Technical Notes

Periodic Updates on Current Technology
From Urban Forestry South

Technical Note number: TN_20120411

Date: April 11, 2012

Series: Debris volume estimation

i-Tree Application: Eco

Subject: Using i-Tree Eco to estimate vegetative debris volumes before and after a storm

Executive Summary: Since i-Tree Eco uses randomly placed plots throughout an area-of-interest such as a municipality, potential vegetative debris volumes can be estimated for developed or "improved" parts of that area before a storm for planning purposes. This model provides for multiple uses as an environmental benefits tools as well as a debris estimation tool. This document provides the steps necessary to use existing i-Tree Eco data to estimate potential vegetative debris volume.

Background: Before a natural disaster such as an ice storm or wind event, it could be helpful for municipalities and local or county emergency managers to know and plan for potential vegetative debris volumes that these storms can generate. Debris volumes can be estimated for any combination of land use categories using data collected from an i-Tree Eco project, however, reimbursement for clean-up by FEMA is generally for developed or "improved" land use areas.

When setting up an i-Tree Eco project for a municipality or large area-of-interest, hundreds of $1/10^{th}$ acre plots are randomly located throughout the entire area. These plots can fall on developed or non-developed areas as well as public and privately-owned land. All trees within these plots are inventoried. Using whole tree volume equations developed by Martin et al. (1998)[1], total potential debris volumes can be estimated for the city.

With total potential debris volumes known, the municipality or emergency manager can then prepare for various disaster scenarios based on percentage of canopy loss. After a natural disaster has passed, a percentage of the measured plots can then be re-assessed to determine canopy loss and/or whole tree failure. That percentage of tree failure can then be applied to the original estimated debris volume to approximate the total volume of vegetative debris the city can expect to accumulate in the clean-up effort.

[1] Martin, J.G., Kloeppel, B.D.,Schaefer, T.L., Kimbler, D.L., and McNulty, S.G. 1998. Aboveground biomass and nitrogen allocation of ten deciduous southern Appalachian tree species. Can. J. For. Res. 28:1648-1659

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Methodology:

Procedure for estimating total potential vegetative debris for developed land use

1. Obtain the total land area for the municipality or area-of-interest (AOI)
    a. Via GIS or in your i-Tree Eco project
        i. Edit > Manage Map Land Use under LandUseSize (click here for help)
    b. This can be in acres or hectares, but be consistent with the area units throughout this process
    c. If your AOI is stratified, you may want to record the land use size for each stratum to be used in step 2

2. Calculate the total percentage of developed land area (i.e. commercial, residential, institutional, etc.) for the entire AOI.
    a. In your i-Tree Eco project, this information can be found in Reports > Tables >Standard Tables > Percent of predicted land use in actual land use (click here for help)
    b. Export this table into CSV format and open it into a spreadsheet (i.e. Excel) to calculate the percentage of developed land in your AOI (click here for help)
    c. If the Eco project is stratified, you will need to
        i. calculate the amount of developed land area for each stratum
            1. multiply the percentage of developed land use by the total land area of that stratum
        ii. sum the developed land area for each stratum
        iii. divide the total developed land area for each stratum (step 2.c.ii.) by the total land area of your AOI (click here for help)

3. Calculate the area of the municipality that is developed or improved
    a. Multiply step 1 by step 2 (click here for help)

4. Sum the area of all measured plots in developed areas (i.e. actual land use = commercial, residential, etc.)
    a. From your project input database (Project_input.mdb), export the "Field Land Uses" table into an Excel spreadsheet (click here for help)
    b. Use the Data>Filter tool to exclude all "non-developed" land classes in the FieldLandUse field (click here for help)
    c. Divide all values in the "PercentofSubplot" field by 100 and then multiply that value by the size of the plot
    d. Sum all plot sizes to obtain the total area inventoried (click here for help)
    e. Note: Include all plots in developed areas whether they had trees on them or not

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5. Convert all tree diameters in the developed plots to centimeters (click here for help)
    a. Export the "TreeDiameters" table from your project input database (Project_input.mdb) to a spreadsheet and exclude all plots except for those developed plots from step 4 above
    b. Convert all diameters to centimeters by multiplying dbh in inches by 2.54

