# Harvard Forest Data Archive

**HF003**

## Phenology of Woody Species at Harvard Forest since 1990

**Related Publications** (http://harvardforest.fas.harvard.edu:8080/exist/apps/pubs/pb-id.html?id=hf003)

### Data

- **hf003-01** (http://harvardforest.fas.harvard.edu/data/p00/hf003/hf003-01-plant.csv) : plant information (**preview** (http://harvardforest.fas.harvard.edu/data/plots/hf003-01.pdf) )
- **hf003-02** (http://harvardforest.fas.harvard.edu/data/p00/hf003/hf003-02-daily.csv) : daily conditions (**preview** (http://harvardforest.fas.harvard.edu/data/plots/hf003-02.pdf) )
- **hf003-03** (http://harvardforest.fas.harvard.edu/data/p00/hf003/hf003-03-spring.csv) : spring phenology (**preview** (http://harvardforest.fas.harvard.edu/data/plots/hf003-03.pdf) )
- **hf003-04** (http://harvardforest.fas.harvard.edu/data/p00/hf003/hf003-04-fall.csv) : fall phenology (**preview** (http://harvardforest.fas.harvard.edu/data/plots/hf003-04.pdf) )
- **hf003-05** (http://harvardforest.fas.harvard.edu/data/p00/hf003/hf003-05-mean-ind.csv) : mean spring dates (individual) (**preview** (http://harvardforest.fas.harvard.edu/data/plots/hf003-05.pdf) )
- **hf003-06** (http://harvardforest.fas.harvard.edu/data/p00/hf003/hf003-06-mean-spp.csv) : mean spring dates (species) (**preview** (http://harvardforest.fas.harvard.edu/data/plots/hf003-06.pdf) )
- **hf003-07** (http://harvardforest.fas.harvard.edu/data/p00/hf003/hf003-07-spring-dates.r) : R code to calculate spring dates

### Overview

- **Lead:** John O'Keefe
- **Investigators:**
- **Contact:** **John O'Keefe** (mailto:jokeefe@fas.harvard.edu)
- **Start date:** 1990-01-01
- **End date:** 2014-11-18
- **Status:** ongoing
- **Location:** Prospect Hill Tract (Harvard Forest)
- **Latitude:** +42.53 to +42.54
- **Longitude:** -72.19 to -72.18
- **Elevation:** 335 to 365 meter
- **Taxa:** *Acer pennsylvanicum* (striped maple), *Acer rubrum* (red maple), *Acer saccharum* (sugar maple), *Amelanchier canadensis* (shadbush), *Aronia* (chokeberry), *Betula alleghaniensis* (yellow birch), *Betula lenta* (black birch), *Betula papyrifera* (paper birch), *Betula populifolia* (grey birch), *Castanea dentata* (chestnut), *Cornus alternifolia* (alternate-leaf dogwood), *Crataegus* (hawthorn), *Fagus grandifolia* (beech), *Fraxinus americana* (white ash), *Hamamelis virginiana* (witch hazel), *Ilex verticillata* (winterberry), *Kalmia angustifolia* (sheep laurel), *Kalmia latifolia* (mountain laurel), *Lyonia ligustrina* (maleberry), *Nemopanthus mucronata* (mountain holly), *Nyssa sylvatica* (black gum), *Pinus strobus* (white pine), *Populus tremuloides* (trembling aspen), *Prunus serotina* (black cherry), *Quercus alba* (white oak), *Quercus rubra* (red oak), *Quercus velutina* (black oak), *Rhododendron nudiflorum* (azalea), *Sambucus canadensis* (red elderberry), *Tsuga canadensis* (hemlock), *Vaccinium*

*corymbosum* (highbush blueberry), *Viburnum alnifolium* (hobblebush), *Viburnum cassinoides* (witherod)

- **Release date:** 2000
- **Revisions:** data updated 2015-04-22
- **EML file:** **knb-lter-hfr.3.28** (http://harvardforest.fas.harvard.edu/data/eml/hf003.xml)
- **DOI:** **digital object identifier** (http://pasta.lternet.edu/package/doi/eml/knb-lter-hfr/3/28)
- **Related links:**
- **Study type:** long-term measurement
- **Research topic:** forest-atmosphere exchange; large experiments and permanent plot studies
- **LTER core area:** populations
- **Keywords:** climate, phenology, plant species
- **Abstract:**

Starting in the spring of 1990 we have observed the timing of woody vegetation development during the growing season. For the first twelve years (1990-2001) we observed bud break (50% leaf emergence) and leaf development (75% final size) on two to five permanently tagged individuals of 33 woody species at 3-7 day intervals from April through June. All individuals are located within 1.5 km of the Harvard Forest headquarters at elevations between 335 and 365 m, in habitats ranging from closed forest, through forest-swamp margins, to dry, open fields. For most species both overstory and understory individuals are represented.

