Scaling carbon estimates to the wider region

How much total carbon is stored in the trees at your schoolyard?

GLOBE Carbon Cycle

What two major pieces of information do you need to know to answer this question?

1. How much carbon is stored in a given area of your schoolyard?

2. How much of your schoolyard is covered by trees?

What are the methods/steps required for getting the necessary information to answer the question?

GLOBE Carbon Cycle

1a. How much carbon is stored in a given area of your schoolyard?

Using the Model

- Find local climate data for your site (average annual temperature and average total precipitation)
- Find the estimated turnover rate based on your biome
- Estimate the approximate age of the trees on your site
- Use the above information in the model to determine biomass g/m2
- Record the total grams of carbon per square meter

GLOBE Carbon Cycle

1b. How much carbon is stored in a given area of your schoolyard?

Using the Field Data

- Set up a Carbon Cycle Sample Site - measure circumference and record species for all trees greater than 15 cm
- Use the field datasheet and *PlotBiomassAnalysis.xls* to get total site biomass and grams of carbon per square meter (g/m^2)

2. How much of your schoolyard is covered by trees?

- Use a map with a scale to determine the total schoolyard area covered by trees
  - Remote sensing image of your schoolyard
  - Google Maps/Google Earth image
  - Go outside and survey the area for forested locations, mark them on a planning/zoning map of the school site
- Use a ruler or other analytical method (GIS, multi-spec) to measure the area covered by trees
- Be sure to convert all area measurements into meters squared


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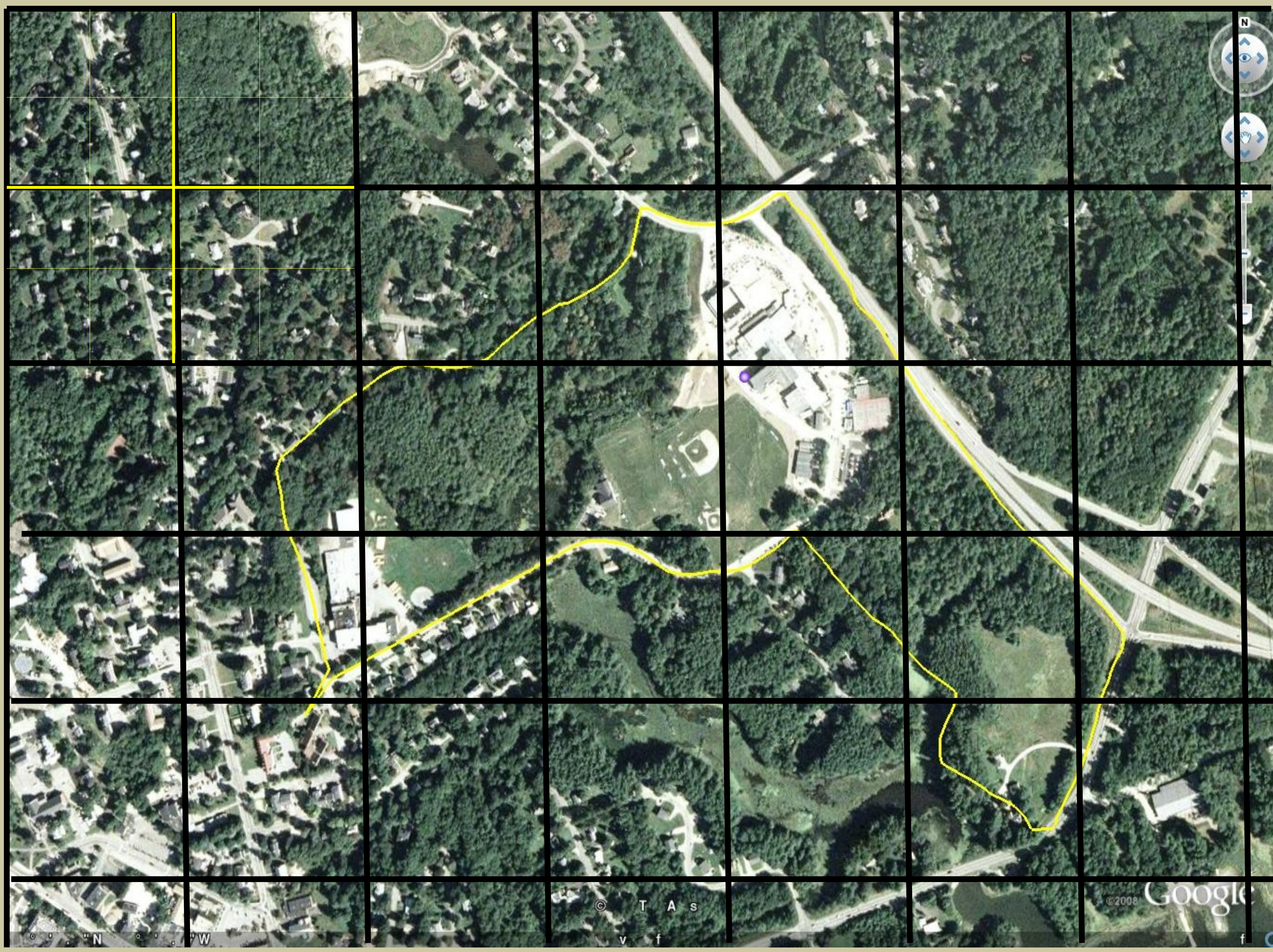
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Final Steps…

