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Flowering Phenology along the UWM Field Station Boardwalk in the Cedarburg Bog

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Abstract. Flowering phenology of 254 plant species was studied over eight growing seasons between 1984 and 1993. Most of the phenological observations were made along the Field Station's boardwalk in the Cedarburg Bog. We report on the flowering phenology of 189 species for which there was sufficient data for an accurate description. Correlations of flowering phenology with weather data are also summarized.

Introduction

Phenology, or the study of the timing of periodic biological phenomena, is an ancient but quiet science. As a science, phenology is closely related to ecology, physiology, meteorology, and genetics. Agriculture, forestry, and game management are among the applied sciences that depend heavily on phenological knowledge (Stearns 1969). Phenological studies that relate variation in the timing of natural events to spatial or temporal variations in climate or local variations in microclimate, are of particular interest (Cantlon 1953, Jackson 1966, Mowbray and Oosting 1968). Descriptive studies which correlate timing of biological phenomena with year to year variations in climate or with variation in microclimate offer some insight into the factors which signal and control events in nature.

A flowering phenology data base is valuable both to the educational and research programs of the Field Station. The Field Station frequently receives requests for phenological information pertaining to the timing of flowering of individual plant species, or of plant communities. Researchers studying plant reproduction or ecology want to know

when their species of interest is likely to be in bloom at the Station. Instructors ask when the peak blooming period is for certain plant communities. Teachers using the Field Station for workshops on specific groups of plants (for example Composites) ask when the largest number of members of that group are likely to be in bloom.

Without a flowering phenology data base specific for the site, we often must rely on the blooming period information contained in the available plant manuals. Since the manuals are written for a wide geographic area and usually estimate the full range of the blooming period, they tend to be very imprecise when applied to our site. Remembering blooming periods for a species without a formal data base is very difficult, and summary of the peak blooming time for a community would take a great deal of effort.

This paper presents data on the timing of flowering over eight growing seasons, of 189 selected plant species which grow along the Field Station's boardwalk in the Cedarburg Bog. The boardwalk is the Station's most used teaching facility and represents the main research access to much of the wetland. The boardwalk extends through six of the ten vegetation types found in the Bog and over upland forested habitat on the Bog islands. This list therefore represents a broad sample of the flora of the wetland, although the selected species concentrate primarily on showy species and exclude grasses and sedges. The data are presented in two ways so that plants likely to be blooming during any given period, or the blooming period of any of the 189 species can be easily retrieved. Year to year variation in the blooming period is correlated with variation in weather data for the area.

Methods

The study area was the UWM Field Station boardwalk in the Cedarburg Bog (Ozaukee Co., Wisconsin, T.11N, R.21E, Sec. 29 and 30). The boardwalk traverses sections of the conifer swamp, shrub carr, sedge meadow, swamp hardwoods, and string bog vegetation types in addition to upland islands within the wetland complex. For a complete description of these vegetation types and the Cedarburg Bog wetland see

Reinartz (1985 and 1986). For a list of the vascular plant species of the Bog and the Field Station area, and the habitats in which the species are found see Reinartz (1990).

The names of plants in flower along the boardwalk were recorded periodically throughout the growing season of eight out of the ten years between 1984 and 1993. Some upland plants growing along the boardwalk trail were included on the list. Observations were made every seven to ten days, on average, during the growing season. All phenology observations were recorded by Kate Redmond. Plants were selected for observation based on familiarity and interest to the observer. Over this period, flowering observations were recorded on 254 species. Sixty-five species were omitted from this report because there were too few observations to generate a reliable idea of the species' blooming period in the Bog, or because identification of the species was questionable or ambiguous. Nomenclature follows Voss (1972) for monocots and Voss (1985) for dicots which are included in his manuals. Nomenclature for species not included in Voss (1972;1985) follows Fernald (1970).

