INTERNAL REPORT 41

PHENOLOGICAL OBSERVATIONS ON REFERENCE STANDS IN THE H. J. ANDREWS EXPERIMENTAL FOREST IN 1971

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INTRODUCTION

The phenology program was initiated with two objectives. The first was to examine the possible relationships between easily observed phenophases and those of more interest, which are observed with difficulty. The second was to provide additional data for the ordination of communities. The phenological data were collected on reference stands that had been established on the Andrews Experimental Forest to represent modal communities of different types. The key to numbers used for reference stands is given in Table 1.

The observer became familiar with each reference stand noting the location of individuals, clones, or colonies of the species of interest. Stands were visited weekly during May and June, less frequently thereafter. As the initial list of species to be observed contained some unsuitable species, the observer began to record data on all the more common or conspicuous species.

Biologically meaningful phenophases such as initiation of vegetative activity and flowering were noted. Some of the species had growth patterns that offered several clearly definable stages or phenophases. These phenophases were recorded with the hope that a correlation could be established with other more important phenophases. All observations or estimates of degree of enlargement or elongation were ocular estimates. These were adjusted as the observer became more familiar with the vegetation.

Conspicuous correlations between phenophases of species were noted. When casual observation of a species indicated that it had clearly definable phenophases, the species was included in the list of those more carefully observed. This "shotgun" approach provided a data base for preliminary comparisons of communities. It also permitted an examination of the potential suitability for phenological analysis of a wide range of species.

SPECIES OBSERVED

Table 2 lists the 33 species on which phenological observations were recorded during 1971. Few data were actually recorded on some of the species listed. They were found to be unsuitable for various reasons and observations were stopped.

Twelve species appear to be suitable for phenological analysis. These species, listed in Table 3, are found on a wide range of sites. They also have phenophases that are distinct and easily recognized. The value of some of these species was not realized by the observer until quite late in the season; consequently data for 1971 are wanting on some sites studied.

Those species that would be suitable for phenological analysis but are restricted to a few sites are listed in Table 4. These species would be of value for comparisons of sites in the community types in which they are found. Bunchberry, Cornus canadensis, is an example of a species that would be of value in comparing communities at higher elevations. It has clearly definable phenophases, and tends to be abundant where found.

Unsuitable Species

Unsuitable species (Table 5) were categorized as such for various reasons. Some species may prove to be of value when examined more closely; Trillium ovatum and Smilacina stellata may prove to be useful in ordering sites with regard to temperature. Their inclusion in this category may result from lack of data.

Other species have phenophases that are not easily definable. Xerophyllum tenax, Clintonia uniflora, and Pyrola secunda are examples. The tremendous amount of within-site variation in Berberis spp., Achlys triphylla, Whipplea modesta, and Gaultheria shallon made it difficult to use these species.

Goodyera oblongifolia varied within and between sites in a most peculiar manner. The species blooms late in the summer. The observer first noted individuals in flower at the highest elevations. Weeks later the species was noted to be in flower at lower elevations, and was still in flower at the higher elevations. It proved impossible to find a seasonal pattern that seemed correlated with elevation or temperature. Correlations with phenophases of other species would prove as difficult.

Suitable Species

Conifers

All of the conifers with the exceptions of western redcedar and incensecedar have a clearly defined phenophase of vegetative bud break. The within-site variation is small enough on most sites to allow a resolution of less than a week, on a stand basis. The sites at higher elevations have not only more within-site variation but more within-individual variation. Pacific silver fir had a terminal bud on the leader that broke much later than the terminal buds of the lateral branches. This delay seemed more prolonged at the higher sites.

Figure 1 shows the order of vegetative bud break for five species of conifers on the reference stands. Vegetative bud break was said to have occurred when at least 10 percent of the lateral branch terminals had broken. The order of species bud break appears to be Thuja plicata before Taxus brevifolia before Pseudotsuga menziesii, Abies amabilis, and Tsuga heterophylla. Douglas-fir and Pacific silver fir seem slightly ahead of hemlock when either occurred in the same stand as hemlock.

Pacific yew was the only member of the coniferous component of the understory that would be suitable for observations on regenerative phenophases. No data were collected on reproduction for this species in 1971.

Hardwoods

Vine maple, Acer circinatum, is a widely distributed component of the understory that has rather clearly defined vegetative phenophases. There seems to be little within-site variation in the timing of bud break. The first pair of leaves appears in a folded state and the leaves expand over a period of 7 to 10 days to another clearly defined state. The initiation of rapid, conspicuous stem elongation follows. The regenerative phenophases seem much more variable within each site. The difficulty of finding flowers on some sites makes observations on the

regenerative phenophases of vine maple a task with uncertain rewards.

Figure 2 shows the pattern of some vegetative phenophases of vine maple. The points were located with very few data. The potential of vine maple was not realized until later in the season. In spite of the general nature of the data, one can order the stands at the low elevations using either phenophase 2 or 3. Vine maple should prove of great value when observed with more care.

Pacific dogwood, Cornus nuttallii, is less widely distributed than vine maple. It is abundant only on reference stand 6, the Tsuga/Castanopsis type. On other sites, as few as two individuals compose the sample. The paucity of individuals on some sites would pose sampling problems.

Pacific dogwood has clearly defined vegetative and regenerative phenophases. Figure 3 shows a plot of selected phenophases. Phenophase 3, the conspicuous expansion of floral bracts, immediately preceded the bud break of the understory conifers on the lower sites. The correlation was less reliable at higher elevations. This is a pattern worth investigating.

Rhododendron macrophyllum is perhaps the most suitable of the understory hardwoods for phenological analysis. It has conspicuous and easily described vegetative and reproductive phenophases. Selected phenophases are plotted in Figure 4. The phenophases seem to be controlled by temperature as well as photoperiod. This assumption permits ordering of stands along climatic gradients. The vegetative and floral bud breaks appear to coincide with the bud break of the understory Douglas-fir and western hemlock. The species may prove to be less useful at the higher elevations. There, it tends to be sparse and has more within-site variation, which could pose problems.

