Buds, Leaves and Global Warming

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- www.harvardforest.harvard.edu/schoolyard-lter-program
- www.harvardforest.harvard.edu/buds-leaves-global-warming
- www.harvardforest.harvard.edu/autumn-foliage-color

What is **phenology**?

The science of the relations between climate and periodic biological phenomena (i.e leaf emergence, flowering, leaf senescence/drop, animal migration, hibernation etc.)

Why study phenology?

- Data provide markers to track mass and energy interactions between the atmosphere and biosphere.

- Long-term data sets are records of the biosphere's responses to global change.

- Native species and inter-regional indicator plant (clones) observations can be used to calibrate satellite and 'phenocam' digital data.

- Leafout and leaf senescence in temperate regions influence meteorological phenomena.

What are the main factors affecting the timing of woody species leaf phenology?

- **Fall leaf drop**
  - Temperature and frosts
  - Day length
  - Drought
  - Wind

- **Spring leafout**
  - Cold treatment
  - Cumulative heat sum (growing degree days)
  - Day length

Trees approaching full color at Harvard Forest

As leaves senesce in the fall chlorophyll breaks down and the components are stored for use in the spring. This reveals yellow pigments, carotenoids, which have also been present during the growing season, but masked by chlorophyll.

Many, but not all, trees in our area also have the ability to produce red pigments, called anthocyanins, by using energy from sunlight. These red pigments produce the beautiful orange, red and purple colors that make our forests so beautiful each fall.

Because anthocyanins need sunlight for their production, red leaves tend to develop around the edges of a tree first.

This is not the case for yellow leaves, which are the result of unmasking the already present corotenoids as the chlorophyll breaks down.

For more on fall color see: **www.harvardforest.harvard.edu/autumn-foliage-color**

Harvard Forest Study

- Started in 1990 (spring) and 1991 (fall, but fall 1992 not done)

- Originally 33 species of trees and shrubs (3-5 individuals per species), but in 2002 decreased to 15 species in fall and 9 species in spring to reduce the time needed for the study

- I observe about weekly, but more often in late April-early May and early October when events are progressing most rapidly

- I observe and estimate % values (leaf emergence, leaf development, leaf color, leaf drop) over the entire tree (rather than a set number of tagged leaves/bids), which is in fact easier but doesn't work with younger students

NAME: JOK   DATE: 9-2-04 AM MID 60'S CLR

COM NAME	TREE ID	TAG	LF COLOR	LF FALL	FOPEN	FPAST	COMMENTS
SHADBUSH	AMSP-01	PP003	— ?	—			a couple of orange/yellow lvs
WHITE ASH	FRAM-01	PP004	~15% ?	<1% ?			yellow
BLK. CHERRY	PRSE-01	PP005	<5% ?	~1%			yellow
RED MAPLE	ACRU-01	PP008	~1% ?	— ?			yellowing
SHADBUSH	AMSP-02	PP011	<1%	—			orange/yellow
SUG. MAPLE	ACSA-01	PP012	—	—			
BLK. BIRCH	BELE-01	PP013	~1%	— ?			yellow
YEL. BIRCH	BEAL-01	PP014	~1%	— ?			a few lvs on gnd yellow
RED OAK	QURU-01	PP016	~ ?	—			poss slight yellowing
WHITE OAK	QUAL-04	PP019A	—	~			
BEECH	FAGR-01	PP020	✓	—			slight yellowing
STR. MAPLE	ACPE-01	PP022	~1%	— ?			a few lvs yellow
BLACK OAK	QUVE-01	PP024	—	—			
PAPER BIRCH	BEPA-01	PP031	<1%	— ?			a few yellowing lvs.
RED MAPLE	ACRU-02	PP033	~5%	~1% ?			yellow/red.
STR. MAPLE	ACRE-02	PP035	~1%	— ?			yellow
BLACK GUM	NYSY-04	PP037A	~1% ?	—			yellow/orange
BEECH	FAGR-05	PP039A	—	~			
STR. MAPLE	ACPE-03	PP040	— ?	~			
YEL. BIRCH	BEAL-02	PP042	—	—			
BLK. BIRCH	BELE-02	PP043	—	—			
BEECH	FAGR-06	PP046A	—	—			
SHADBUSH	AMSP-03	PP056	~1%	— ?			yellow (a few lvs)
BLACK GUM	NYSY-02	PP057	<1%	—			several webworm nests red/orange
YEL. BIRCH	BEAL-03	PP059	— ?	—			
BLACK GUM	NYSY-03	PP059A	~3%	— ?			orange/red.
RED OAK	QURU-02	PP061	—	—			
RED MAPLE	ACRU-03	PP063	<1%	— ?			a few yellowing lvs.
STR. MAPLE	ACPE-04	PP067	— ?	—			some paling
BLACK OAK	QUVE-02	PP069	—	—			
RED MAPLE	ACRU-04	PP074	~1%	— ?			yellow
WHITE OAK	QUAL-02	PP075	<1%	— ?			yellow/red
BLK. BIRCH	BELE-03	PP079	—	~			
BLACK OAK	QUVE-03	PP081	~3%	— ?			yellow/brown
BLACK OAK	QUVE-04	PP083	—	—			
RED OAK	QURU-03	PP084	✓	—			
BLK. CHERRY	PRSE-02	PP086	~10% ?	~1%			Yellow/brown.
PAPER BIRCH	BEPA-02	PP087	✓	~			
PAPER BIRCH	BEPA-03	PP088	—	~			
PAPER BIRCH	BEPA-04	PP089	~3% ?	~1% ?			yellow/brown.
WHITE ASH	FRAM-02	PP091	~ ?	✓			
BEECH	FAGR-04	PP092	✓	—			
WHITE OAK	QUAL-03	PP093	—	~			
SUG. MAPLE	ACSA-02	PP095	✓	—			
WHITE ASH	FRAM-03	PP096	—	—			
SUG. MAPLE	ACSA-03	PP103	~1%	<1%			orange/yellow
BLK. CHERRY	PRSE-04	PP104A	~1% ?	— ?			yellow - several webworm nests
RED OAK	QURU-04	PP105	— ?	—			a few brown/yellow lvs.
RED MAPLE	ACRU-05	PP106	~2%	— ?			tinged red.
WHITE ASH	FRAM-04	PP108	—	~			

STREAM BY # 10 not flowing   a few small puddles.
STREAM BY # 42 not flowing - a few puddles mud damp.
STREAM BY # 84 dry /mud dry
STREAM BY # 94 not flowing /no puddles   HEMLOCK HOLLOW small pool of water (2-3 m across) <5% full.

