TREE PHENOLOGY MONITORING

Vermont Department of Forests, Parks and Recreation

Sandra H. Wilmot

COOPERATORS

H. Brenton Teillon, Thomas Simmons, Cecilia Polansky, Vermont Forestry Division.

INTRODUCTION

The objective of this project is to begin gathering baseline information on the phenology of three hardwood tree species growing at two elevations on Mount Mansfield, with the intent to identify key phenological stages for long-term monitoring. In addition, techniques for monitoring phenology will be developed where no methods exist.

Annual fluctuations in the timing of tree development can be important in detecting and explaining future changes in tree condition. Monitoring phenology annually may also aid in relating stress agent activity with tree injury.

In 1991, we began monitoring the timing and duration of vegetative and flower bud development in the spring, full leaf size, and the timing of fall color and leaf drop on sugar maple trees at the Proctor Maple Research Center (elevation 1400 ft). We expanded this project in 1992 to include sugar maple, yellow birch and beech at two elevations on the mountain, 1400 and 2200 ft.

METHODS

Vegetative and flower bud development through leaf expansion is monitored using adaptations of visual assessments of developmental stages defined by Parker and Skinner (in press) for sugar maple. At least twice weekly, from dormant bud stage (early April) through full leaf expansion (early June) buds of 5 mature and 5 sapling trees per species and elevation are assessed for development using a 45 X spotting scope. Lower and upper canopy, and sapling buds are assessed separately. Bud development is categorized into 8 vegetative bud stages and 7 reproductive bud stages (Table 1). Data are expressed as the percent of buds in each developmental stage on each sampling date.

Leaf collections are made on each canopy tree monthly from late June to late August to measure leaf size. Twenty leaves are collected from mid-canopy on each of the phenology trees using pole

Table 1. Description of phenological stages used to assess vegetative and flower bud development on sugar maple, yellow birch, and American beech trees.

VEGETATIVE STAGE	SUGAR MAPLE	YELLOW BIRCH	BEECH
V0	dormant	dormant	dormant
V1	initial swell	initial swell	lengthening
V2	bud elongation		wide at bud base, exaggerated point at tip
V3	green tip stage		scales separating and bending back slightly
V4	bud break, leaf tips expanded beyond the bud tip	bud break, leaf tip exposed	bud break, leaf tips exposed
V5	extended bud break, leaves not yet spread apart	extended bud break	extended bud break
V6	initial leaf expansion	initial leaf expansion	initial leaf expansion
V7	leaves unfolded slightly,but individual leaves not yet expanded	leaves unfolded slightly	leaves unfolded slightly
V8	leaves expanded, may not be full size yet	leaves expanded, may not be full size yet	leaves expanded, may not be full size yet

FLOWER STAGES	SUGAR MAPLE	YELLOW BIRCH	BEECH
F0	dormant	dormant	dormant
F1	initial bud swell		
F2	bud elongation, buds more rounded at tip than vegetative buds	bud elongation	
F3	green tip stage	full bud elongation	
F4	bud break, flower tips show expanded beyond bud tip		
F5	initial flower expansion, flower bundle expands beyond bud scales	initial flower expansion	
F6	full flower expansion and pollen dispersal	full flower expansion and pollen dispersal	full flower expansion and pollen dispersal
F7	flower senescence and drop	flower senescence and drop	flower senescence and drop

pruners. Leaves are pressed, dried and processed through a leaf area meter for size determinations.

Fall color and leaf senescence are monitored using modifications of the visual crown rating system used for the National Forest Health Monitoring Program (Conkling and Byers, 1992). Each mature tree and sapling is rated bi-weekly for crown discoloration (fall color), crown dieback, foliage transparency and crown density (leaf drop measurements) from late July through mid-October. Field crews are certified under the NFHM for standardized crown rating evaluations. Field audits of field crews are made to aid in data quality assurance.

RESULTS

Bud and leaf development

Sugar maple, yellow birch and beech buds were all dormant at the beginning of field observations on April 5, 1992. Initial bud swell (V1) began first with sugar maple at both elevations and beech at the lower elevation on April 20 (Figure 1).

Sugar maple at the lower elevation reached bud break (V4) on May 8, followed by yellow birch on May 9 and beech on May 11, also at the lower elevation. The same sequence of bud break was observed at the higher elevation site, with sugar maple bud break 8 days behind the lower elevation (May 16), yellow birch bud break 5 days later than at 1400 feet (May 14) and beech bud break 8 days after the lower elevation (May 19).