Rhododendron macrophyllum is also interesting in the apparent shift in order of vegetative or regenerative bud break with elevation. There seems to be a trend toward delay in reproductive bud break, relative to vegetative bud break, with increasing elevation. It is also interesting to speculate on the timing of the fall of the past year's leaves. A comparison of timing of leaf fall with the cessation of cambial activity of other species (specifically Douglas-fir, western hemlock, and western redcedar) ought to be made.

Low shrubs and herbs

Prince's pine, Chimaphila umbellata var. occidentalis, was not in the initial list of species to be observed. Its value was not realized until late in the season. Consequently, the dates shown in Figure 5 are derived from very general data.

Prince's pine seems to be a fine species for phenological analysis. It is found on a wide variety of sites. The vegetative growth can be broken into fairly definite phenophases: (1) Bud break is followed by a period of leaf expansion with the leaves nearly parallel to the axis of the stem. (2) When the leaves are about half expanded they are at a 45° angle to the stem. (3) When fully enlarged, they are at right angles to the stem. The emergence of flower buds seemed variable, but that may be an artifact of the variable period between sampling dates. The reproductive phenophases form another set of clearly defined stages. The number of clearly definable phenophases makes Chimaphila potentially valuable as a species for either correlating with phenophases of other species or for ordering stands.

The huckleberries, Vaccinium spp., as a group are found in nearly every community. Selected phenophases of the three species common on the Andrews Experimental Forest are shown in Figure 6. Within-site variation and lack of clearly defined vegetative phenophases make working with the Vaccinium group a bit more difficult than with other species. The phenology of the members of the genus seems to be quite closely tied to temperature; within-site variation is greatest early in the season when patches of snow make the temperature variations greatest. The genus could prove valuable in comparing site environments; however, it appears that other species may be easier to study for the same sorts of general information on community phenology.

Twinflower, Linnaea borealis, is perhaps the most ubiquitous herb on the Andrews Experimental Forest; it is rare or lacking only on the higher elevations (>1,220 m). Vegetative growth is initiated early in the season, and development can be broken into clearly defined phenophases. After vegetative bud break, the first pair of leaves expands parallel to the main axis of the elongating stem, and then folds back. The second pair of leaves follows the same pattern, after which the pattern breaks down. These events are spread out over a month, after which the reproductive phenophases begin to occur. As with the vegetative phenophases, several regenerative phenophases can be defined. Figure 7 shows the nice distribution over time of these easily recognized phenophases.

My impression is that the vegetative phenophases are more correlated with temperature than are the regenerative phenophases. Twinflower does not seem to have the degree of within-site variation that Vaccinium spp. have. The large number of clearly definable phenophases, the small within-site variation, and the cosmopolitan nature of the species make it an excellent subject for phenological investigation.

DISCUSSION

The two objectives stated in the introduction have been only partly realized. The time spent on other, higher priority projects resulted in the neglect of many important events. The low resolution of the data is the natural result of observing so many species; however, preliminary correlations between different species' phenophases can be made.

The four plots in Figure 8 indicate the difficulty of finding universally coinciding phenophases between species. On all of the sites shown in Figure 8, rhododendron's initiation of activity matched western hemlock's vegetative activity. This is promising until one compares Figures 1 and 4 and begins to find holes. These holes may be artifacts of the subjective sampling technique; a more objective quantitative method should be used next year.

The value of the data in ordinating communities is still being examined. Table 6 gives some information on the potential of different species' phenophases for separating stands; the degree of resolution is an artifact of the number of data collected. The ordering of stands resulting from any one of the phenophases used is what one would expect from experience in the field.

A wide range of species has been examined, and the apparent suitability of species for phenological studies can be stated with a fair degree of confidence. For the purposes of our group, Chimaphila umbellata, Linnaea borealis, Rhododendron macrophyllum, and the conifers offer the most promise of information return for hours invested. If there is to be an expansion of effort and a more quantitative approach to the possibility of using phenological information for predictive purposes, then these are the species on which to concentrate.

Table 1. Reference stands on the H. J. Andrews Experimental Forest.

Reference stand	Elevation (*m*)	Forest Community
1	488	Pseudotsuga menziesii/ Holodiscus discolor
2	488	Tsuga heterophylla/Rhododendron macrophyllum/Berberis nervosa
3	945	Tsuga heterophylla-Abies amabilis/Linnaea borealis
4	1,311	Abies amabilis/Tiarella unifoliata
5	884	Tsuga heterophylla -Abies amabilis/Rhododendron macrophyllum/Berberis nervosa
6	610	Tsuga heterophylla/Castanopsis chrysophylla
7	457	Tsuga heterophylla/Polystichum munitum-Oxalis oregana
8	488	Pseudotsuga menziesii-Tsuga heterophylla/Corylus cornuta
9	457	Tsuga heterophylla/Acer circinatum/Polystichum munitum
10	610	Tsuga heterophylla/Rhododendron macrophyllum/Gaultheria shallon
11	1,006	Pseudotsuga menziesii/Acer circinatum/Berberis nervosa
12	1,006	Abies amabilis/Vaccinium alaskaense/Cornus canadensis
13	1,311	Abies procera/Clintonia uniflora
14	1,433	Abies amabilis-Tsuga mertensiana/Xerophyllum tenax

Table 2. Species whose phenology was observed by sites. (See Table 1, 3-5 for key to species abbreviations, and reference stand number)

	Reference stand number														
Species	Δ	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Psme		X					X	X	X		X				
Tshe	X		X	X	X	X	X	X	X	X	X	X	X	X	
Abam				X	X								X	X	X
Conu	X	X	X				X	X	X	X	X	X			
Hodi		X													
Rhma			X	X		X	X		X	X	X		X		X
Gash			X			X	X	X	X	X	X	X			
Bene	X	X	X	X		X	X	X	X	X	X	X	X		
Vapa	X	X	X	X			X	X	X	X		X	X		
Vame				X	X	X						X	X	X	X
Libo	X	X	X	X		X	X	X	X	X	X	X	X		
Xete			X			X	X								X
Actr		X	X	X	X		X	X	X	X			X	X	X
CoCa				X	X								X		
Tabr			X	X				X		X	X				
Thlp			X				X	X		X	X				
Lide	X								X						
Abgr	X														
Pila							X								
CoCoCa	X	X							X						
Cach							X				X				
Acci		X	X			X	X	X	X	X	X	X	X		
Beaq	X														
Chum		X	X	X	X	X		X	X		X	X	X	X	
Pyse					X									X	
Vaal													X		
Clun					X								X	X	
Smst													X	X	
Trov					X										
Goob				X	X	X					X	X		X	
Whmo	X	X							X						
Oxor	X							X		X					
Vise	X			X	X					X		X			

Table 3. Species observed and found suitable.