6. Determine whole tree volume of all trees in developed plots by plugging stem diameter value from step 5 into the equation: $10^{\{-4.061+[2.705*LOG10(DBHcm)]\}}*1.021$
    a. To account for air space when debris is tightly loaded whole into trailers, divide the value from the above equation by 0.25 (see footnote [2] below for explanation)
    b. To convert the volume above from cubic meters to cubic yards, multiply the value by 1.30795 (click here for help)

7. Sum all whole tree volumes in the developed plots (click here for help)

8. Calculate the estimated potential debris volume for the developed portion of the AOI: (click here for help)
    a. Divide total tree volume (step 7) by the total plot area (step 4) to get the total debris volume per acre of developed land use in the city
    b. Multiply step 8a. by the total developed land area (step 3) to estimate total debris volume in all of the developed areas of the city
    c. This value represents the total potential vegetative debris volume for the AOI. In other words, if every tree in the developed or improved areas of the city were to fail in a natural disaster, this is the estimated volume of debris that would be generated.

[2] FEMA 325, Public Assistance Debris Management Guide, July 2007,Chapter 9 – Debris Reduction/Recycling Methods and Disposal, p. 87

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Procedure for estimating vegetative debris volume after a storm

1. Soon after the storm passes, visually inspect a representative number of developed plots (i.e. residential, institutional, commercial) in the AOI that contain trees

2. Estimate the percentage of tree failure (either crown loss or whole tree failure) that is on the ground in each inspected plot
    a. Estimating debris that is still standing or hanging in trees can be difficult; you may want to assume that the property owner will hire a contractor to remove that debris and thus not have it hauled to the right-of-way

3. Average the percentage of tree failure over all inspected plots

4. Multiply that average percentage by the total potential vegetative debris value estimated in step 8 above.
    a. This value represents the total vegetative debris volume the city can expect to haul and temporarily store.

Conclusion: Having an estimate of the total potential vegetative debris volume before a storm can help municipal and regional governmental entities better prepare for natural disasters. Multiple disaster scenarios can be simulated with varying degrees of tree canopy impacts to allow these entities to better plan.

After a natural disaster involving storm-damaged trees, residents are usually instructed to drag their debris to the curb so that the city can haul it away. Having fairly accurate debris volume estimates can help a municipality better plan their resources for the clean-up efforts. Since i-Tree Eco uses random plots in its methodology, this method can more accurately estimate debris volumes for the entire municipality (front and back yards) rather than relying on visual estimates from the rights-of-way. Having accurate debris volume estimation values allows a city to clean-up after a storm more efficiently thus saving tax revenues.

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Thanks to P. Eric Wiseman at Virginia Tech and Micah Pace with the Texas Forest Service for their invaluable critique and suggestions for improving this document.