- Multiply carbon storage in g C/m^2 (as determined by your plot measurements or the model) by the total schoolyard area in m^2 to find g C for the entire school yard.

Extensions

- How would schoolyard carbon storage change if…
  - Trees were cleared to put in a parking lot?
  - Trees were cleared to make a new sports field?
  - Trees were cleared and used to make several sports equipment sheds for the school, but the area was then allowed to re-grow?
  - Additional trees were planted around the school courtyard, at parking lot edges, or elsewhere on school property?
  - How can we determine how much carbon is added to the schoolyard each year through growth? And what additional questions can we address with this information?

Field Measurements of Forest Carbon

•Measuring carbon in your own schoolyard – plot measurements and scaling locally

•Establishing a Carbon Cycle plot

•Measuring trees – tagging, species ID, tree diameter, etc

•Existing GLOBE protocols and Carbon Cycle modifications

•NEW!!! Converting field measurements to estimates of carbon storage

•How do these measurements relate to the GLOBE Carbon Cycle biomass modeling activities?

Sample Site Protocol

Carbon sample site protocol is based on GLOBE Land Cover Sample Site Protocol.

If the protocol for a Land Cover site can be followed, the site could serve both purposes. The basic difference is that Carbon Cycle requirements are more flexible than those of Landcover.

Establishment of a 30x30m* plot

Requirements:

Compass, Pacing, Measuring tape, Flagging, GPS

*Carbon Cycle plot size can be varied if necessary

Field Measurements of Forest Carbon

Biometry – the measurement of living organisms.

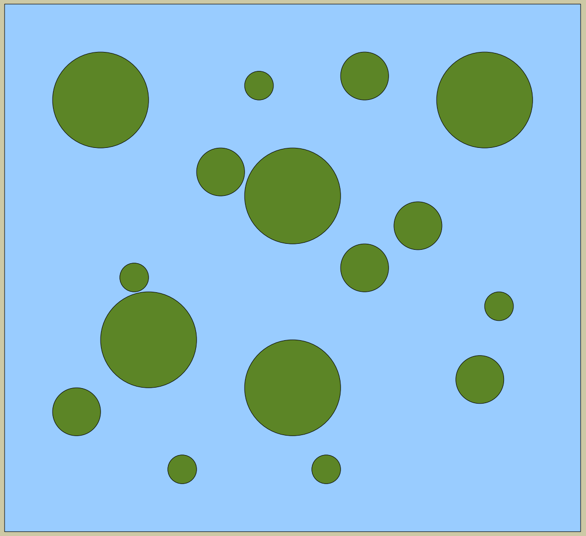
•GLOBE Land Cover Biometry goals:
Measurement of vegetation cover to classify landcover