Species	Abbreviation	Common name
Understory trees and tall shrubs:		
Taxus brevifolia Nutt.	(Tabr)	western yew
Thuja plicata	(Thpl)	western redcedar
Abies amabilis (Dougl.) Forbes	(Abam)	Pacific silver fir
Pseudotsuga menziesii (Mirb.) Franco	(Psme)	Douglas-fir
Tsuga heterophylla (Raf.) Sarg.	(Tshe)	western hemlock
Acer circinatum Pursh	(Acci)	vine maple
Cornus nuttallii Aud.	(Conu)	Pacific dogwood
Rhododendron macrophyllum D. Don	(Rhma)	Pacific rhododendron
Low shrubs and herbs:		
Chimaphila umbellata (L.) Bart. var. *occidentalis* (Rydb.) Blake	(Chum)	western prince's pine
Vaccinium membranaceum Dougl. ex Hook	(Vame)	thin-leaved huckleberry
Vaccinium parvifolium Smith	(Vapa)	red huckleberry
Linnaea borealis L. var. *longiflora* Torr.	(Libo)	American twinflower

Table 4. Species observed and suitable but restricted to a few sites.

Species	Abbreviation	Common name
Understory trees and tall shrubs:		
Libocedrus decurrens Torr.	(Lide)	incense-cedar
Abies grandis (Dougl.)	(Abgr)	grand fir
Pinus lambertiana Dougl.	(Pila)	sugar pine
Corylus cornuta Marsh. var. *californica* (DC.) Sharp	(Cococa)	California hazel
Castanopsis chrysophylla (Dougl.) A.DC.	(Cach)	golden chinkapin
Holodiscus discolor (Pursh) Maxim.	(Hodi)	oceanspray
Low shrubs and herbs:		
Oxalis oregana Nutt.	(Oxor)	Oregon oxalis
Cornus canadensis L.	(Coca)	bunchberry
Vaccinium alaskaense Howell	(Vaal)	Alaska blueberry

Table 5. Species observed but found not suitable.

Species	Abbreviation	Common name
Low shrubs and herbs:		
Clintonia uniflora (Schult.) Kunth	(Clun)	green-cup bead lily
Smilacina stellata (L.) Desf.	(Smst)	few-flowered false Solomon's leaf
Trillium ovatum Pursh	(Trov)	western trillium
Xerophyllum tenax (Pursh) Nutt.	(Xete)	bear grass
Goodyera oblongifolia Raf.	(Goob)	rattlesnake plantain
Achlys triphylla (Smith) DC.	(Actr)	vanilla leaf
Berberis aquifolium Pursh	(Beaq)	Oregon grape
Berberis nervosa Pursh	(Bene)	long-leaved Oregon grape
Whipplea modesta Torr.	(Whmo)	modest whipplea
Viola sempervirens Greene	(Vise)	evergreen violet
Gaultheria shallon Pursh	(Gash)	salal
Pyrola secunda L. var. *secunda*	(Pyse)	one-sided wintergreen

Table 6. Stands ordered by phenophases (see Tables 2-4 for abbreviations).[a]

Species	Phenophase	Order (earliest → latest)
Libo	First pair leaves expanded, parallel to stem	(1, 8) Δ, 2, (6, 9), (10, 7), 5, 11, 3, 12
	Initiation of flowering	(1, 8, Δ), (7, 9, 2, 6), 10, (5, 11), 3, 12
Chum	Leaves fully expanded, perpendicular to stem	1, (8, 2), 7, (5, 12), (10, 11, 3), 4, 13
Acci	First pair leaves out of bud, still folded	(1, 8, 2, 9), (6, 10), 5, 11
Conu	Vegetative bud break	(1, 8, Δ, 2), (6, 9, 10, 7), 11
Rhma	Vegetative bud break	(8, 2, 6, 10, 9), 5, 3, 12, 14
	Leaves 1/4 - 1/2 expanded	8, (2, 6, 10), 5, 3, 12, 14
Tshe	Budbreak	(8, Δ), 7. 6. 10), (2, 9), (5, 11), 3, 12, 4
Psme	Bud break	(1, 6, 8), 7
Abam	Bud break	3, 12, 4
Thpl	Bud break	6, (7, 10, 9)
Tabr	Bud break	7, (2, 10), 9, 3
Vapa	Initiation of flowering	(1, 8, Δ), (2, 6, 9), 7, (11, 3), 12

[a]Stands enclosed in parentheses show no differences in time or the phenophase.