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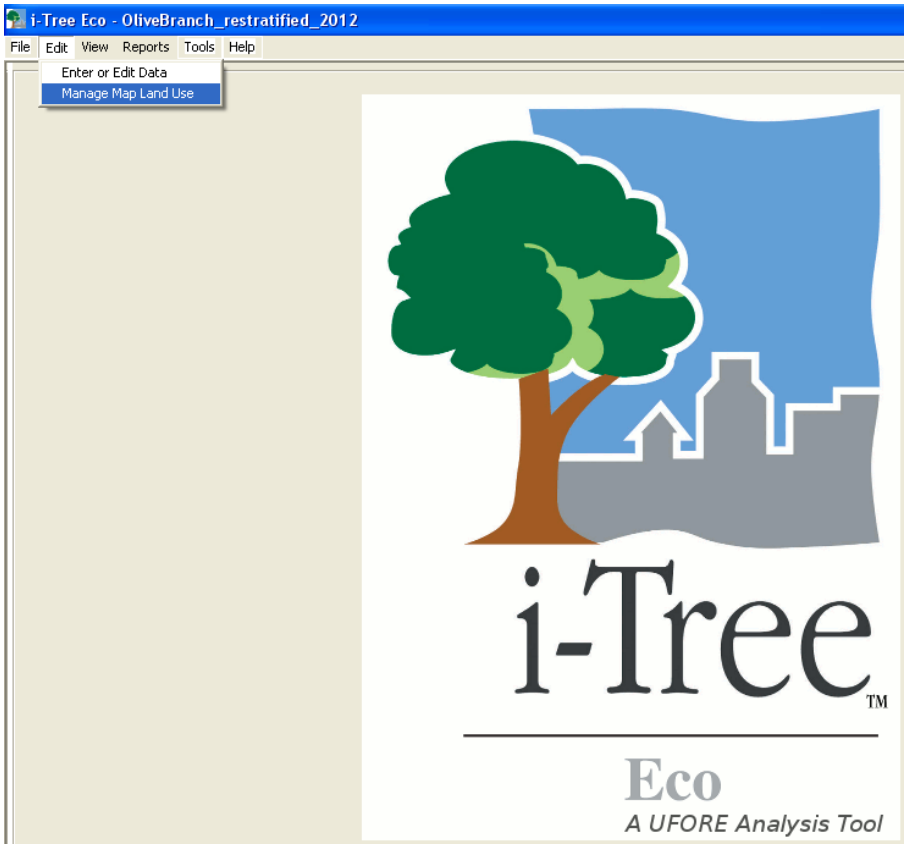
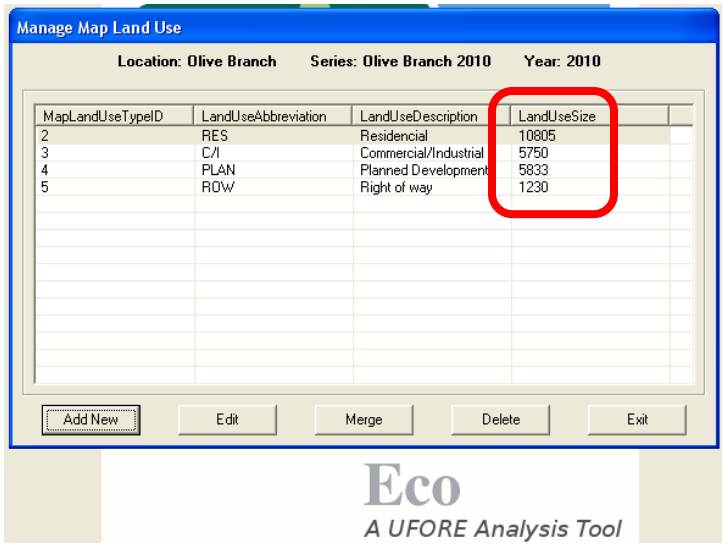
Step 1.a.i. Open "Manage Map Land Use" table to obtain total land for the area of interest





(Back to methods section)