Bud break is defined as when 50% of the buds on the individual have recognizable leaves emerging from them. Leaf development (75%) is defined as when at least 75% of the leaves on the individual have reached 75% of their final (mature) size. This point is used rather than "fully developed" because the leaves are functional but still developing rapidly during this period, which permits better estimation of a date between observations. Flowering and fruit development are also recorded if they occurred during the observation period.

Through 2001 these observations documented substantial (up to three weeks difference) inter-annual variation in the timing of leaf emergence (50%) and leaf development (75% final size), but good relative consistency among species and among individuals within species during these twelve years.

Therefore, starting in 2002 we maintained the same observation protocol, but reduced the number of species observed to nine, including striped maple (Acer pensylvanicum), red maple (A. rubrum), sugar maple (A. saccharum), yellow birch (Betula alleghaniensis), beech (Fagus grandifolia), white ash (Fraxinus americana), witch hazel (Hamamelis virginiana), white oak (Q. alba) and red oak (Q. rubra). This subset of important, representative species allows us to continue to characterize leaf development each spring, and document inter-annual variability while reducing the resources required for the study significantly.

We have also recorded fall phenology since 1991, with the exception of 1992. Weekly observations of percent leaf coloration and percent leaf fall begin in September and continue through leaf fall. Observations of leaf drop through 2001 exhibited less variation than those of leaf emergence, but similar relative consistency among species and among individuals within species. In 2002 we reduced the number of species observed in the fall to fourteen, including red maple (Acer rubrum), sugar maple (A. saccharum), striped maple (A. pensylvanicum), shadbush (Amelanchier laevis), yellow birch (Betula alleghaniensis), black birch (B. lenta), paper birch (B. papyrifera), beech (Fagus grandifolia), white ash (Fraxinus americana), black gum (Nyssa sylvatica), black cherry (Prunus serotina), white oak (Quercus alba), (Q. rubra) and black oak (Q. velutina).

Although leaf fall continues to exhibit somewhat less variability than leaf emergence, very late leaf drop in 2002 and 2005 has expanded leaf drop variability significantly.

- **Methods:**

The timing of spring bud break and leaf development and of autumn leaf coloration and leaf fall are recorded for permanently tagged individuals in the field.

- **Use:**



- **Citation:**

O'Keefe J. 2000. Phenology of Woody Species at Harvard Forest since 1990. Harvard Forest Data Archive: HF003.

## Detailed Metadata

### hf003-01: plant information

1. tree.id: tree ID is comprised of the first two letters of the genus plus the first two letters of the species followed by a two digit number

2. tag: the order in which the plants are observed in the study area
3. start: date of first observation, if different from 3/23/1990
4. end: date of final observation, if no longer observed
5. latin: latin name of the plant
6. common: common name of the plant
7. site: where the plant grows in the study area
    - CSRD: Causeway Rd.
    - LORD: Locust Opening Rd.
    - PHRD: Prospect Hill Rd.
    - SFLD: Shaler Hall Fields
    - SSBN: south slope burn
    - SWED: swamp edge
8. length: maximum length of a leaf for that tree (unit: centimeter / missing value: NA)
9. width: maximum width of a leaf for that tree (unit: centimeter / missing value: NA)
10. sex: sex
    - B: monoecious, meaning both
    - M: male
    - P: perfect flower
    - U: unknown
11. hgt.91: height of the plant measured in 1991 (unit: meter / missing value: NA)
12. dbh.91: Diameter Breast Height of the plant measured in 1991 (unit: centimeter / missing value: NA)
13. can.91: canopy position of the plant as determined in 1991
    - C: codominant
    - D: dominant
    - I: intermediate
    - S: suppressed

**hf003-02: daily conditions**

1. date: date
2. obs.1: initials of principle observer
3. obs.2: initials of additional observer, when applicable
4. time: time
    - AM: AM
    - PM: PM
    - NA: missing data
5. weath: general conditions during observation
    - CL: mostly cloudy
    - MC: mostly cloudy
    - PC: partly cloudy
    - PS: partly sunny
    - SH: cloudy with showers or flurries
    - NA: missing data
6. temp: temperature range
    - 3: 30's
    - 4: 40's
    - 5: 50's
    - 6: 60's
    - 7: 70's
    - 8: 80's
    - 9: 90's
7. snow.cov: snow cover
    - 0: none
    - 1: a few patches
    - 2: many patches
    - 3: some open patches
    - 4: total
8. snow.dep: snow depth (unit: centimeter / missing value: NA)
9. strm.1: condition of the first stream observed in the study area