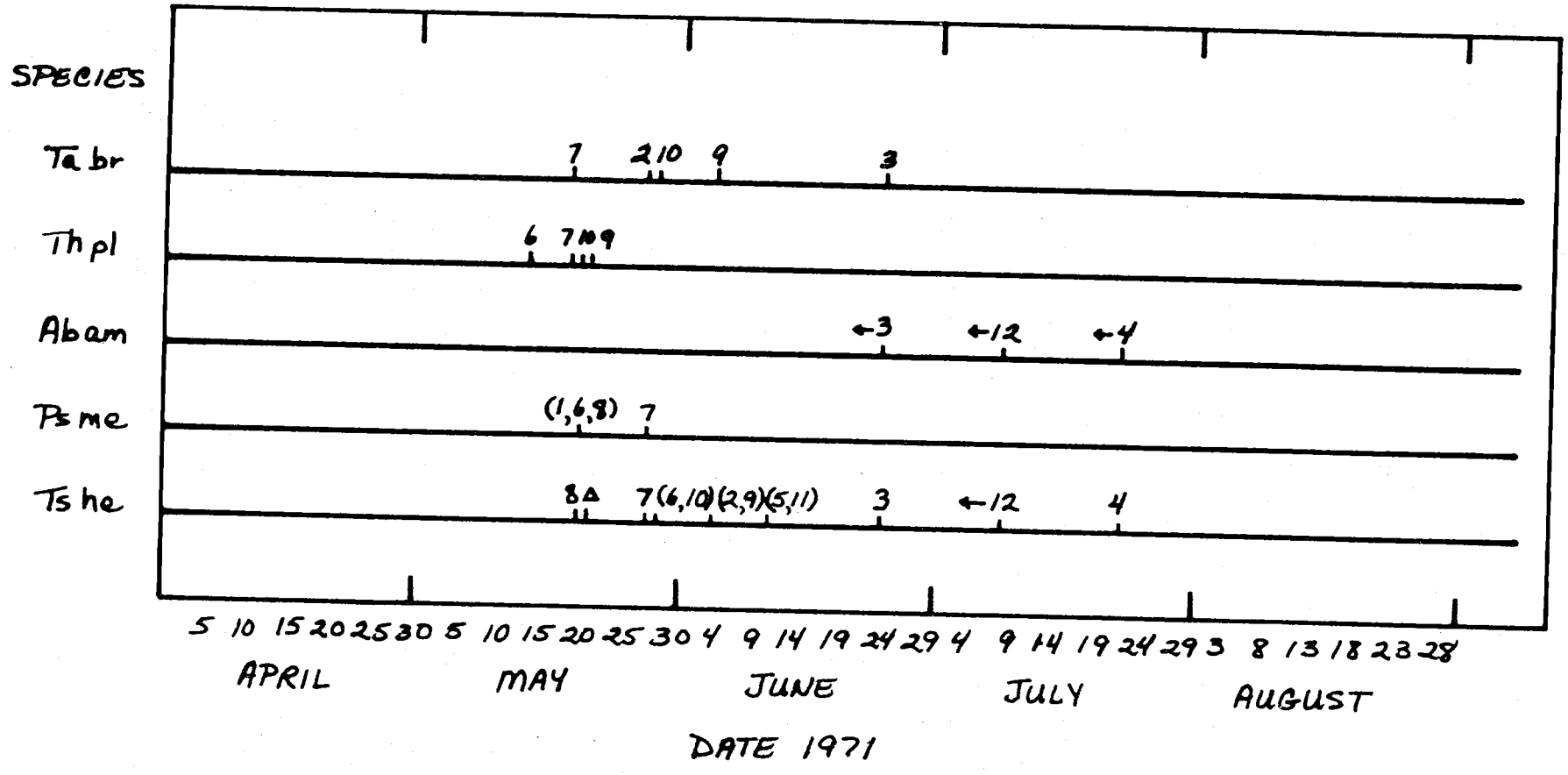

Figure 1. Date of vegetative bud break in understory individuals of tree species. Numbers refer to reference stands.

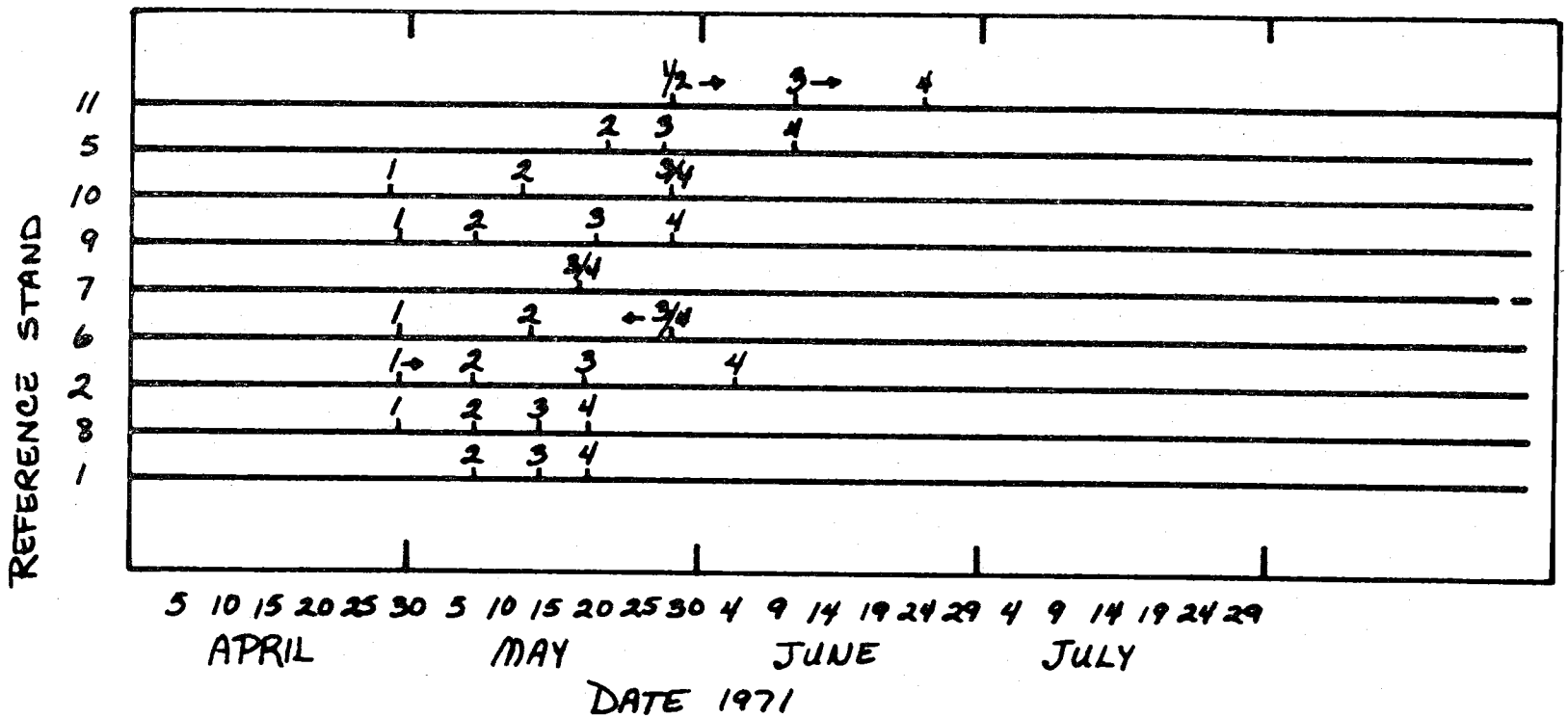

Figure 2. Phenophases of Acer circinatum: (1) vegetative bud break; (2) first pair of leaves out of bud, folded; (3) first pair of leaves unfolded; (4) stem elongation initiated.