Cloned lilac N - paling none fallen mud wet.   Euonymous - lower ~1% R —
       S - "   "   "   "   "   slope N ~ 2% —
                                                 "   sides S "

NAME: JOK   DATE: 9-30-03   PM   UPPER 50's NYC
acorns falling

COM NAME	TREE ID	TAG	LF COLOR	LF FALL	FOPEN	FPAST	COMMENTS
SHADBUSH	AMSP-01	PP003	~30%?	~3%?			yellow/orange
WHITE ASH	FRAM-01	PP004	~75%?	~12%?			yellow/brown/purple
BLK. CHERRY	PRSE-01	PP005	~20%?	~25%?			yellow
RED MAPLE	ACRU-01	PP008	~30%?	~3%?			yellow/red.
SHADBUSH	AMSP-02	PP011	~10%?	~1%?			yellow/orange
SUG. MAPLE	ACSA-01	PP012	~1%?	~?			yellowing
BLK. BIRCH	BELE-01	PP013	~30%?	~5%?			yellow/gold.
YEL. BIRCH	BEAL-01	PP014	~25%?	~3%?			yellow/gold
RED OAK	QURU-01	PP016	~3%?	~?			yellowing
WHITE OAK	QUAL-04	PP019A	~5%?	~?			yellow
BEECH	FAGR-01	PP020	~1%?	~1%?			yellowing
STR. MAPLE	ACPE-01	PP022	~5%?	~1%			yellow
BLACK OAK	QUVE-01	PP024	~5%?	~3%?			yellow/brown
PAPER BIRCH	BEPA-01	PP031	~20%	~5%?			yellow/brown
RED MAPLE	ACRU-02	PP033	~45%?	~15%?			yellow/red
STR. MAPLE	ACRE-02	PP035	~5%?	~1%			yellow
BLACK GUM	NYSY-04	PP037A	~10%	~1%			orange/yellow
BEECH	FAGR-05	PP039A	~1%	~?			yellowing
STR. MAPLE	ACPE-03	PP040	~7%?	~1%?			yellow
YEL. BIRCH	BEAL-02	PP042	~12%?	~5%?			yellow
BLK. BIRCH	BELE-02	PP043	~10%?	~3%?			yellow/gold.
BEECH	FAGR-03	PP046	~100%	~90%?			brown/gold
SHADBUSH	AMSP-03	PP056	~45%?	~22%?			yellow/brown/orange
BLACK GUM	NYSY-02	PP057	~17%?	~2%?			orange
YEL. BIRCH	BEAL-03	PP059	~65%?	~5%?			yellow
BLACK GUM	NYSY-03	PP059A	~50%?	~5%?			orange/red.
RED OAK	QURU-02	PP061	~3%?	~?			yellowing
RED MAPLE	ACRU-03	PP063	~20%?	~2%?			red/yellow
STR. MAPLE	ACPE-04	PP067	~23%?	~1%?			yellow/brown.
BLACK OAK	QUVE-02	PP069	~3%?	~?			yellow/brown.
RED MAPLE	ACRU-04	PP074	~40%?	~5%?			red/yellow.
WHITE OAK	QUAL-02	PP075	~60%?	~5%?			brown/yellow
BLK. BIRCH	BELE-03	PP079	~27%?	~2%?			yellow/gold
BLACK OAK	QUVE-03	PP081	~35%?	~10%?			brown/yellow
BLACK OAK	QUVE-04	PP083	~3%?	~?			brown/yellow
RED OAK	QURU-03	PP084	~1%?	~?			paling
BLK. CHERRY	PRSE-02	PP086	~33%	~10%??			yellow/brown spots/pink
PAPER BIRCH	BEPA-02	PP087	~8%?	~2%?			yellow/brown.
PAPER BIRCH	BEPA-03	PP088	~10%?	~1%?			yellow
PAPER BIRCH	BEPA-04	PP089	~45%?	~17%?			yellow
WHITE ASH	FRAM-02	PP091	~70%?	~3%?			yellow/purple/brown
BEECH	FAGR-04	PP092	~3%?	~?			gold/brown.
WHITE OAK	QUAL-03	PP093	~3%?	~1%?			red/yellow
SUG. MAPLE	ACSA-02	PP095	~1%?	~1%?			yellowing
WHITE ASH	FRAM-03	PP096	~10%?	~1%?			yellow/brown.
SUG. MAPLE	ACSA-03	PP103	~38%?	~15%?			orange/yellow - seeds just starting to drop.
BLK. CHERRY	PRSE-04	PP104A	~40%?	~30%?			yellow/pink
RED OAK	QURU-04	PP105	~5%?	~1%?			brown/yellow
RED MAPLE	ACRU-05	PP106	~20%?	~2%?			red/yellow
WHITE ASH	FRAM-04	PP108	~12%?	~1%?			purple/yellow

STREAM BY # 10 flowing well
STREAM BY # 42 flowing - puddles fairly full
STREAM BY # 84 dry - muddy
STREAM BY # 94 flowing fairly well (moderate)

witch hazel #41 first flowers open.
" #60 many flowers open
" #60 don't see flws

HEMLOCK HOLLOW ~25% full?   Euonymous on lawn   color fall
cloned lilac N ~65%? ~? yellow/brown   Lyrur L   ~25%? ~3%?
"   S ~50%? ~?   "   "   R   ~5%? ~?
"   "   ~3%? ~?