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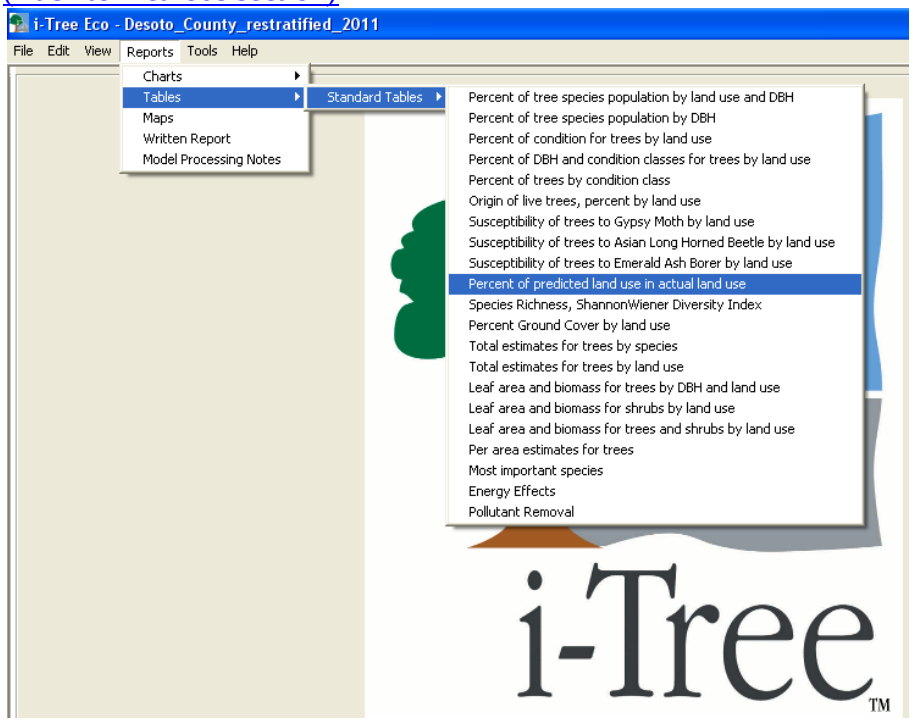
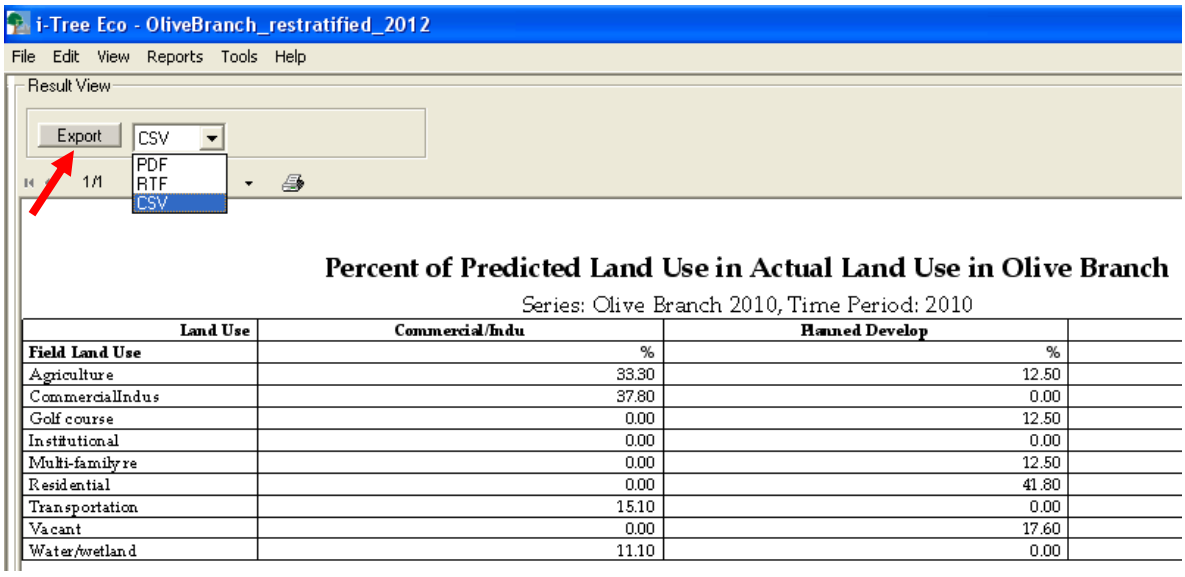
Step 2.a. Open "Percent of predicted land use in actual land use" table
(Back to methods section)



Step 2.b. Export table in CSV format (Back to methods section)



Percent of Predicted Land Use in Actual Land Use in Olive Branch

Series: Olive Branch 2010, Time Period: 2010

Land Use	Commercial/Indu	Planned Develop
Field Land Use	%	%
Agriculture	33.30	12.50
CommercialIndus	37.80	0.00
Golf course	0.00	12.50
Institutional	0.00	0.00
Multi-familyre	0.00	12.50
Residential	0.00	41.80
Transportation	15.10	0.00
Vacant	0.00	17.60
Water/wetland	11.10	0.00