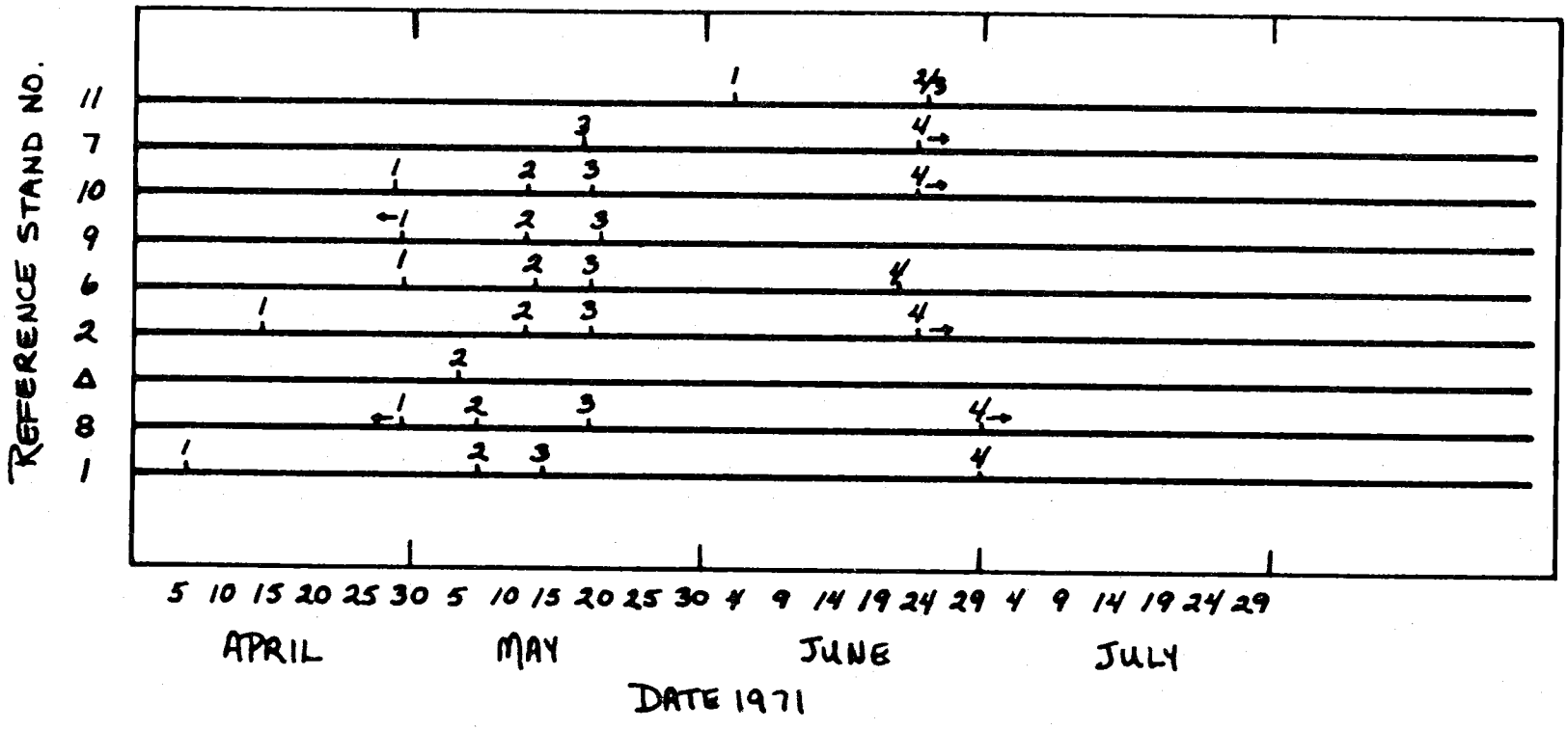

Figure 3. Phenophases of Cornus nuttalli: (1) vegetative bud break, (2) first pair of leaves unfolded, (3) flower bracts expanded, (4) bracts fallen.