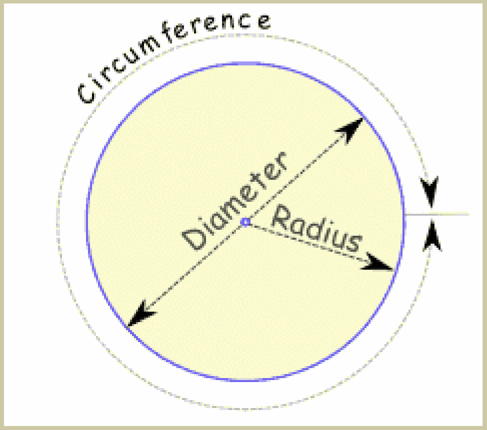
•GLOBE Carbon Cycle Biometry goals:
Measurement of trees to determine biomass and carbon storage

•Modified Biometry protocol for GLOBE Carbon Cycle
Major difference is that Carbon Cycle requires the measurement of ALL trees on the plot, not just a sampling of dominant species.

•The next exercises this afternoon will use sample data from a GLOBE CC plot

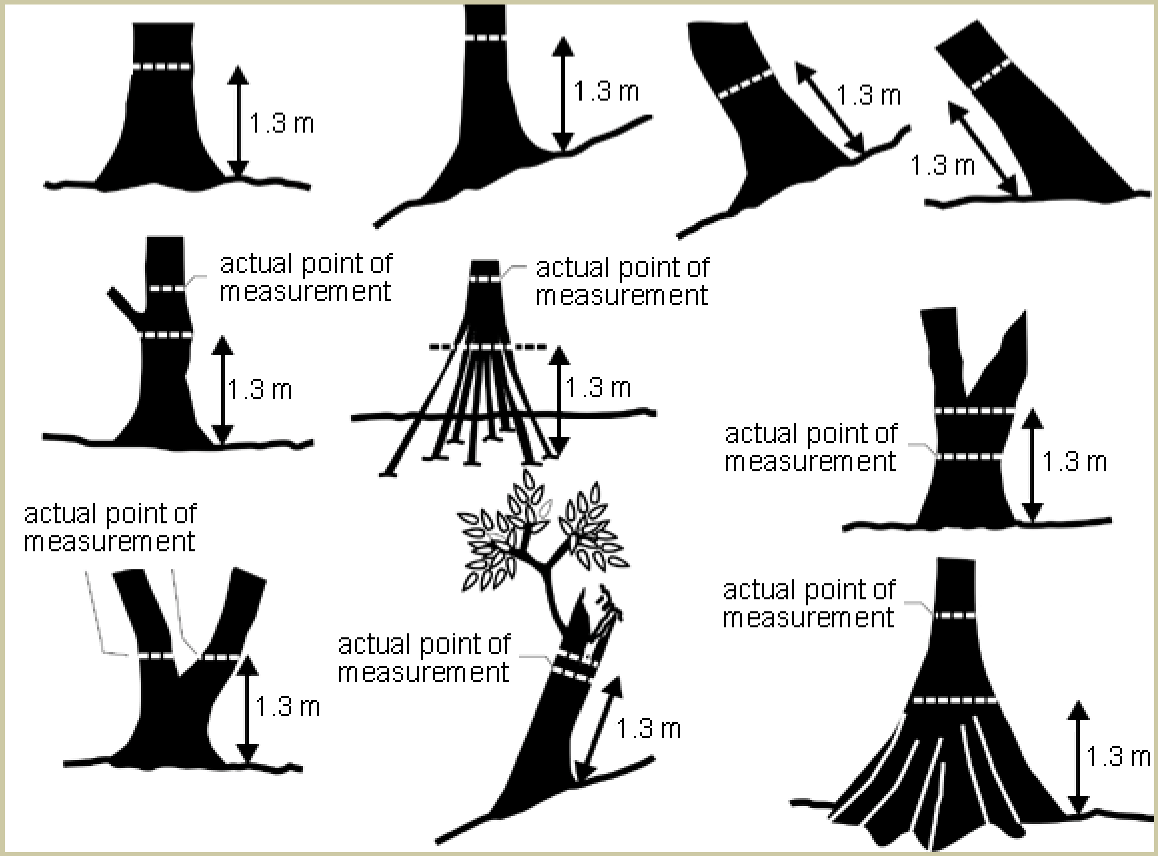
Field Measurements of Forest Carbon





DBH = circumference / pi

Field Measurements of Forest Carbon



Field Measurements of Forest Carbon

Allometry – study of the relative growth of a part of an organism in relation to the growth of the whole

For Carbon Cycle applications, we use the relationship between tree diameter (DBH) and biomass.