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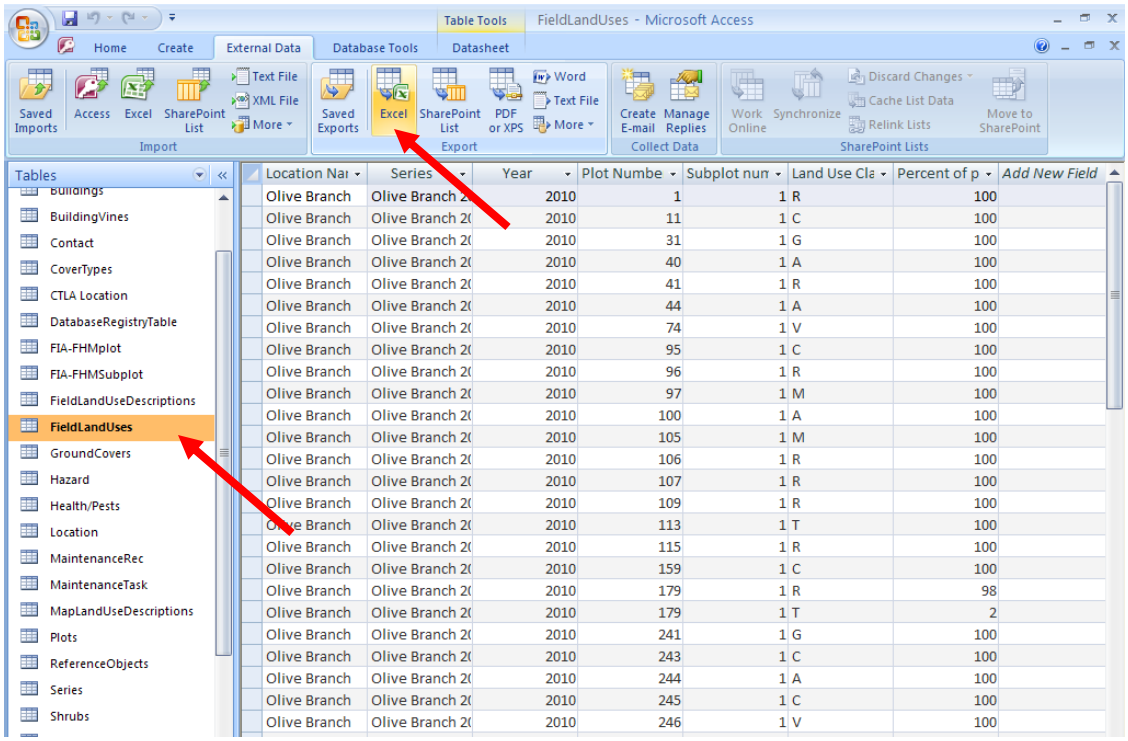
Step 2.c. Calculate the total percentage of developed land area per stratum
(Back to methods section)

predicted land use vs actual landuse.xlsx

	A	B	C	D	E
1	Percent of Predicted Land Use in Actual Land Use in Olive Branch				
2					
3	Land Use	Commercial/ Indu	Planned Develop	Residential	
4					
5	Field Land Use	%	%	%	
6					
7					
8	Agriculture	33%	13%	6%	
9	CommercialIndus	38%		24%	
10	Golf course		13%	6%	
11	Institutional			6%	
12	Multi-family re		13%	6%	
13	Residential		42%	47%	
14	Transportation	15%			
15	Vacant		18%	6%	
16	Water/wetland	11%			
17					total
18	Total area (ac)	5750	5833	10805	22388
19	% total developed	53%	67%	88%	74%
20	Acres developed	3042	3896	9541	16479
21					

Step 3: multiply total land area by percent of developed land use area

Step 4.a. Export the "Field Land Uses" table into an Excel spreadsheet (Back to methods section)