Full leaf expansion (V8) was completed by May 15 for sugar maple, May 20 for beech and May 28 for yellow birch, all at the lower elevation. At the upper elevation, full leaf expansion was 13 days later than the lower elevation site for sugar maple and beech (May 28 and June 2, respectively), but only 4 days later for yellow birch (June 2).

Sugar maple flower buds reached bud break (F4) on May 8 and May 14 for the lower and upper elevations sites, respectively. Flower bud development was difficult to assess on beech and yellow birch until buds were open (F6), so bud break data is not available for these species. Open flowers were first observed open on May 11 for sugar maple and yellow birch, and May 15 for beech, at the low elevation site. At the higher elevation site, open flowers were first observed on May 15, 19, and 21 for sugar maple, yellow birch and beech, respectively.

Figure 1. Vegetative bud development of sugar maple (1a), yellow birch (1b) and American beech (1c) at two elevations on Mount Mansfield, VT.

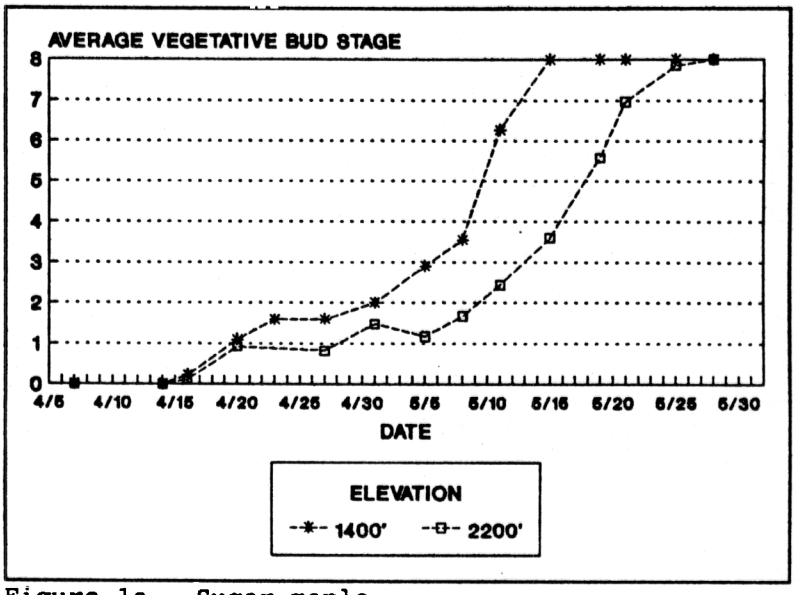


Figure 1a. Sugar maple.

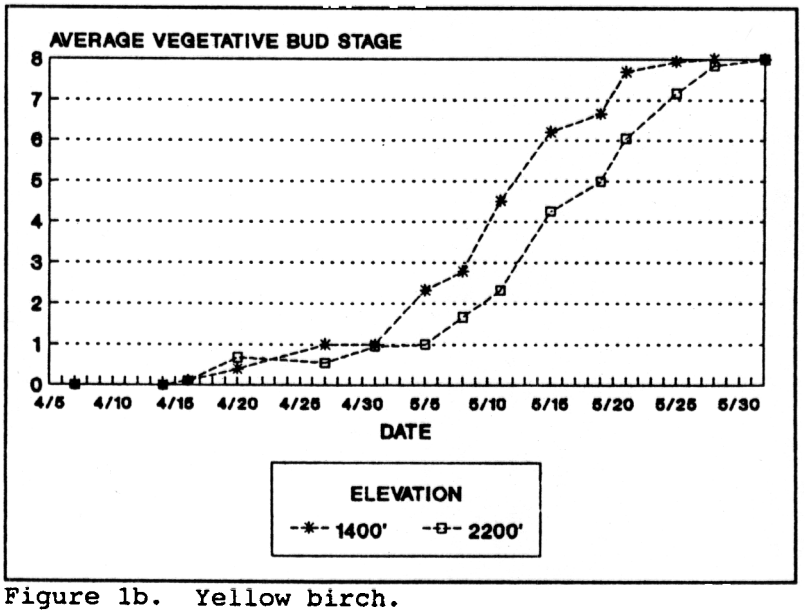


Figure 1b. Yellow birch.