Breezy   heavy rain last night

slimy cap mushrooms by #46 up/some going past

Eur larch by #14 just starting to yellow
Lots of wp needles (fresh?) on grd

| COM NAME	TREE ID	TAG	LF COLOR	LF FALL	FOPEN	FPAST	COMMENTS
SHADBUSH	AMSP-01	PP003	~99%	~98%?			orange/brown
WHITE ASH	FRAM-01	PP004	100	100			
BLK. CHERRY	PRSE-01	PP005	~65%?	~55%?			yellow/pink/brown spots.
RED MAPLE	ACRU-01	PP008	100%	100%			
SHADBUSH	AMSP-02	PP011	~99%?	~30%?			orange/brown/yellow
SUG. MAPLE	ACSA-01	PP012	~50%?	~3%?			yellow/orange/brown
BLK. BIRCH	BELE-01	PP013	~98%?	~33%??			gold/yellow
YEL. BIRCH	BEAL-01	PP014	~98%	~98%?			brown/yellow
RED OAK	QURU-01	PP016	~37%?	~3%??			yellow/brown
WHITE OAK	QUAL-04	PP019A	~60%?	~5%??			red/brown/yellow
BEECH	FAGR-01	PP020	~7%?	~1%?			yellow/brown.
STR. MAPLE	ACPE-01	PP022	~75%?	~5%?			yellow
BLACK OAK	QUVE-01	PP024	~60%??	~10%??			brown/yellow
PAPER BIRCH	BEPA-01	PP031	~100%	~78%?			yellow/brown
RED MAPLE	ACRU-02	PP033	100%	~100%			
STR. MAPLE	ACRE-02	PP035	100%	~70%?			yellow/gold/brown.
BLACK GUM	NYSY-04	PP037A	~80%?	~60%?			orange/brown.
BEECH	FAGR-05	PP039A	~33%?	~5%??			yellow/copper
STR. MAPLE	ACPE-03	PP040	~100%	~85%?			yellow/brown
YEL. BIRCH	BEAL-02	PP042	~100%	~97%?			yellow/brown
BLK. BIRCH	BELE-02	PP043	~100%	~78%?			yellow/brown
BEECH	FAGR-06	PP046A	~15%?	~3%?			yellow/brown
SHADBUSH	AMSP-03	PP056	100%	99%			brown/orange
BLACK GUM	NYSY-02	PP057	100%	99%			brown/red.
YEL. BIRCH	BEAL-03	PP059	100%	99%			brown/(curled)
BLACK GUM	NYSY-03	PP059A	100%	~97%?			orange/yellow
RED OAK	QURU-02	PP061	~90%?	~42%?			brown/yellow
RED MAPLE	ACRU-03	PP063	100%	100%			
STR. MAPLE	ACPE-04	PP067	~100%	~78%?			yellow/brown.
BLACK OAK	QUVE-02	PP069	~90%?	~55%?			brown/yellow
RED MAPLE	ACRU-04	PP074	100%	100%			
WHITE OAK	QUAL-02	PP075	~100%	~65%?			brown/red/yellow
BLK. BIRCH	BELE-03	PP079	~99%	~63%?			yellow/gold/brown.
BLACK OAK	QUVE-03	PP081	~85%?	~75%?			brown/yellow
BLACK OAK	QUVE-04	PP083	~70%?	~15%??			brown/red.
RED OAK	QURU-03	PP084	~40%?	~3%??			yellow/brown
BLK. CHERRY	PRSE-02	PP086	~73%?	~62%?			yellow/brown
PAPER BIRCH	BEPA-02	PP087	~90%?	~95%?			yellow/brown
PAPER BIRCH	BEPA-03	PP088	100%	~100%			
PAPER BIRCH	BEPA-04	PP089	~100%	~95%?			yellow/brown
WHITE ASH	FRAM-02	PP091	100	100			
BEECH	FAGR-04	PP092	~10%?	~5%??			yellow/brown
WHITE OAK	QUAL-03	PP093	~50%?	~3%??			brown/yellow/red. (past 5% full.)
SUG. MAPLE	ACSA-02	PP095	~67%?	~3%?			orange/yellow
WHITE ASH	FRAM-03	PP096	~100%	98%?			brown
SUG. MAPLE	ACSA-03	PP103	~97%?	~42%?			orange/yellow/red
BLK. CHERRY	PRSE-04	PP104A	~80%?	~55%??			pink/yellow
RED OAK	QURU-04	PP105	~50%?	~5%?			yellow/brown (reg~78 fall?)
RED MAPLE	ACRU-05	PP106	~100%	~90%?			red/yellow
WHITE ASH	FRAM-04	PP108	~80%?	~55%?			yellow/brown/purple

STREAM BY # 10 flowing very well
STREAM BY # 42 flowing gently puddles ~full
STREAM BY # 84 dry/mud abt damp(damp/dry)
STREAM BY # 94 flowing well

witch hazel # 41   color fall bloom
                    ~100% ~35%? going past?
         60   100% ~50%? some buds, past
         80   ~80%? ~50%? ~full bloom?

HEMLOCK HOLLOW ~full

                    color fall
evonymous lawn   ~85%? ~15%?
         near L   ~65%? ~1%?
             " R ~40%? ~?