For most individual species, there were insufficient data to determine the effects of weather on annual variation in blooming period. For analysis of the effects of weather conditions on the mean blooming time of the flora, we categorized the species into groups based on the one month period during which they began to bloom. We calculated the mean first blooming date for each species based on observations from each year in which it was included in the study. For this analysis some year by species, or year by period combinations had to be excluded if an artifact of the data collection threatened to bias the results. For example: 1) Certain species were excluded from the data set of certain years when for that year the first recorded observation of the species was well after the beginning of its blooming time. 2) One-month periods were removed from the data for some years if the first observation during that year fell during that period. For example, in 1986 the first observation visit was during May. Inclusion of 1986 in the May blooming time analysis would be likely to generate an artificially late blooming date for those species which may have begun blooming before the first visit. We only used six of the eight seasons for correlation of blooming dates and weather conditions because there were insufficient data for the other two seasons.

To correlate the first bloom date in a season with the mean temperatures before or during the blooming period, we calculated the deviation of the first blooming date of a species in that season from the mean first blooming date of the species. The mean first blooming date of each species calculated over all years of the study was subtracted from the first observed blooming date of every season. These deviations from the average first bloom date were then correlated with average temperatures.

Weather records from the Milwaukee General Mitchell Field weather station (NOAA, 1984-1993) (49 km from the site) were used to correlate first blooming dates with weather conditions. We calculated monthly averages of temperature, precipitation and growing-degree-days at 10°C for each year of record. Growing-degree-days at 10°C is the total number of days during the period during which the temperature exceeded 10°C.

Although some data were excluded from the analysis and only a selected set of species are presented here, all of the original phenological observations are maintained in a data base at the Field Station. The Field Station invites and encourages contributions to this phenology data base.

Results and Discussion

Figure 1 presents the blooming period of 189 species arranged in order of mean first blooming date over the eight years of study. Figure 2 shows the blooming period of the species arranged alphabetically. Scientific and common names of the species are given in Table 1.

Mean spring temperatures varied considerably among the years of study. For example the mean temperature for the period from March to May varied from 6.3°C in 1989 to 10.3°C in 1991. While a range of 4°C may seem small, this difference in means over a three month period in spring represents a large difference in the growth rate potential of the plants.

The initiation of blooming was, on average, later for spring blooming plants in years with colder mean spring temperatures (Figure 3, A and

B). March through May mean temperature explained 28% of the variation in first bloom date of plants which normally began to bloom in May, and 40% of variation in first bloom date of June blooming plants. Plants blooming later in the season were not affected significantly by mean temperature. The squared correlation coefficient of deviations in July blooming dates with March to May mean temperature was only $r^2 = 0.031$. The correlations of July blooming with June mean temperature ($r^2 = 0.012$) and April to June mean temperature ($r^2 = 0.029$).

Neither growing-degree-days at 10°C , nor precipitation correlated significantly with deviations in first blooming dates for plants in any of the periods.

