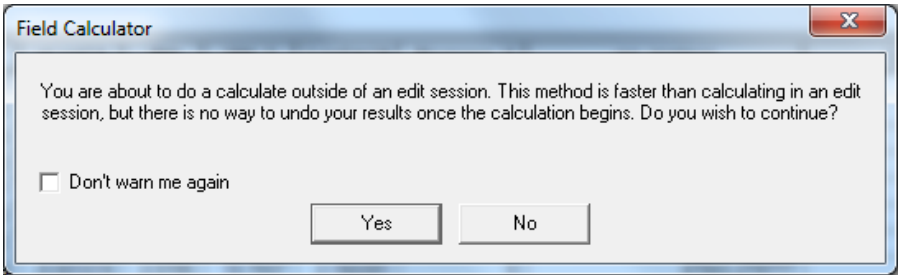
This process is similar to that in *Excel*, the main difference it how the equations will be entered into the table. The attribute table is where all calculations will take place and the syntax needed for the field calculator can be difficult. It is for this reason that all calculations were done in *Excel*. After each new attribute field you calculate, **check the numbers from your *Excel* table.**

1. Open the tamarisk shapefile in *ArcMap* if you do not already have it open. Right click on the layer and open the attribute table.

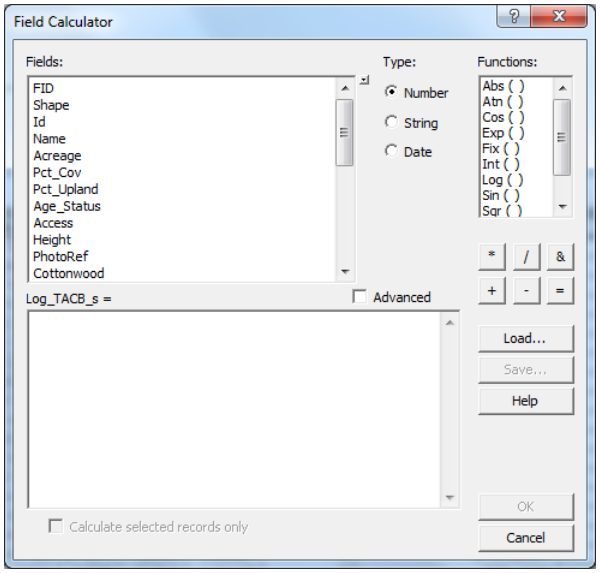
2. Add a field by going to the **Options** tab in the bottom right and select **Add Field…**

3. Give the field a name, and select the type of value; I use Double and it seems to do just fine. The field will appear on the far right side of your attribute table without any values in the cells.

4. Right click on the title of the field and select **Field Calculator**. The prompt below will appear, click **Yes**.



5. The field calculator window looks like this:



The blank box on the lower half is where the equations will be entered for the field you selected. All other fields are at the top to select from by double clicking on each name. By double clicking on one, it enters the field value into the equation and subsequently appears in the lower box. Functions to use can be selected from the list on the right and common arithmetic commands are just below the function list.

6. You will need to repeat steps 2-4 to add a new field and perform a calculation for each variable in the equation. Below is the list of syntax to be used within the field calculator for each variable within the biomass equation. **Make sure spaces are entered where necessary in the syntax otherwise you will get error messages and it will not finish calculating.**

   Variable: C
   Syntax: **-1.1993**

   Variable: Area in sq. meters

Syntax: **[Acreage] * 4046.8564**

Variable: Canopy Area (sq. meters)
Syntax: **([sq_meters] * [Pct_Cov]) / 100**

Variable: αLog(CA)
Syntax: **1.109 * (Log ([CA_sqmeter]) / Log (10))**

Variable: βHt
Syntax: **0.8595 * [Height]**

Variable: $\gamma Ht.^2$
Syntax: **-1 * (0.0927 * ([Height] ^ 2))**

Variable: Log(biomass)
Syntax: **-1.1993 + [aLogCAsq] + [BHt] + [YHt_2]**

Variable: Biomass (kg)
Syntax: **(10 ^ [Log_Biomass]) * 1.17**

7. The two sets of data should now show the same values for biomass. Please double check your work and if numbers do not match up, most likely there is a small calculation mistake.

You have now completed calculations and steps necessary to arrive at Biomass for invasive tamarisk within both *Microsoft Excel* and *ArcMap*.