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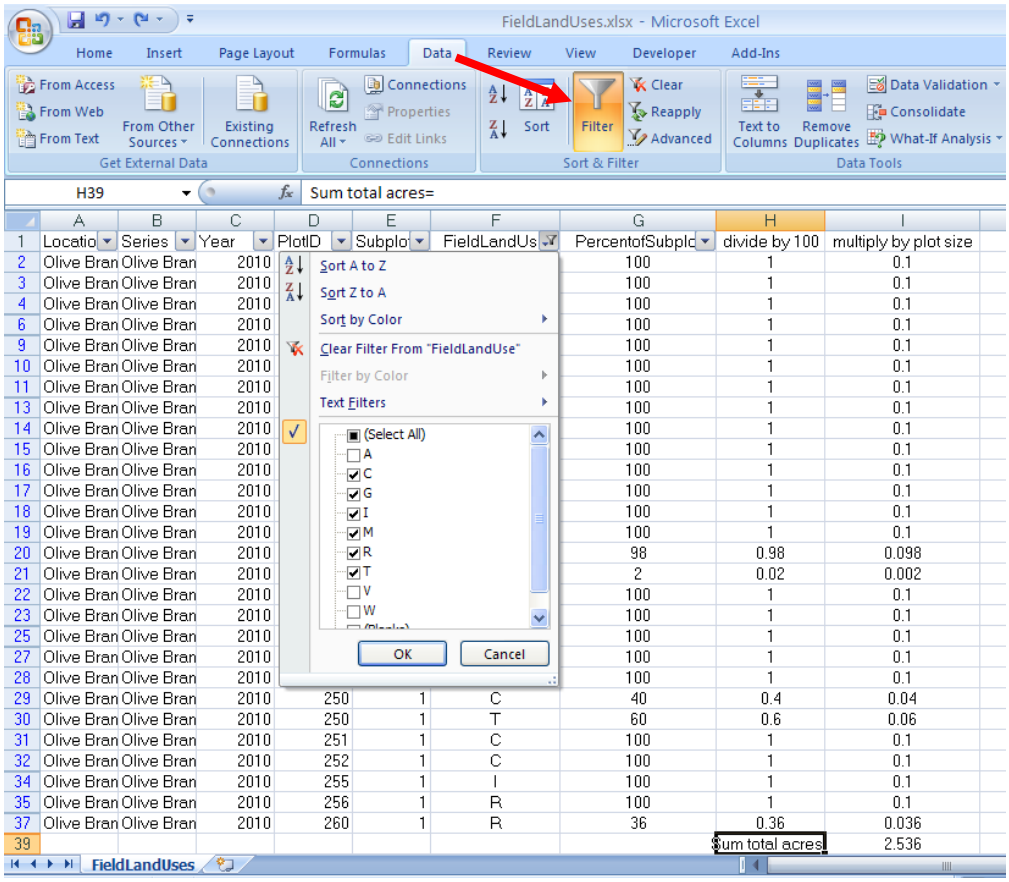
4.b. Exclude all "non-developed" land classes in the FieldLandUse field (column F)
4.c. Divide all "PercentofSubplot" values by 100 (column H)
4.d. Multiply 4.c. by plot size and sum for total area inventoried (column I)
(Back to methods section)



	A	B	C	D	E	F	G	H	I
1	Locatio	Series	Year	PlotID	Subplo	FieldLandUs	PercentofSubplc	divide by 100	multiply by plot size
2	Olive Bran	Olive Bran	2010				100	1	0.1
3	Olive Bran	Olive Bran	2010				100	1	0.1
4	Olive Bran	Olive Bran	2010				100	1	0.1
6	Olive Bran	Olive Bran	2010				100	1	0.1
9	Olive Bran	Olive Bran	2010				100	1	0.1
10	Olive Bran	Olive Bran	2010				100	1	0.1
11	Olive Bran	Olive Bran	2010				100	1	0.1
13	Olive Bran	Olive Bran	2010				100	1	0.1
14	Olive Bran	Olive Bran	2010				100	1	0.1
15	Olive Bran	Olive Bran	2010				100	1	0.1
16	Olive Bran	Olive Bran	2010				100	1	0.1
17	Olive Bran	Olive Bran	2010				100	1	0.1
18	Olive Bran	Olive Bran	2010				100	1	0.1
19	Olive Bran	Olive Bran	2010				100	1	0.1
20	Olive Bran	Olive Bran	2010				98	0.98	0.098
21	Olive Bran	Olive Bran	2010				2	0.02	0.002
22	Olive Bran	Olive Bran	2010				100	1	0.1
23	Olive Bran	Olive Bran	2010				100	1	0.1
25	Olive Bran	Olive Bran	2010				100	1	0.1
27	Olive Bran	Olive Bran	2010				100	1	0.1
28	Olive Bran	Olive Bran	2010				100	1	0.1
29	Olive Bran	Olive Bran	2010	250	1	C	40	0.4	0.04
30	Olive Bran	Olive Bran	2010	250	1	T	60	0.6	0.06
31	Olive Bran	Olive Bran	2010	251	1	C	100	1	0.1
32	Olive Bran	Olive Bran	2010	252	1	C	100	1	0.1
34	Olive Bran	Olive Bran	2010	255	1	I	100	1	0.1
35	Olive Bran	Olive Bran	2010	256	1	R	100	1	0.1
37	Olive Bran	Olive Bran	2010	260	1	R	36	0.36	0.036
39								Sum total acres	2.536