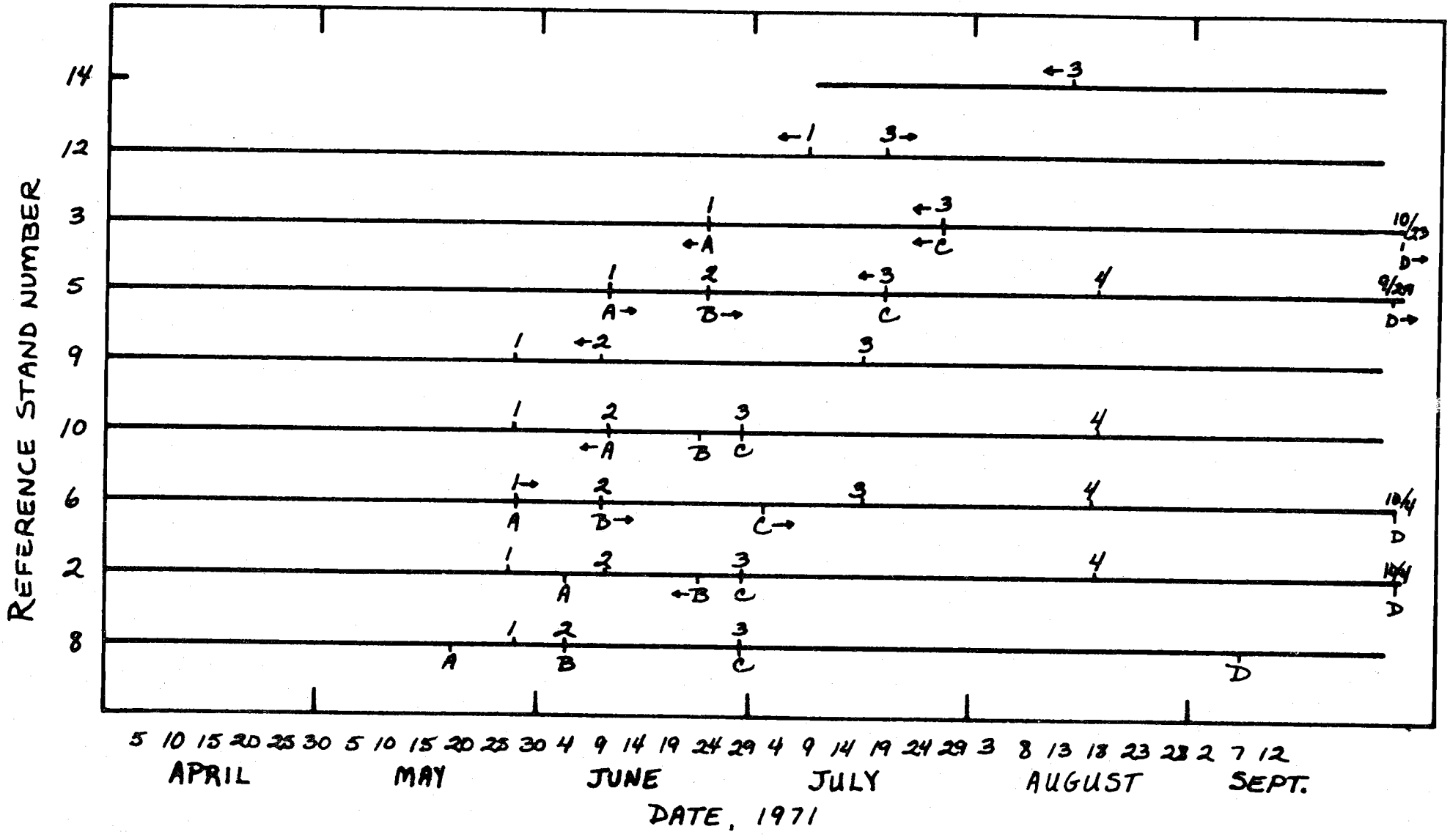

Figure 4. Phenophases of Rhododendron macrophyllum: reproductive--(A) buds broken, (B) corollas 75-100 percent open, (C) corollas 75-100 percent fallen, (D) capsules dehisced; vegetative--(1) buds broken, (2) leaves one-fourth to one-half expanded, (3) leaves fully expanded, (4) past year's leaves falling.

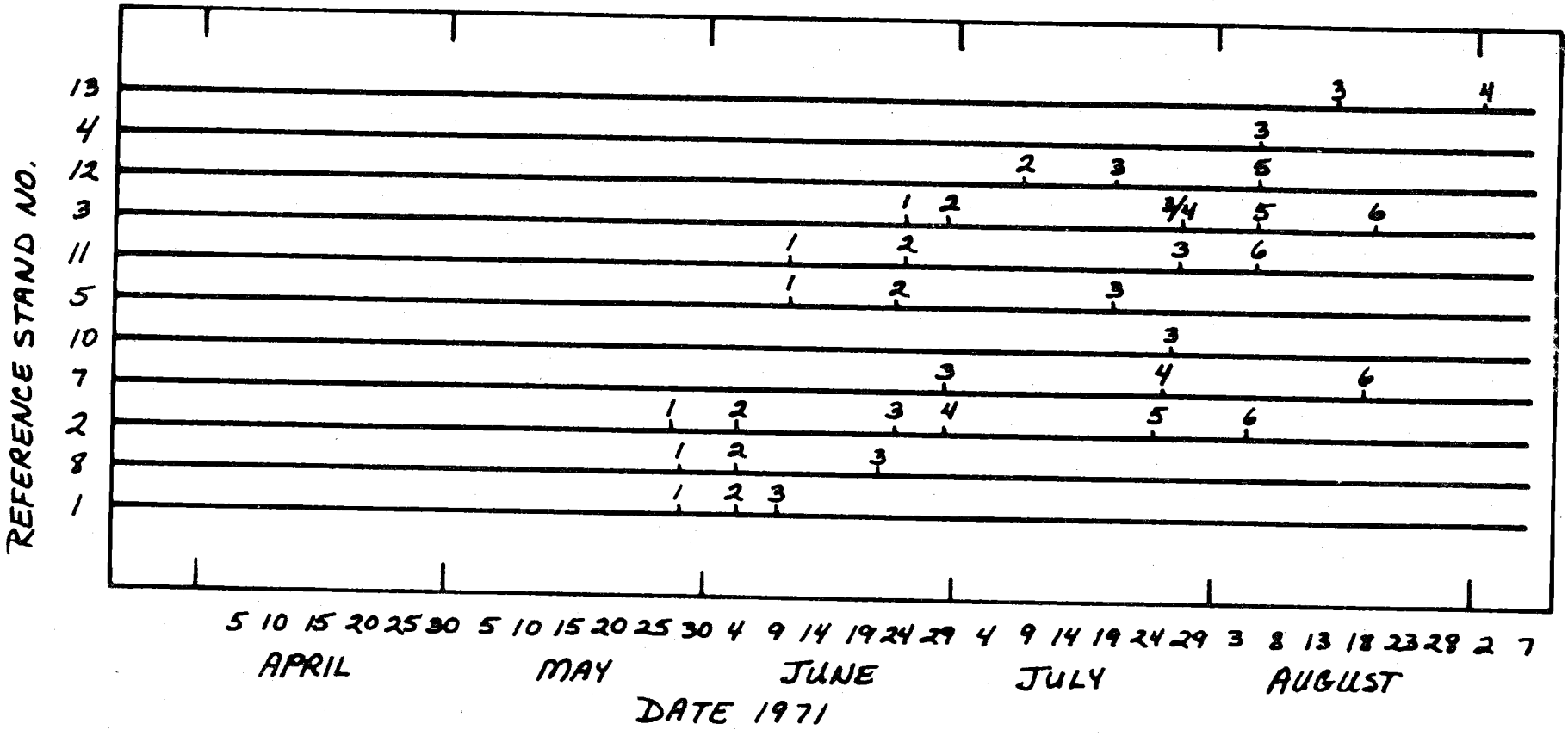

Figure 5. Phenophases of Chimaphila umbellata: (1) vegetative bud break; (2) leaves one-fourth to three-fourths expanded, at 45° to axis of stem; (3) leaves fully expanded, perpendicular to axis of stem; (4) flower buds emerging: (5) in flower; (6) past flowering.