Clover lline   N ~75%? ~52%? stem/leaves spots
               S ~90%? ~15%?

| DATE	TREE ID	TAG	LF COLOR	LF FALL	FOPEN	FPAST	COMMENTS	CIRCUIT
9/2/2004	AMSP-01	PP003	0	0				1
9/7/2004	AMSP-01	PP003	1	0				1
9/16/2004	AMSP-01	PP003	3	1				1
9/23/2004	AMSP-01	PP003	5	1				1
9/30/2004	AMSP-01	PP003	23	2				1
10/7/2004	AMSP-01	PP003	45	5				1
10/12/2004	AMSP-01	PP003	95	35				1
10/16/2004	AMSP-01	PP003	99	92				1
10/22/2004	AMSP-01	PP003	100	100				1
10/28/2004	AMSP-01	PP003	100	100				1
11/4/2004	AMSP-01	PP003	100	100				1
11/16/2004	AMSP-01	PP003	100	100				1
9/2/2004	FRAM-01	PP004	15	0				2
9/7/2004	FRAM-01	PP004	18	1				2
9/16/2004	FRAM-01	PP004	50	5				2
9/23/2004	FRAM-01	PP004	65	8				2
9/30/2004	FRAM-01	PP004	95	70				2
10/7/2004	FRAM-01	PP004	100	98				2
10/12/2004	FRAM-01	PP004	100	100				2
10/16/2004	FRAM-01	PP004	100	100				2
10/22/2004	FRAM-01	PP004	100	100				2
10/28/2004	FRAM-01	PP004	100	100				2
11/4/2004	FRAM-01	PP004	100	100				2
11/16/2004	FRAM-01	PP004	100	100				2
9/2/2004	PRSE-01	PP005	3	1				3
9/7/2004	PRSE-01	PP005	3	1				3
9/16/2004	PRSE-01	PP005	18	5				3
9/23/2004	PRSE-01	PP005	18	15				3
9/30/2004	PRSE-01	PP005	15	17				3
10/7/2004	PRSE-01	PP005	17	27				3
10/12/2004	PRSE-01	PP005	40	50				3
10/16/2004	PRSE-01	PP005	65	55				3
10/22/2004	PRSE-01	PP005	80	73				3
10/28/2004	PRSE-01	PP005	95	85				3
11/4/2004	PRSE-01	PP005	100	100				3
11/16/2004	PRSE-01	PP005	100	100				3
9/2/2004	ACRU-01	PP008	1	0				4
9/7/2004	ACRU-01	PP008	1	0				4
9/16/2004	ACRU-01	PP008	7	1				4
9/23/2004	ACRU-01	PP008	10	2				4
9/30/2004	ACRU-01	PP008	22	8				4
10/7/2004	ACRU-01	PP008	80	15				4
10/12/2004	ACRU-01	PP008	100	90				4
10/16/2004	ACRU-01	PP008	100	100				4
10/22/2004	ACRU-01	PP008	100	100				4
10/28/2004	ACRU-01	PP008	100	100				4
11/4/2004	ACRU-01	PP008	100	100				4
11/16/2004	ACRU-01	PP008	100	100				4
9/2/2004	AMSP-02	PP011	0	0				5
9/7/2004	AMSP-02	PP011	0	0				5
9/16/2004	AMSP-02	PP011	3	0				5
9/23/2004	AMSP-02	PP011	3	0				5
9/30/2004	AMSP-02	PP011	7	1				5
10/7/2004	AMSP-02	PP011	20	2				5
10/12/2004	AMSP-02	PP011	90	10				5
10/16/2004	AMSP-02	PP011	99	30				5
10/22/2004	AMSP-02	PP011	100	82				5