How do we determine the relationship between dbh and biomass?

Existing allometric equations – how were they developed, and what do they look like?

Examples – variation between and within species

GLOBE Carbon Cycle

Field Measurements of Forest Carbon

Table 6.—Equation form key

Equation form description
log10 biomass = a + b * (log10(dia^c))
ln biomass = a + b * dia + c * (ln(dia^d))
ln biomass = a + b * ln(dia) + c * (d + (e * ln(dia)))
biomass = a + b * dia + c * (dia ^ d)
biomass = a + (b * dia) + c * (dia ^ 2) + d * (dia ^ 3)
biomass = a * (exp(b + (c * ln(dia)) + (d * dia)))
biomass = a + ((b * (dia ^ c))/((dia ^ c) + d))
log100 biomass = a + (b * log10(dia))
ln biomass = ln(a) + (b * ln(dia))

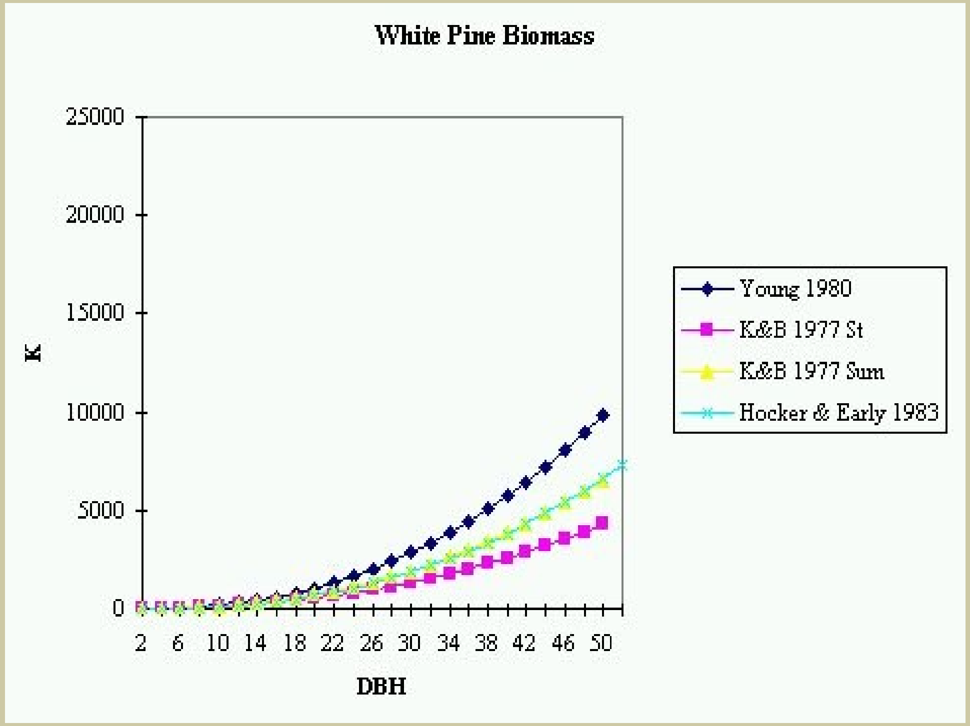
Many different variations on the form of the equation