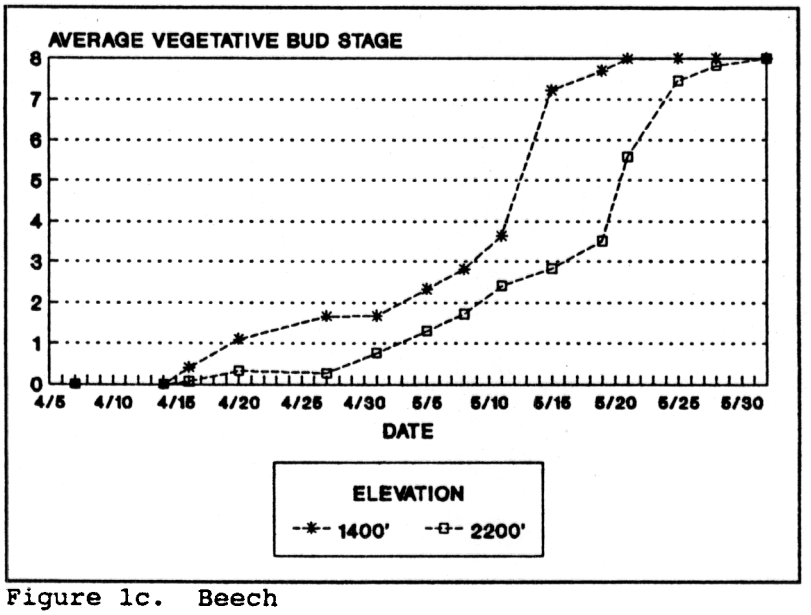


Figure 1c. Beech

Leaf size

Full leaf size for each species was greater at the lower elevation site. Sugar maple leaves reached full size on June 26 at the 1400 foot elevation (49.86 cm^2) and on July 24 at the 2200 foot elevation (43.02 cm^2) (Table 2). Beech leaves reached full size on July 24 (high elevation) and August 25 (lower elevation), and were 35.38 and 36.96 cm^2, respectively. Yellow birch leaves reached full size on July 24 at both elevations, with leaf sizes of 24.11 and 20.95 cm^2 for the low and high elevation sites respectively.

Table 2. Average leaf size for 1992 of sugar maple, yellow birch and American beech growing at two elevations on Mount Mansfield, VT.

SPECIES	LOCATION-elevation	AVERAGE LEAF SIZE (cm^2) BY DATE		
		June 24	July 26	August 25
SUGAR MAPLE	1400 ft	49.86	39.85	41.26
	2200 ft	41.24	43.02	37.97
YELLOW BIRCH	1400 ft	24.11	21.85	22.26
	2200 ft	20.95	19.35	14.71
AMERICAN BEECH	1400 ft	34.70	29.04	36.96
	2200 ft	32.64	35.38	26.82

Sugar maple leaf size at the 1400 foot elevation site was larger in 1992 than in 1991 (49.86 cm^2 compared to 44.21 cm^2). Differences in growing conditions between the two years may be responsible.

Fall color and leaf drop

Sugar maple and yellow birch at 2200 feet were the earliest to reach full color (> 75% of crown with colored foliage) in 1992 (Figure 2a). By October 5, most species at both elevations were showing some fall color without leaf drop, and by October 13, significant leaf drop had occurred at both elevations (Figure 2b & 2c). Sugar maple at 1400 feet and beech at 2200 feet were the slowest to drop their leaves, loosing > 80 % of their leaves by October 20. The timing of fall coloration and leaf drop on sugar maples at 1400 feet were similar between 1991 and 1992 (Figure 3).

Figure 2. Fall coloration (2a) and leaf drop (2b & 2c) progression for 1992 of sugar maple, yellow birch and American beech at two elevations on Mount Mansfield, VT.