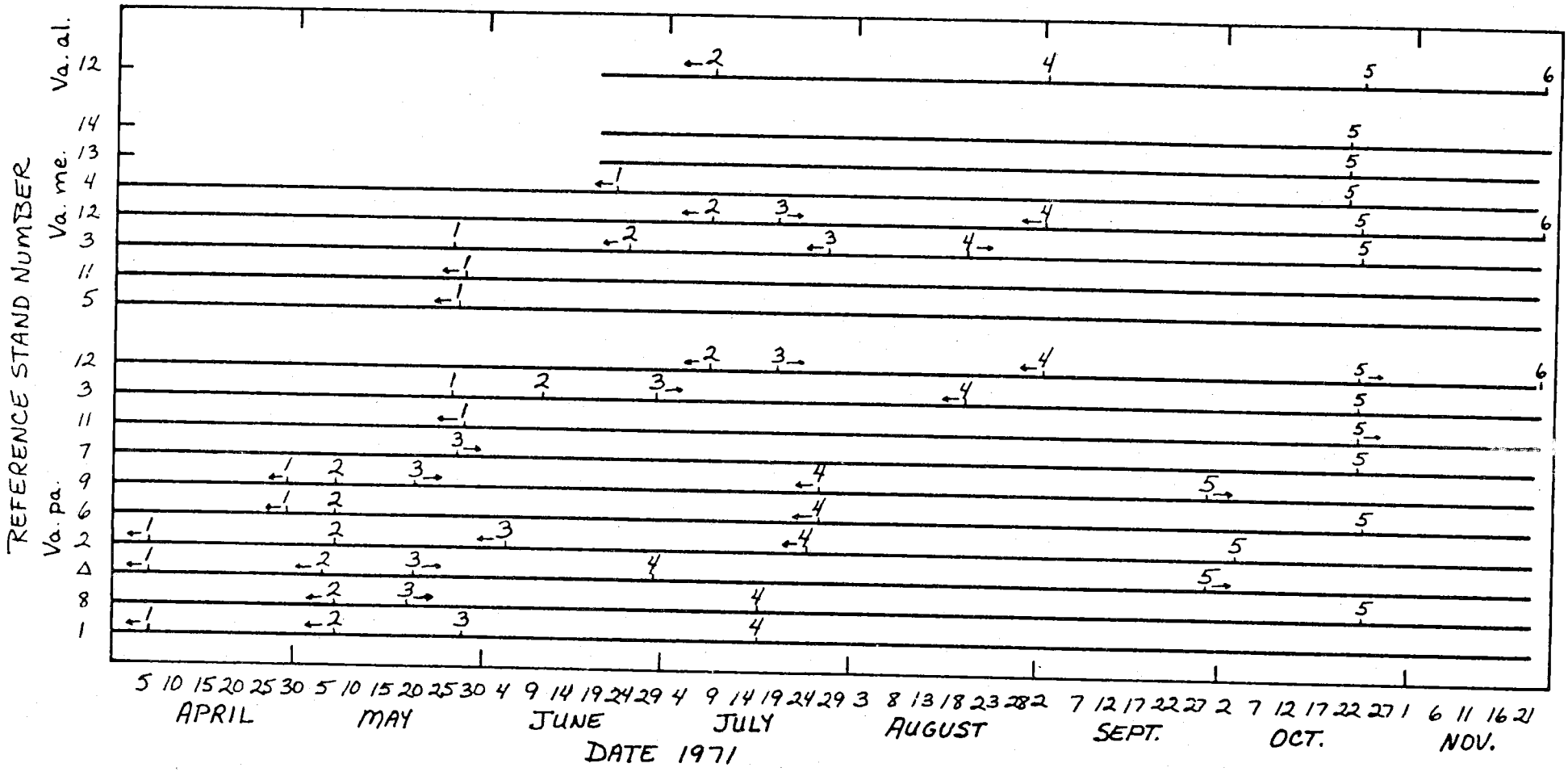

Figure 6. Phenophases of Vaccinium sp.: (1) vegetative bud break, (2) initiation of flowering, (3) cessation of flowering, (4) appearance of ripe fruit, (5) initiation of leaf fall, (6) cessation of leaf fall.