50% bud break(BB) 75% leaf development(75) and 50% leaf fall(L50) for 4 species (Acer rubrum-ACRU, Betula alleghaniensis-BEAL, Quercus rubra-QURU and Q. alba-QUAL)
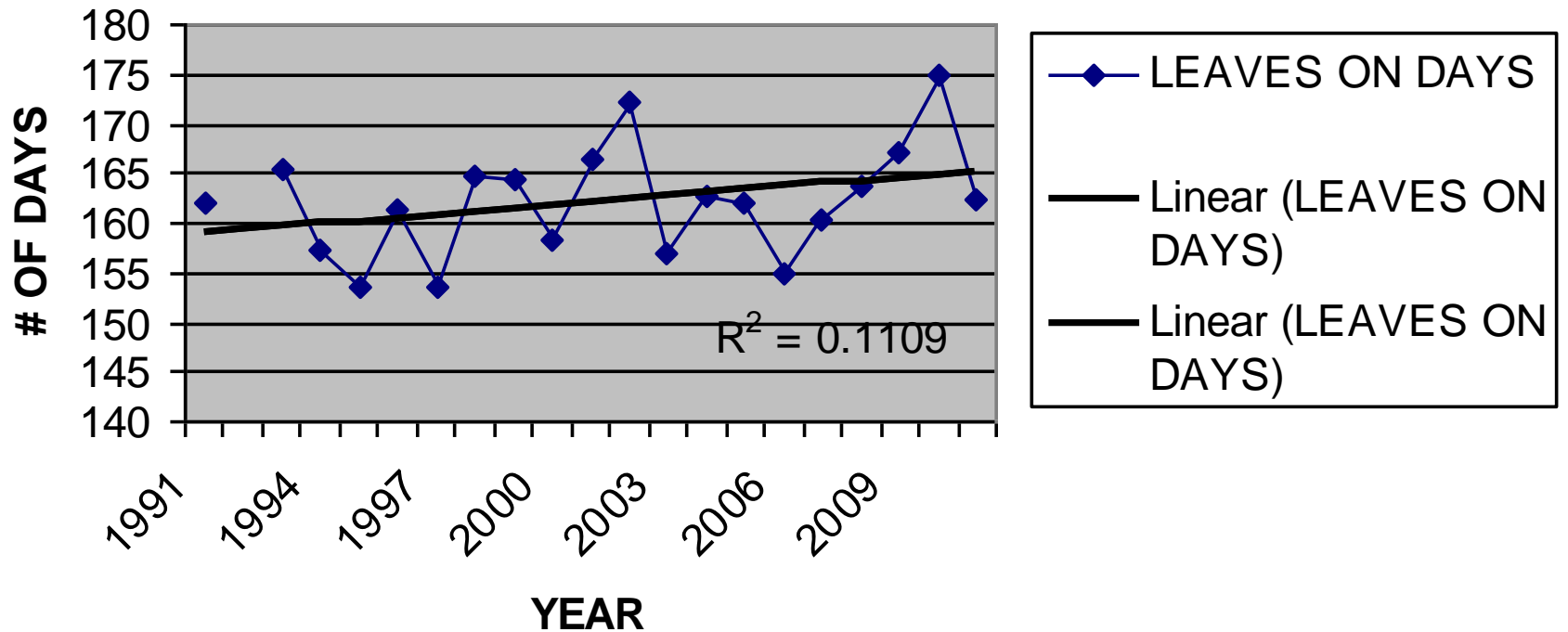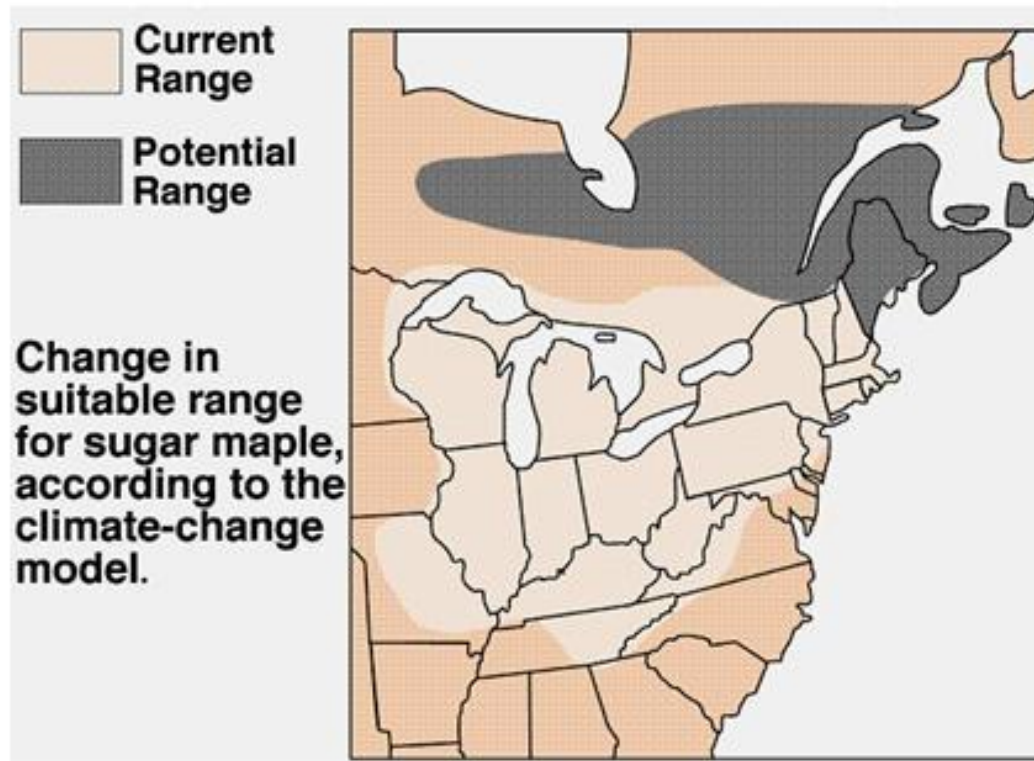
MEAN BB50 (4 SPP, N=15)