- DM: dry mud
- DY: dry
- FR: frozen
- HF: heavy flow
- LP: large puddles
- MF: moderate flow
- SL: slight flow
- SP: small puddles
- WM: wet mud
- NA: missing data

10. strm.2: condition of the second stream observed in the study area
    - DM: dry mud
    - DY: dry
    - FR: frozen
    - HF: heavy flow
    - LP: large puddles
    - MF: moderate flow
    - SL: slight flow
    - SP: small puddles
    - WM: wet mud
    - NA: missing data
11. strm.3: condition of the third stream observed in the study area
    - DM: dry mud
    - DY: dry
    - MF: moderate flow
    - SL: slight flow
    - NA: missing data
12. h.ice: percent of ice cover in the hemlock hollow pool (unit: number / missing value: NA)
13. h.wat: percent fullness of the hemlock hollow pool (unit: number / missing value: NA)

**hf003-03: spring phenology**

1. date: date
2. julian: Julian date (unit: nominalDay)
3. tree.id: tree ID is comprised of the first two letters of the genus plus the first two letters of the species followed by a two digit number
4. circuit: order in the circuit in which the trees were observed (unit: number / missing value: NA)
5. bcon: Bud condition. This refers to the leaf bud from when it first begins to swell to when it has opened and leaves first appear.
    - BB: bud break
    - MS: moderate swelling
    - NS: no swelling
    - SS: slight swelling
    - VS: very swollen
6. bbrk: percentage of buds on the tree that have broken open, revealing leaves (unit: number / missing value: NA)
7. fbud: similar to bud condition, except it's for flower buds
    - BB: bud break, petals out
    - MS: moderate swelling
    - NA: no data
    - SS: slight swelling
    - VS: very swollen
8. fopn: percentage of flower buds open on a tree (unit: number / missing value: NA)
9. fpst: percentage of flowers past bloom, either shrivelled, pollen gone, or petals fallen (unit: number / missing value: NA)
10. sex: sex
    - M: Male
    - F: Female
    - P: Perfect
    - B: Monoecous
    - NA: No data
11. length: leaf length in centimeters. The longest leaf is measured; this is not an average. Not recorded for all plants. (unit: centimeter / missing value: NA)

12. width: leaf width in centimeters. The largest leaf is measured; this is not an average. Not recorded for all plants. (unit: centimeter / missing value: NA)
13. lfin: amount of individual leaf growth given as the percentage of final size, i.e. leaves are 25% of total leaf size. This is an average. (unit: number / missing value: NA)
14. l75: percentage of leaves on the tree that are at least 75% of their total size. It does not go above 80. (unit: number / missing value: NA)
15. l95: percentage of leaves on the tree that are greater or equal to their 95% of their final size. It does not go above 97. (unit: number / missing value: NA)
16. tip: leaf tip growth
    - 0: no mention, no growth
    - F: few tips growing
    - S: some tips growing
    - M: many tips growing
17. comments: comments

**hf003-04: fall phenology**

1. date: date
2. julian: Julian date (unit: nominalDay)
3. tree.id: tree ID is comprised of the first two letters of the genus plus the first two letters of the species followed by a two digit number
4. tag: tree tag
5. circuit: order in the circuit in which the trees were observed (unit: number / missing value: NA)
6. fopn: percentage of flower buds open on the tree (unit: number / missing value: NA)
7. fpst: percentage of flowers past bloom, either shrivelled, pollen gone, or petals fallen (unit: number / missing value: NA)
8. lcolor: percentage of leaves that have changed color on a given tree (unit: number / missing value: NA)
9. lfall: percentage of leaves that have fallen from a given tree (unit: number / missing value: NA)
10. comments: comments