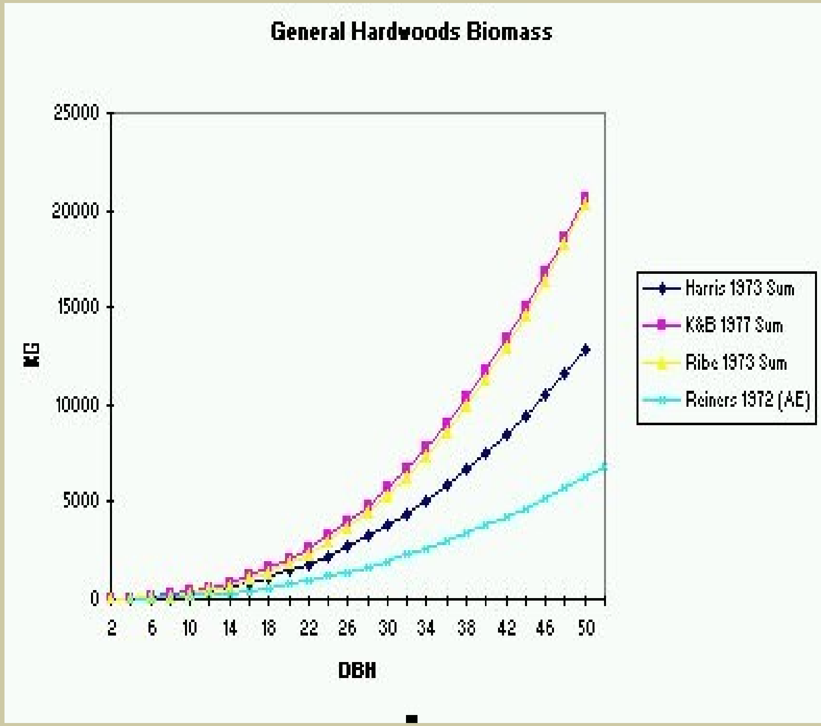
Table 9.—Sources and general locations for all equations (see Appendix A)

Reference no.	Reference	Origin
1	Acker and Easter 1994	Pacific Northwest
2	Adhikari et al. 1995	Himalayas
3	Anurag et al. 1989	India
4	Bajrang et al. 1996	North Indian plains
5	Baldwin 1989	Louisiana
6	Barclay et al. 1986	Vancouver, BC
7	Barney et al. 1978	Alaska
8	Bartelink 1996	Netherlands
9	Baskerville 1965	New Brunswick
10	Baskerville 1966	New Brunswick
11	Bergez et al. 1988	central France
12	Bickelhaupt et al. 1973	New York
13	Binkley 1983	British Columbia, Washington State
14	Binkley et al. 1984	Pacific Northwest
15	Bockheim and Lee 1984	Wisconsin
16	Boerner and Kost 1986	Ohio
17	Bormann 1990	Southeastern Alaska
18	Brenneman et al. 1978	West Virginia
19	Bridge 1979	Rhode Island
20	Briggs et al. 1989	New York

Many sources of equations that vary by geographic region and species

Field Measurements of Forest Carbon





GLOBE Carbon Cycle

Field Measurements of Forest Carbon

Table 1.—Parameters and equations[a] for estimating total aboveground biomass for all hardwood and softwood species in the United States (from Jenkins et al. 2003)