$R^2 = 0.0373$

4 SPP (N=15) LF50

$R^2 = 0.2268$
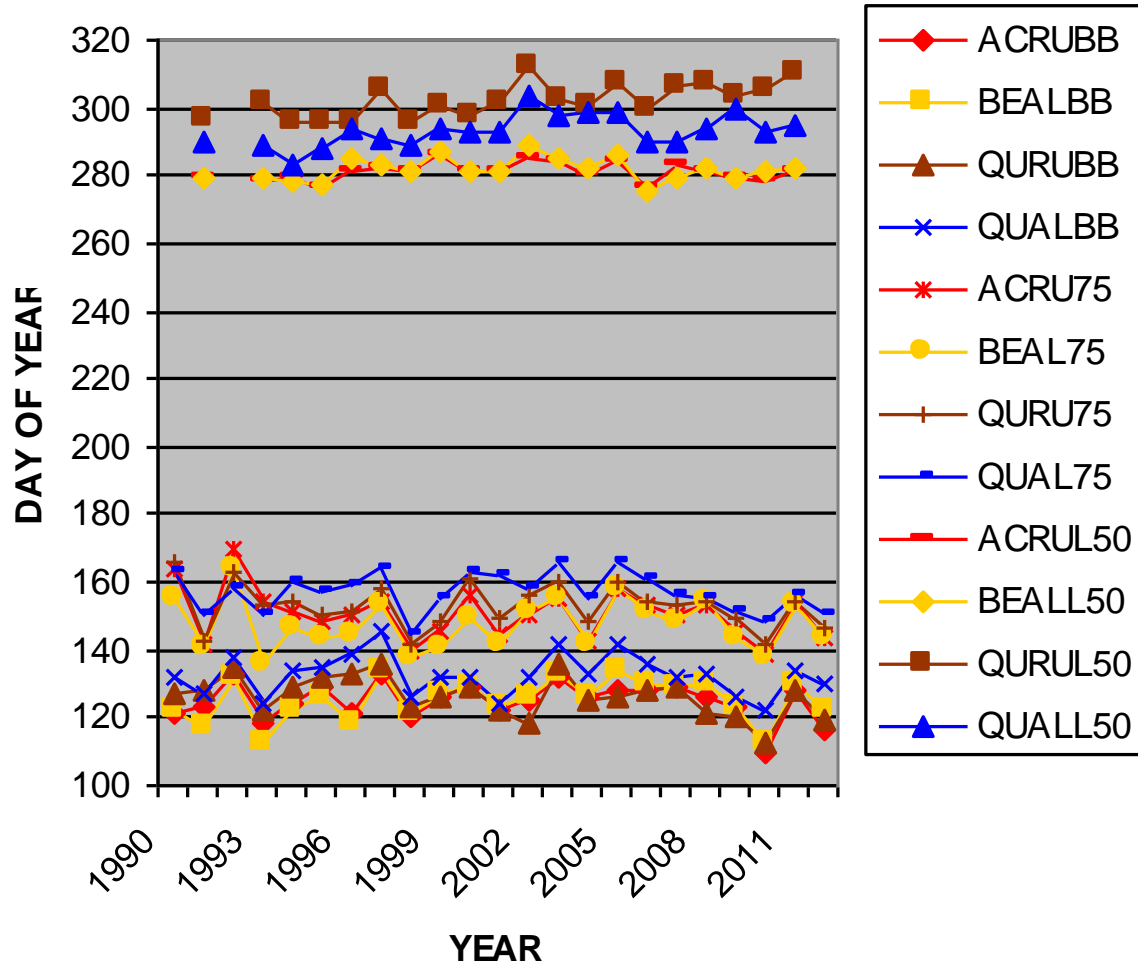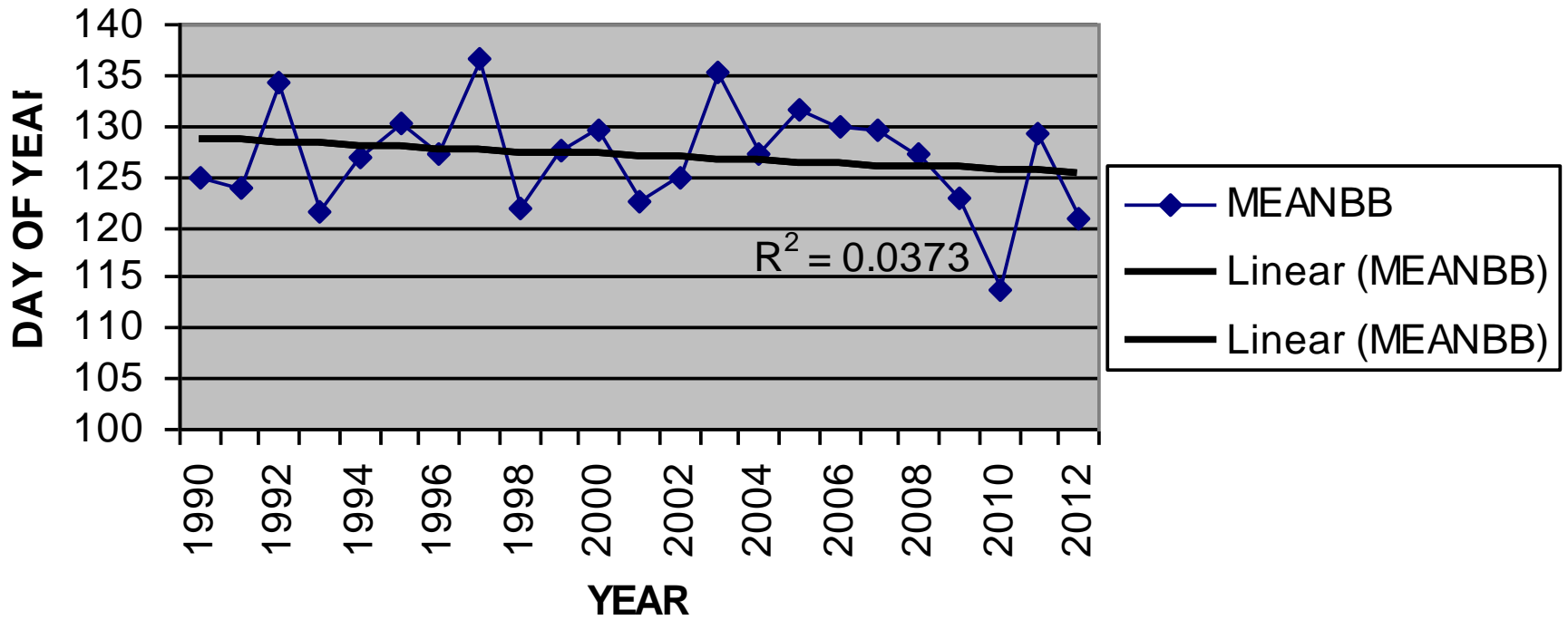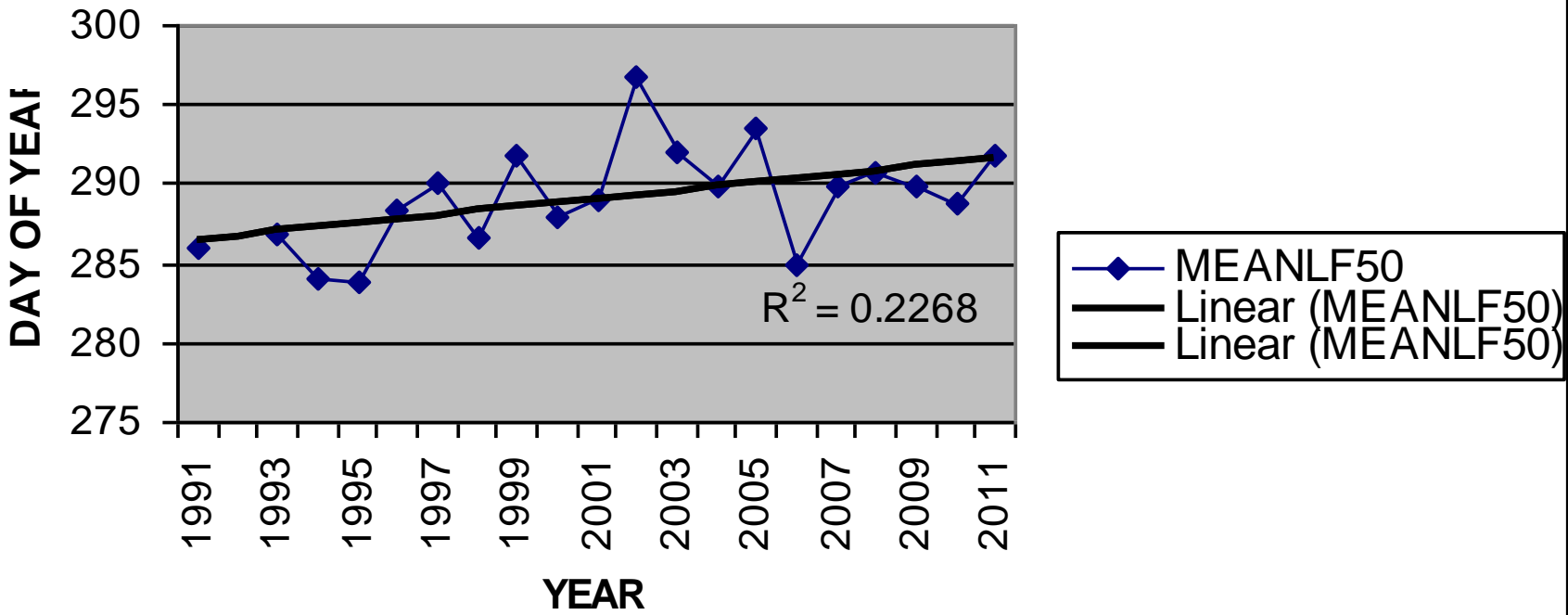
LEAVES ON DAYS (4 SPP, N=15)