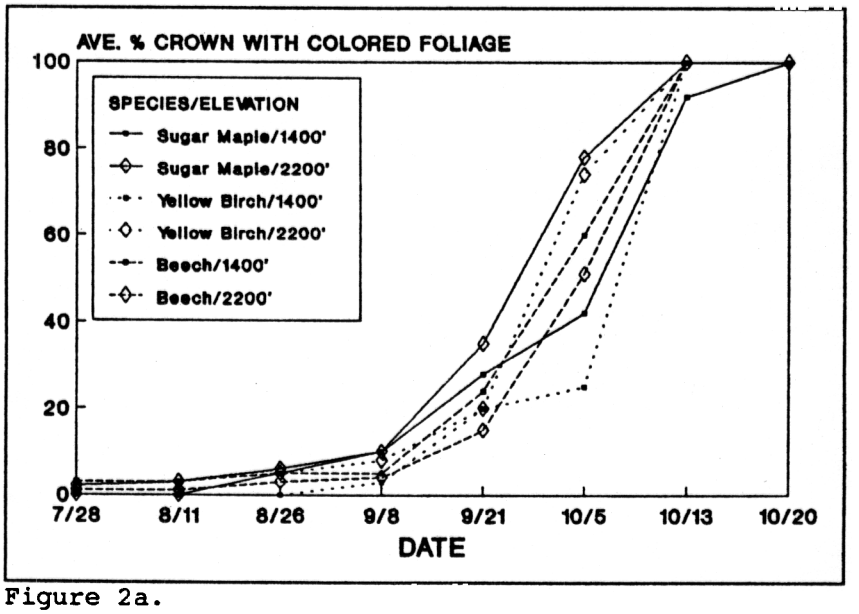


Figure 2a.

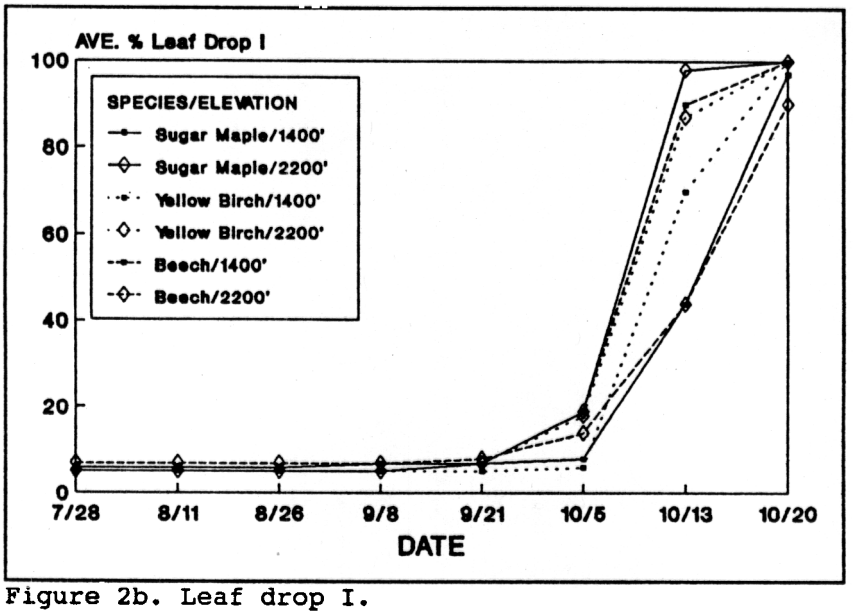


Figure 2b. Leaf drop I.