	Species group[b]	Parameter		Data points[c]	Max d.b.h.[d]	RMSE[e]	R^2
		β_0	β_1				
					cm	*log units*	
Hardwood	Aspen/alder/ cottonwood/ willow	-2.2094	2.3867	230	70	0.507441	0.953
	Soft maple/birch	-1.9123	2.3651	316	66	0.491685	0.958
	Mixed hardwood	-2.4800	2.4835	289	56	0.360458	0.980
	Hard maple/oak/ hickory/ beech	-2.0127	2.4342	485	73	0.236483	0.988
Softwood	Cedar/larch	-2.0336	2.2592	196	250	0.294574	0.981
	Douglas-fir	-2.2304	2.4435	165	210	0.218712	0.992
	True fir/hemlock	-2.5384	2.4814	395	230	0.182329	0.992
	Pine	-2.5356	2.4349	331	180	0.253781	0.987
	Spruce	-2.0773	2.3323	212	250	0.250424	0.988
Woodland[f]	Juniper/oak/ mesquite	-0.7152	1.7029	61	78	0.384331	0.938

[a]Biomass equation:

$$bm = \text{Exp}(\beta_0 + \beta_1 \ln dbh)$$

where

bm = total aboveground biomass (kg) for trees 2.5 cm and larger in d.b.h.

dbh = diameter at breast height (cm)

Exp = exponential function

ln = natural log base "e" (2.718282)

[b]See Table 4 for guidelines on assigning species to each species group.

[c]Number of data points generated from published equations (generally at intervals of 5 cm d.b.h.) for parameter estimation.

[d]Maximum d.b.h. of trees measured in published equations.

[e]Root mean squared error or estimate of the standard deviation of the regression error term in natural log units.

[f]Includes both hardwood and softwood species from dryland forests.

Lookup table for all US species and associated 'species group'

APPENDIX A. Species groups (SG*) identified for Forest Inventory and Analysis (FIA†) species list.

SG	Genus	Species	FIA	Common name
aa	*Alnus*	*rhombifolia*	352	White alder
aa		*rubra*	351	Red alder
...				
mo		*texana*	408	Black hickory
mo		*tomentosa*	409	Mockernut hickory
mo	*Fagus*	*grandifolia*	531	American beech
...				
mh	*Catalpa*	*bignonioides*	451	Southern catalpa
mh		*speciosa*	452	Northern catalpa
mh	*Fraxinus*	*americana*	541	White ash
mh				
...		*latifolia*	542	Oregon ash
mb		*saccharinum*	317	Silver maple
mb		*spicatum*	319	Mountain maple
mb	*Betula*	*alleghaniensis*	371	Yellow birch
mb		*lenta*	372	Sweet birch
...				
dt	*Pseudotsuga*	*macrocarpa*	201	Bigcone Douglas-fir
dt		*menziesii*	202	Douglas-fir
...				

Field Measurements of Forest Carbon

	A	B	C	D	E
4	**Date/Time:**	2007	August	28	9-11 EST/13-15 UT
5		Year	Month	Day	Hour (local)/ Hour (UT)
6	**Latitude:**	43 DEG 7.436' N	**Longitude:**	70 DEG 55.71' W	**Elevation:** ______
7		Decimal Degrees		Decimal Degrees	Meters
8	**Recorded B**	Sarah, Rita, Mary			
9					
10	**Tree Tag #**	All		Collection Year#:	1
11			**Date:**	8/2007	
12	**Tree Tag #**	**Species Common or Scientific Name**	**Species Group**	**Circumference (cm)**	**Field Notes**
13	110	Eastern White Pine	Pine	179.7	
14	132	Eastern White Pine	Pine	236	
15	134	Eastern White Pine	Pine	277.5	
16	150	Eastern White Pine	Pine	142.1	
17	157	Eastern White Pine	Pine	272.5	
18	107	Eastern Hemlock	FirHemlock	26	
19	108	Eastern Hemlock	FirHemlock	29.9	
20	139	Eastern Hemlock	FirHemlock	92.1	
21	149	Basswood	MapleOak	27.9	
22	130	Ironwood	MapleOak	35	