$R^2 = 0.1109$

Impacts of Climate Warming

Climate models predict that most of New England will be outside the range of sugar maple by the end of this century

Current Range

Potential Range

Change in suitable range for sugar maple, according to the climate-change model.

The occurrence of temperatures cold enough to limit the survival of hemlock woolly adelgid will be greatly reduced in central New England

T. canadensis distribution
Projected Minimum Below -28.8°C
Current Minimum Below -28.8°C
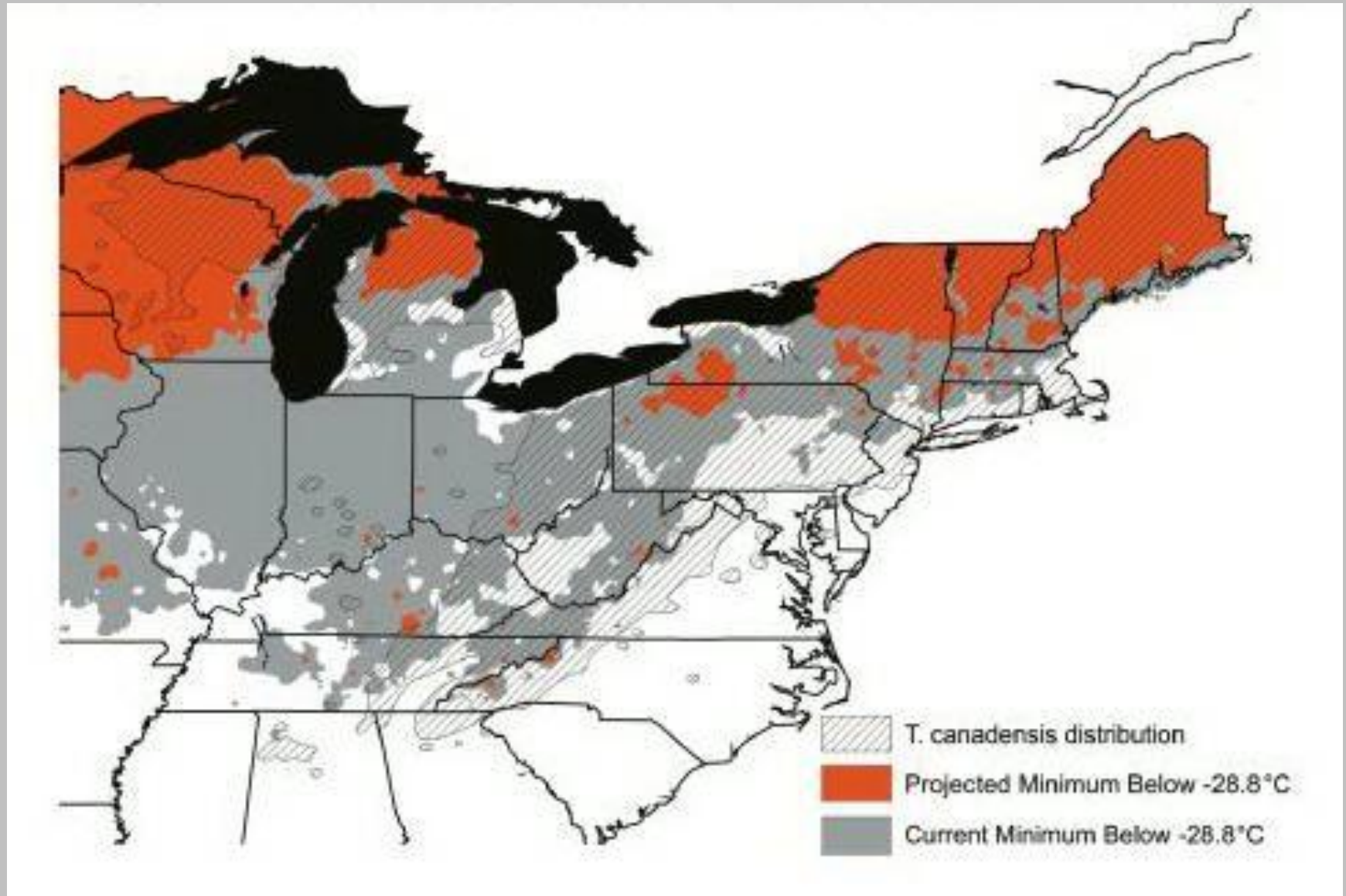
Choosing a Site and Trees