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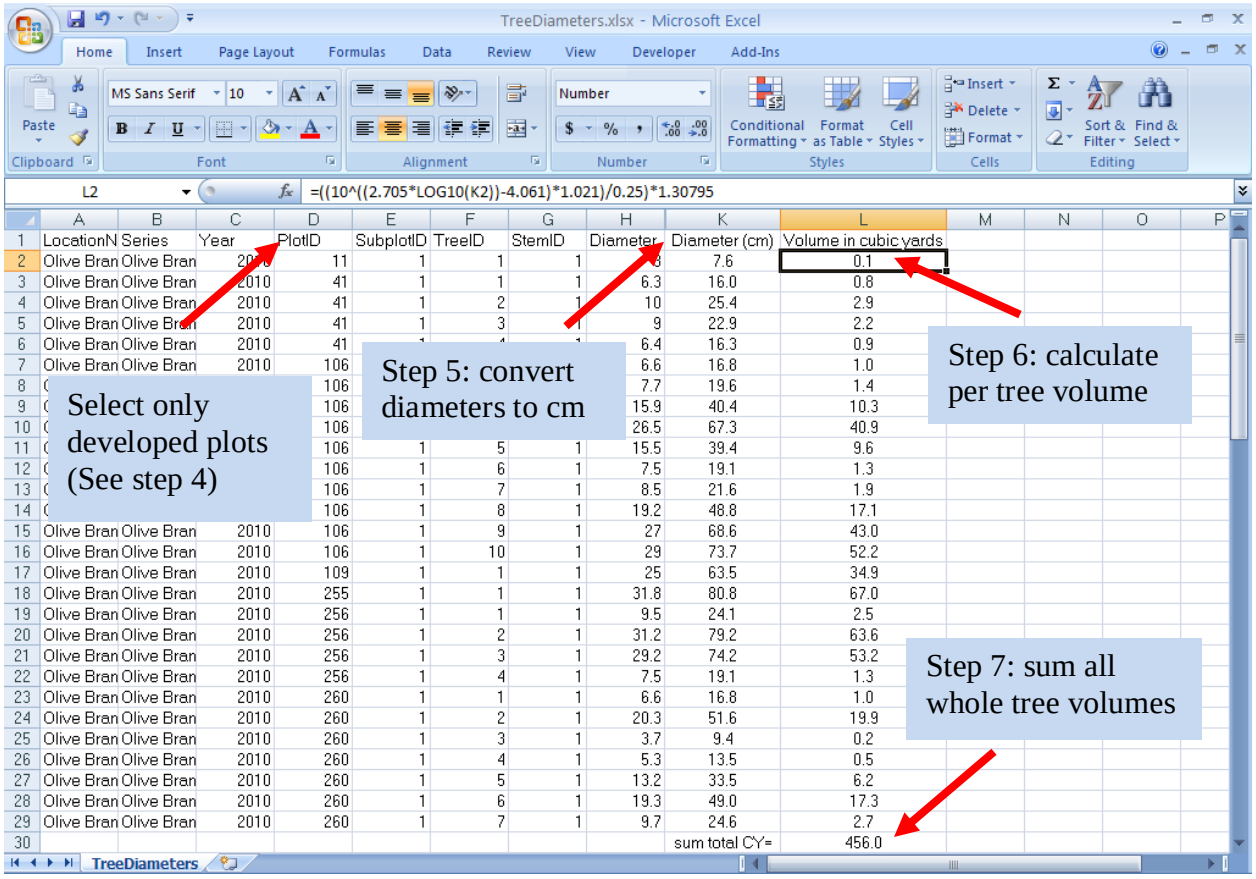
5. Convert all tree diameters in the developed plots to centimeters
6. Calculate the per tree volume in cubic yards using the formula:
((10^((2.705*(LOG10(dbhcm))-4.061)*1.021)/0.25)*1.30795
7. Sum all whole tree volumes

(Back to methods section)



8. Calculate the estimated potential debris volume for the developed portion of the AOI.
   a. Divide total tree volume (step 7) by the total plot area (step 4)
      Example: 456.0 CY / 2.536 ac = 179.8 CY/ac

   b. Multiply step 8a. by the total developed land area (step 3)
      Example: 179.8 CY/ac * 16479 ac = 2.96 million cubic yards

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