Field Measurements of Forest Carbon

GLOBE Carbon Cycle Field Data - Biomass Calculations

Note: Do not edit this sheet. The information on this sheet in the blue sections will automatically be imported from other sheets in this file. To add/change/delete trees, make all of your changes to the FieldDataEntry worksheet. Biomass values for each tree are calculated in the center block.

	A	B	C	D	E	F	G	H	I	J
6	**Data imported from FieldDataEntry tab**				**Calculated Biomass Values - Scroll down to see the total for each column**					
7	**Tree Tag #**	**Common or Scientific Name**	**Species Group**	**Circumference (cm)**	**Diameter (cm)**	**Total Aboveground Biomass(kg)**	**Foliage Biomass (kg)**	**Stem Biomass (kg)**	**Branch Biomass (kg)**	**Total Wood Biomass (kg)**
8	**Tag**	**Name**	**Group**	**Circ**	**Dia**	**TotAboveBio**	**FolBio**	**StemBio**	**BranchBio**	**h**
9	126	Musclewood	MapleOak	15.5	4.93	6.50	0.18	2.21	4.12	6.33
10	125	Musclewood	MapleOak	15.7	5.00	6.71	0.18	2.31	4.22	6.53
11	156	Musclewood	MapleOak	16.2	5.16	7.24	0.19	2.56	4.50	7.06
12	153	Sugar Maple	MapleOak	16.4	5.22	7.46	0.19	2.67	4.61	7.27
13	135	Musclewood	MapleOak	17.1	5.44	8.26	0.20	3.06	5.01	8.06
14	120	Sugar Maple	MapleOak	17.2	5.47	8.38	0.20	3.11	5.06	8.18
15	129	Sugar Maple	MapleOak	17.4	5.54	8.62	0.20	3.23	5.18	8.41
16	141	Musclewood	MapleOak	17.5	5.57	8.74	0.21	3.29	5.24	8.53
17	124	Musclewood	MapleOak	18.6	5.92	10.14	0.23	4.01	5.91	9.91
18	154	Black Birch	SoftMapleBirch	18.6	5.92	9.91	0.22	3.92	5.78	9.69