- **Sites** with a variety of native trees (when possible) with branches in easy reach of students, located in an easily monitored area, are best.

- **Trees in reach**-each study tree should have two or more branches on which students can reach and monitor 6 leaves.

- **Trees that will last**-try to pick trees that will have a low chance of being cut for maintenance or vandalized. This can be a challenge!

- **Tree variety**-a variety of native tree species is best, especially for comparing results across the region.

- **Tree branches**-try to use two or more branches on each tree (for replication), with one branch for each student research team.

A site with maples and birches having many branches within easy reach for this study.

Tree ID tips

- The first thing to look at is the arrangement of leaves, buds and branches. Are they opposite each other or staggered alternately along the branch or stem.
- Only a few native trees (maples, ashes, dogwoods – **MAD**) have opposite leaves/branches. The rest are alternate.
- Are the leaves simple (each leaf has a bud at the base of its stem or petiole) or compound (the leaf stem that is attached to the woody twig next to the bud has many leaflets along it)? The ashes, boxelder(ashleaf maple), hickories, walnut, butternut and sumacs are the main compound leaf species in this region.
- Then look at leaf shape, edges and vein pattern, bud shape and check for twig smell and bark characteristics.

Site preparation

- You will need one branch with 6 leaves/buds for each student team participating in the study.

- Label (with flagging) each tree in your study, 1 through X (X= total number of trees) and record the species of each tree. Plan to observe at least two branches on each study tree.

- Label (with flagging) each branch being studied on each tree with a letter, A, B, C,…etc. So each study branch will be identified with a tree number and branch letter (i.e. 1A, 1B, 1C, 2A etc.)

- If a branch (or tree) dies, not that unusual, try to pick another branch on that tree and use the next letter, pick a branch on another study tree of the same species and use the next letter for that tree, or try to find another tree of that species and add it to your study with new tree and branch labels.

Labeling leaves/buds

- This is probably the hardest part of this study, but it is necessary to ensure consistency in data collection. The teacher should choose and label trees and branches (6 leaves/buds per branch) before bringing students to the site.

- Branches are labeled by tying a piece of flagging or tape (with the tree and branch number/letter) just behind the 6 study leaves/buds on the branch.

- When choosing and labeling leaves/buds do not use the terminal/tip leaf/bud, but start counting at the next leaf from the tip as #1, then the next as #2, etc. On opposite leaved trees #1 and #2 will be paired across from each other. If there is a side branch on your main branch before you reach #6, use the tip bud on the side branch as the next # and continue using buds down the side branch until you reach #6 or, if necessary, return to leaves on the main branch. Note, you do use the tip bud on side branches, just not on the main branch.

Tagging a gray birch branch

Tag placed below the sixth leaf/bud (not counting the terminal leaf/bud).

Fall Data Collection

- Start data collection about the second week in Sept. and continue until all leaves have fallen or turned brown (many oaks and beech), in late Oct. or early Nov.
- Try to collect data once a week.
- Each student team will observe the 6 leaves closest to the branch tip (skipping the terminal leaf if there is one) that have been previously labeled.
- One the first visit they will also measure the length (not including the petiole or stem) and width of the leaves for comparison in the spring, being careful not to pull any leaves off.
- They will record approximately what fraction (see data sheet) of each leaf is not green or if the leaf has fallen.
- They will record what fraction of the leaves on the whole tree are not green.
- The teacher will combine all data for each tree and submit to Harvard Forest.

Field Notes/Observations

- These notes are optional and not submitted, but represent the type of observations scientists make when they are collecting their data.

- Typical observations might include temperature, cloud cover, precipitation, wildlife observations, any unusual conditions or recent events/changes such as a strong windstorm or frost/freeze.

Autumn Student Data Sheet

December 2007

Name:	Date:
Teacher:	School:

Tree Number:_____ Branch letter _____
Tree Species:_____

Please measure leaves only once at beginning of season.

	Leaf 1	Leaf 2	Leaf 3	Leaf 4	Leaf 5	Leaf 6
Leaf Length (cm.)						
Leaf Width(cm.)						

Put a check mark in the correct column below to show Leaf Color and Leaf Drop

Leaf #	Fraction/ Percent of Leaf Color (not green)				Leaf Drop
	0 – 25%	26 – 50%	51 – 75%	76 – 100%	0-not fallen 1- fallen
1					
2					
3					
4					
5					
6					
Whole Tree					N/A

Total number of study leaves observed per branch (fallen and not fallen)	
Total number of leaves fallen	

Teacher note: Remember that the branch total above must be added with branch totals from all branches on the same tree to get the total number of leaves dropped per tree to submit to Harvard Forest to post online.

Optional Field Notes:

Weather Notes: **Animal/ Plant notes:**

Buds, Leaves and Global Warming

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- www.harvardforest.harvard.edu/schoolyard-lter-program
- www.harvardforest.harvard.edu/buds-leaves-global-warming
- www.harvardforest.harvard.edu/autumn-foliage-color