**hf003-05: mean spring dates (individual)**

1. year: year
2. tree.id: tree ID is comprised of the first two letters of the genus plus the first two letters of the species followed by a two digit number
3. species: species code is comprised of the first two letters of the genus plus the first two letters of the species
    - ACPE: Acer pensylvanicum, striped maple
    - ACRU: Acer rubrum, red maple
    - ACSA: Acer saccharum, sugar maple
    - AMSP: Amelanchier species, shadbush
    - ARSP: Aronia species, chokeberry
    - BEAL: Betula alleghaniensis, yellow birch
    - BELE: Betula lenta, blackbirch
    - BEPA: Betula Papyrifera
    - BEPO: Betula popilofolia, gray birch
    - CADE: Castanea dentata, chestnut
    - COAL: Cornus alternifolia, alternate-leaved dogwood
    - CRSP: Crataegus sp., hawthorne
    - FAGR: Fagus grandifolia, beech
    - FRAM: Fraxinus americana, white ash
    - HAVI: Hamamelis virginia, witch hazel
    - ILVE: Ilex verticillata, winterberry
    - KAAN: Kalmia angustifolia, sheep laurel
    - KALA: Kalmia latifolia, mountain laurel
    - LYLI: Lyonia ligustina, maleberry
    - NEMU: Nemopanthus mucronata
    - NYSY: Nyssa sylvatica, blackgum
    - PIST: Pinus strobus, white pine
    - POTR: Populus tremuloides, trembling aspen
    - PRSE: Prunus serotina, black cherry
    - QUAL: Quercus alba, white oak
    - QURU: Quercus rubra, red oak
    - QUVE: Quercus velutina, black oak
    - RHSP: Rhododendron sp., rhododendron

- SAPU: Sambucus pubens, red elderberry
- TSCA: Tsuga canadensis, hemlock
- VACO: Vaccinium corymbosum, highbush blueberry
- VIAL: Viburnum alnifolium, hobblebush
- VICA: Viburnum cassinoides, witherod

4. bb.jd: Julian date on which 50% of the buds were open with visible leaves (unit: nominalDay / missing value: NA)
5. l75.jd: Julian date on which 50% of the leaves were developed to 75% of their final size (unit: nominalDay / missing value: NA)
6. fbb.jd: Julian date on which flower buds first broke with petals visible (unit: nominalDay / missing value: NA)
7. fopn.jd: Julian date on which 50% of the flower buds were open (unit: nominalDay / missing value: NA)

**hf003-06: mean spring dates (species)**

1. year: year
2. species: species code is comprised of the first two letters of the genus plus the first two letters of the species
   - ACPE: Acer pensylvanicum, striped maple
   - ACRU: Acer rubrum, red maple
   - ACSA: Acer saccharum, sugar maple
   - AMSP: Amelanchier species, shadbush
   - ARSP: Aronia species, chokeberry
   - BEAL: Betula alleghaniensis, yellow birch
   - BELE: Betula lenta, blackbirch
   - BEPA: Betula Papyrifera
   - BEPO: Betula popilofolia, gray birch
   - CADE: Castanea dentata, chestnut
   - COAL: Cornus alternifolia, alternate-leaved dogwood
   - CRSP: Crataegus sp., hawthorne
   - FAGR: Fagus grandifolia, beech
   - FRAM: Fraxinus americana, white ash
   - HAVI: Hamamelis virginia, witch hazel
   - ILVE: Ilex verticillata, winterberry
   - KAAN: Kalmia angustifolia, sheep laurel
   - KALA: Kalmia latifolia, mountain laurel
   - LYLI: Lyonia ligustina, maleberry
   - NEMU: Nemopanthus mucronata
   - NYSY: Nyssa sylvatica, blackgum
   - PIST: Pinus strobus, white pine
   - POTR: Populus tremuloides, trembling aspen
   - PRSE: Prunus serotina, black cherry
   - QUAL: Quercus alba, white oak
   - QURU: Quercus rubra, red oak
   - QUVE: Quercus velutina, black oak
   - RHSP: Rhododendron sp., rhododendron
   - SAPU: Sambucus pubens, red elderberry
   - TSCA: Tsuga canadensis, hemlock
   - VACO: Vaccinium corymbosum, highbush blueberry
   - VIAL: Viburnum alnifolium, hobblebush
   - VICA: Viburnum cassinoides, witherod
3. bb.jd: mean Julian date on which individuals of this species had 50% of their buds open with visible leaves (unit: nominalDay / missing value: NA)
4. l75.jd: mean Julian date on which individuals of this species had 50% of their leaves developed to 75% of final size (unit: nominalDay / missing value: NA)
5. fbb.jd: mean Julian date on which individuals of this species had their flower buds first open with visible petals (unit: nominalDay / missing value: NA)
6. fopn.jd: mean Julian date on which individuals of this species had 50% of their flower buds open (unit: nominalDay / missing value: NA)
7. sd.bb.jd: standard deviation of mean Julian date of bud burst for this species (unit: nominalDay / missing value: NA)
8. sd.l75.jd: standard deviation of mean Julian date for 75% leaves open for this species (unit: nominalDay / missing value: NA)
9. sd.fbb.jd: standard deviation of mean Julian date of flower bud burst for this species (unit: nominalDay / missing value: NA)
10. sd.fopen.jd: standard deviation of mean Julian date of flower buds open for this species (unit: nominalDay / missing value: NA)

**hf003-07: R code to calculate spring dates**

- **Compression:** none
- **Format:** text
- **Type:** R code