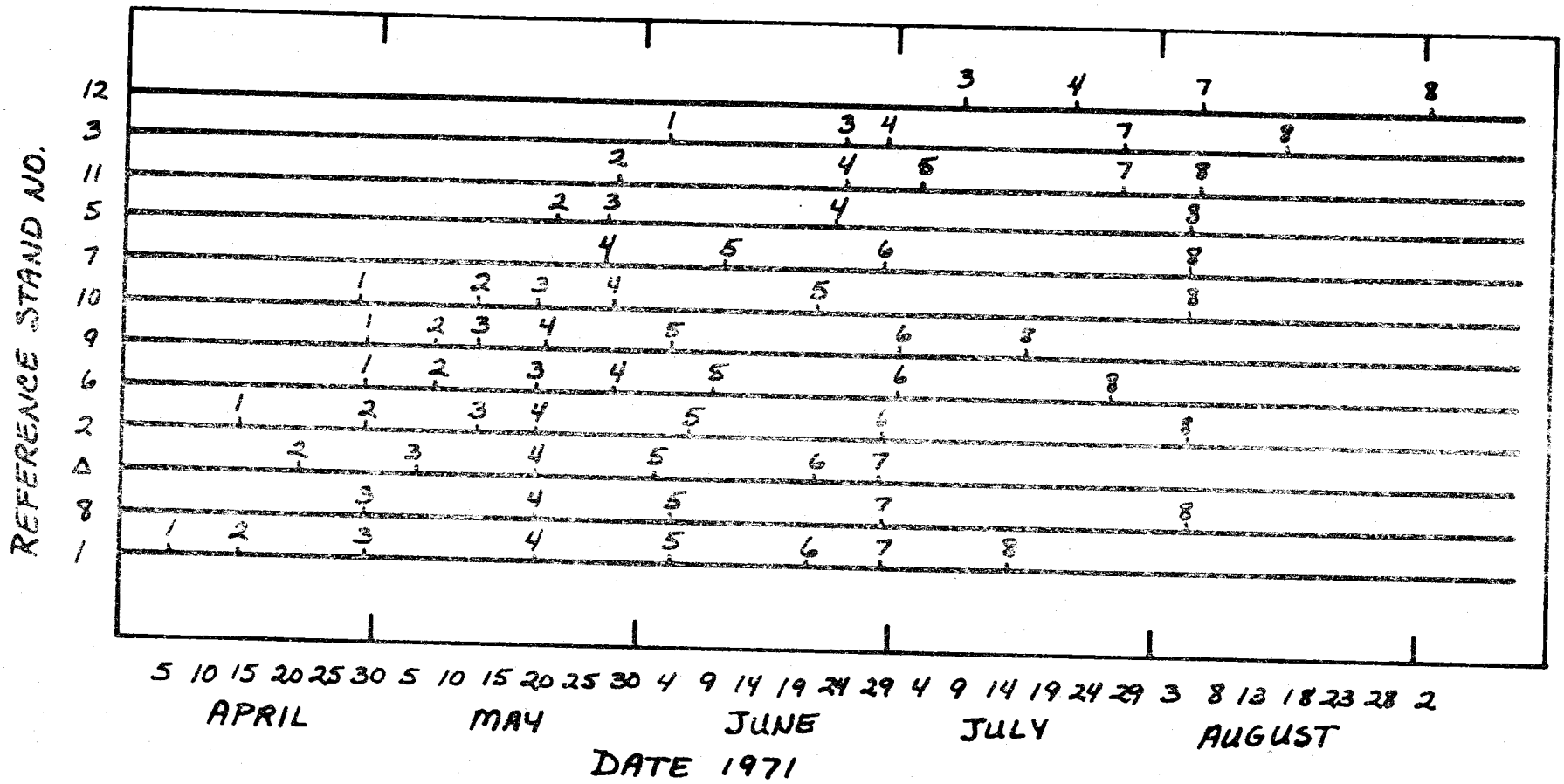

Figure 7. Phenophases of Linnaea borealis: (1) vegetative buds broken; (2) first pair of leaves expanded, parallel to stem; (3) first pair of leaves perpendicular to stem; (4) second pair of leaves perpendicular to stem; (5) flower buds emerging; (6) initiation of flowering; (7) peak of flowering; (8) past flowering.

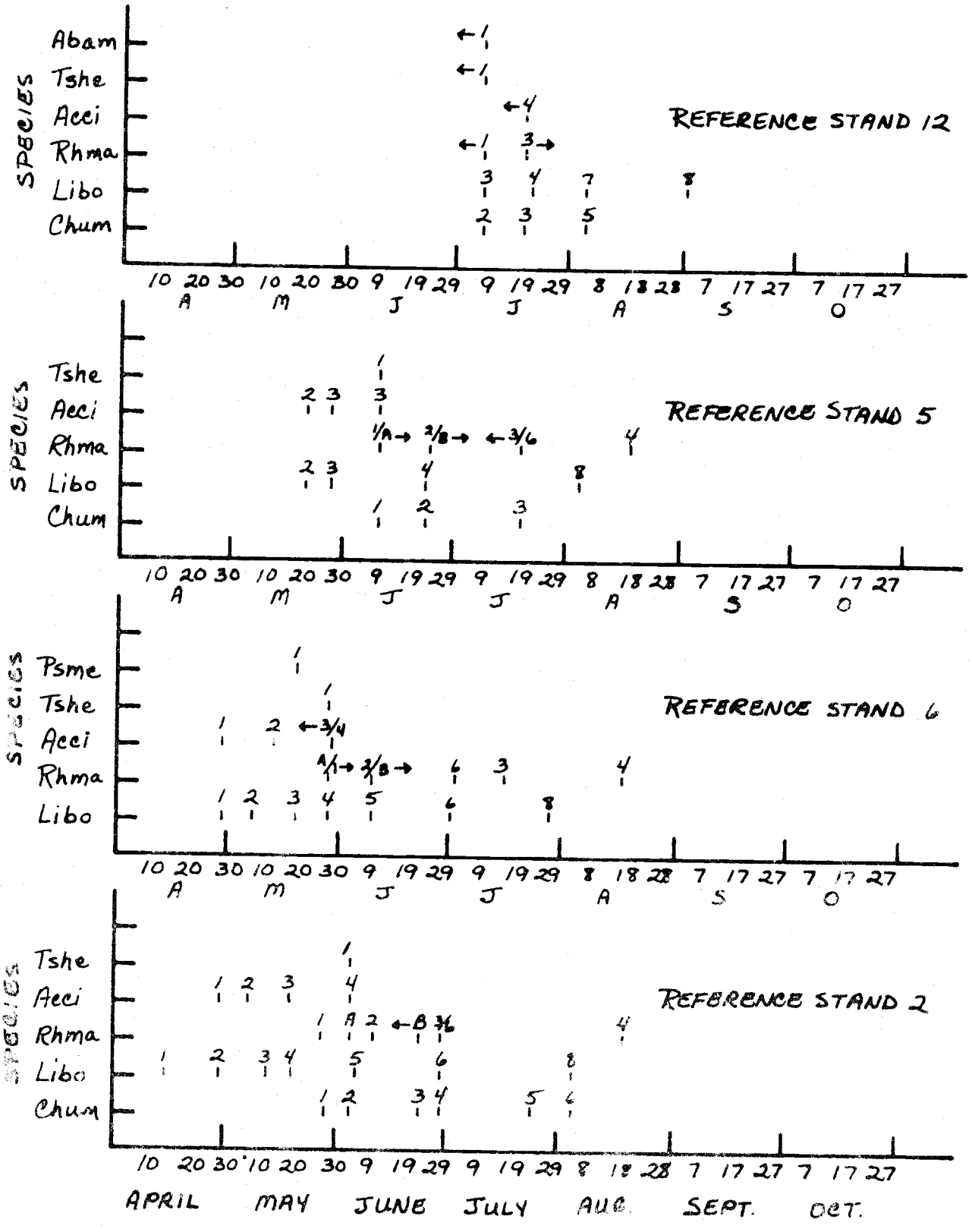

Figure 8. A comparison of phenophases of selected species in different reference stands.