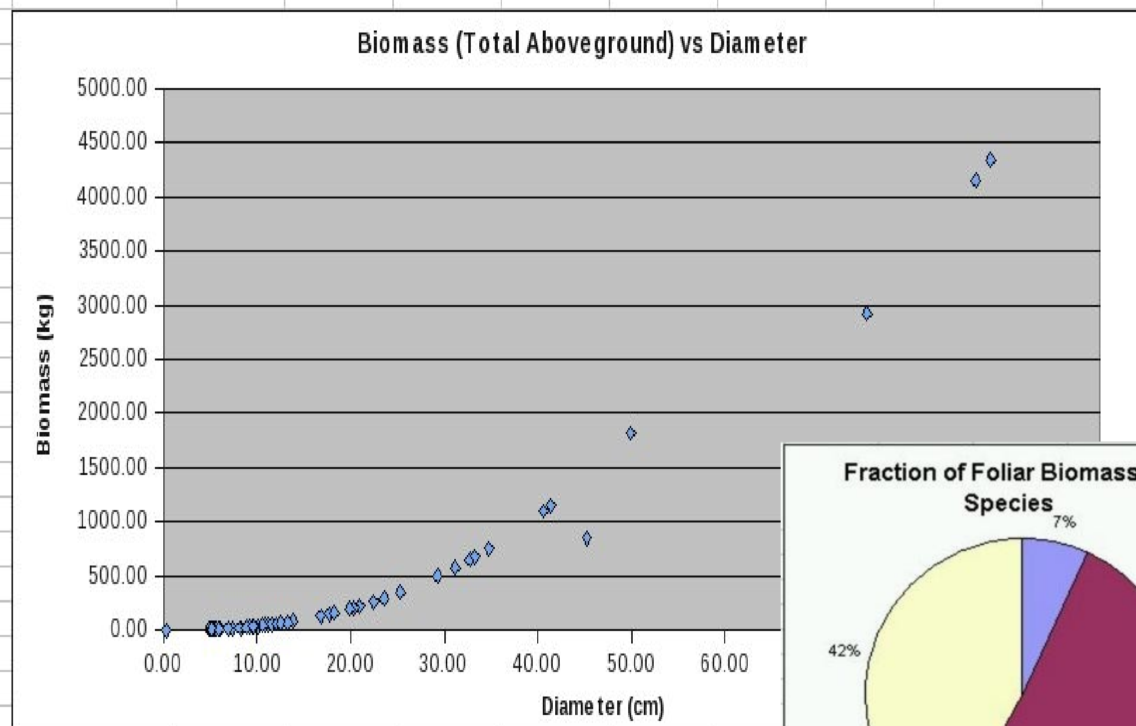
Field Measurements of Forest Carbon

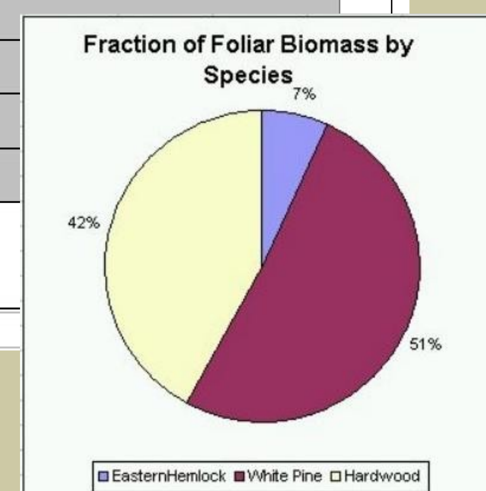
Biomass Summary tables and graphs

This excel 'pivot table' summarizes biomass data from the BiomassCalculations tab. Before using this table, be sure to click right on the table, and select 'refresh data'.

This graph is an example of how you might look at some of the data from this activity. Here you see the relationship between aboveground biomass and tree diameter. What other questions can you ask about this dataset, and how would you design graphs to help answer those questions?

Group	Data	Total
FirHemlock	Sum of TotAboveBio	41
	Sum of FolBio	4
	Sum of StemBio	27
	Sum of BranchBio	10
MapleOak	Sum of TotAboveBio	10806
	Sum of FolBio	111
	Sum of StemBio	7945
	Sum of BranchBio	2750
Pine	Sum of TotAboveBio	12265
	Sum of FolBio	674
	Sum of StemBio	9734
	Sum of BranchBio	1857
SoftMapleBirch	Sum of TotAboveBio	119
	Sum of FolBio	2
	Sum of StemBio	66
	Sum of BranchBio	52
Total Sum of TotAboveBio		23232
Total Sum of FolBio		790
Total Sum of StemBio		17773
Total Sum of BranchBio		4669





GLOBE Carbon Cycle

Field Measurements of Forest Carbon

	A	B	C	D	E	F	G	H	I
1	**Plot Description Worksheet**								
2									
3	In order to compare your data to data collected by others, our calculation of biomass per plot will be converted to biomass per hectare. We will be able to do this with some information that you will enter here about your plot size. Enter data into **either** 1 or 2 below:								
4									
5									
6	1. If your plot is rectangular, enter the **LENGTH of a SHORT and LONG side**					30	30		
7	2. If your plot is circular, enter the plot **RADIUS**					0			
8									
9	Calculated plot size in m^2					900			
10									
11									
12									
13									
14									
15									
16									
17									