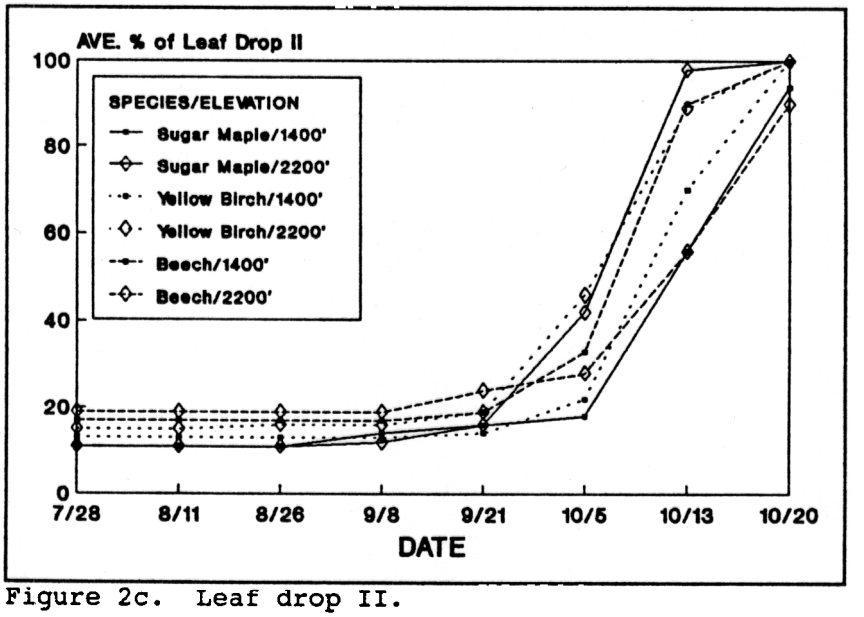
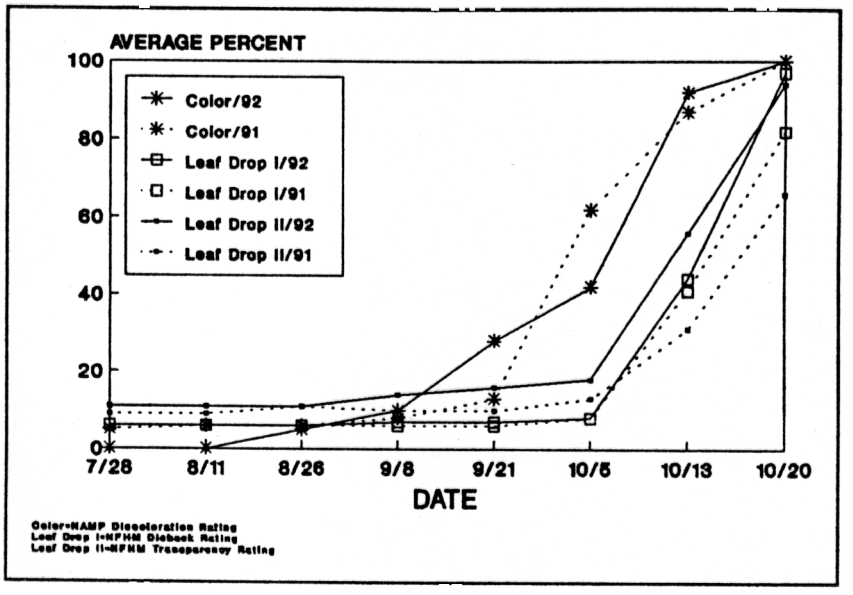


Figure 2c. Leaf drop II.

Figure 3. Sugar maple fall coloration and leaf drop comparison between 1991 and 1992, of trees growing at 1400 feet on Mount Mansfield, VT.



Discussion

At the 1400 foot elevation site sugar maple phenology has been monitored for the last two years. In 1992, bud break was 9 days later than in 1991, although buds developed faster from bud break to full leaf expansion, which was only 2 days later than in 1991. The timing of full leaf size, fall color and leaf drop was also similar between the two years. This indicates that although the season can begin slowly, development can be rapid enough to compensate for this and maintain a "normal" schedule later in the season.

As expected, vegetative bud development was later at the higher elevation site than at the 1400 foot elevation site. Full leaf development of sugar maple and beech was almost 2 weeks later at the higher elevation. Yellow birch development between the 2 elevations was less than a week apart at all stages.

Flower bud development was difficult to monitor in yellow birch and beech. The bud stage descriptions used to monitor sugar maple flower buds are not directly applicable to the other species, but with the modifications made (Table 1) were descriptive of detectable stages of flower development. An additional complication was variation between individuals in the numbers of flower buds, with some trees having very few.

Conversely, sugar maple flowering was abundant in 1992. Flower buds were fully open (F6) within days of vegetative bud break (V4) at both elevations. This may be important for assessing damage from early defoliating insects, like pear thrips, that injure leaves while in the bud break stage, and require pollen for energy and reproduction. Open flowers persisted for only 8 days at the lower elevation site, but for 13 days at the higher elevation site.

The cause or significance of smaller leaf size in 1991 than in 1992 is not known at this time. Integration of other data sets, such as weather and pest activity, with this phenology data is planned to assess interrelations between stress factors and tree phenology.

The method used to assess fall coloration using percent of tree discolored reflects visual assessments. But the techniques for assessing leaf drop using percent dieback and percent transparency need modification. Dieback captures leaf drop when it occurs on branch tips. Transparency captures leaf drop when it occurs throughout the crown. But since leaf drop varies between trees, neither could be used to depict what is seen on each tree. A new crown rating measurement for hardwoods is now being used in the NFHM program with improved accuracy. Crown density may be more appropriate since it takes into account both dieback and transparency, and therefore will be tested next year.