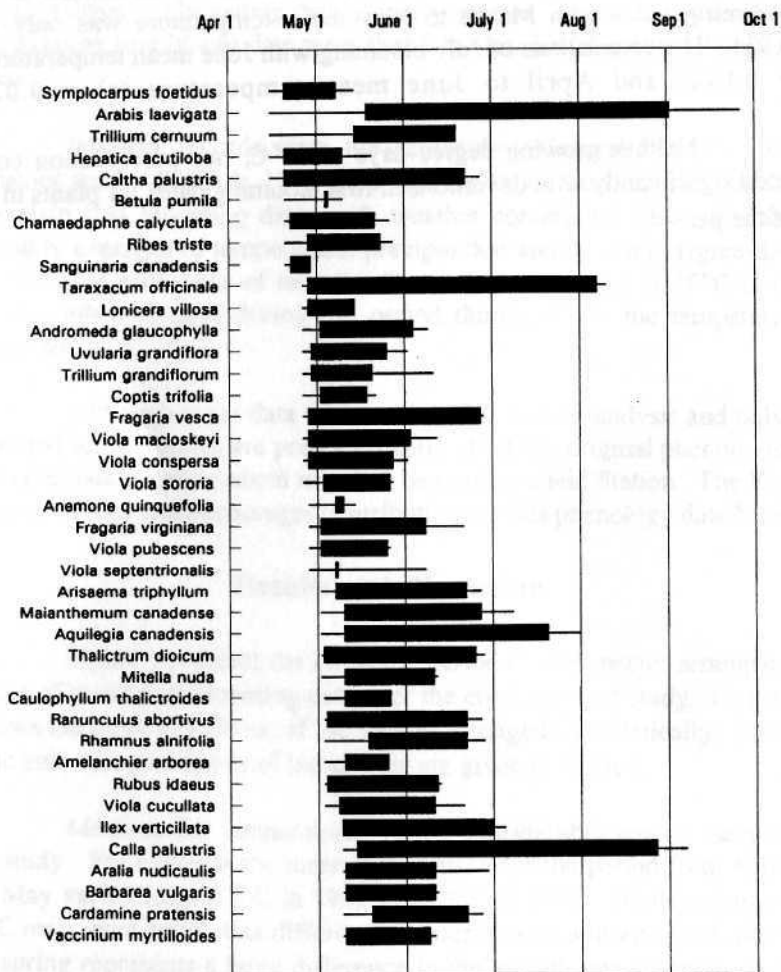


Figure 1. Blooming dates of species arranged by order of first observed blooming date. Lines connect first and last observed blooming dates. Thick bars connect second and second last observed blooming dates.

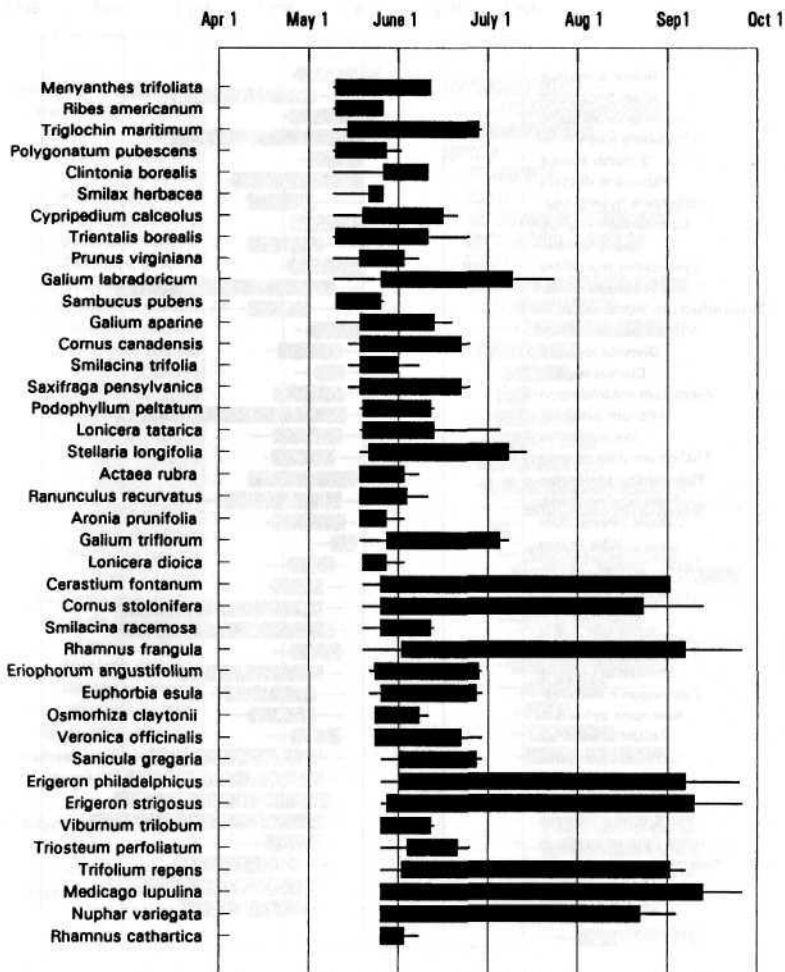


Figure 1 (cont.)

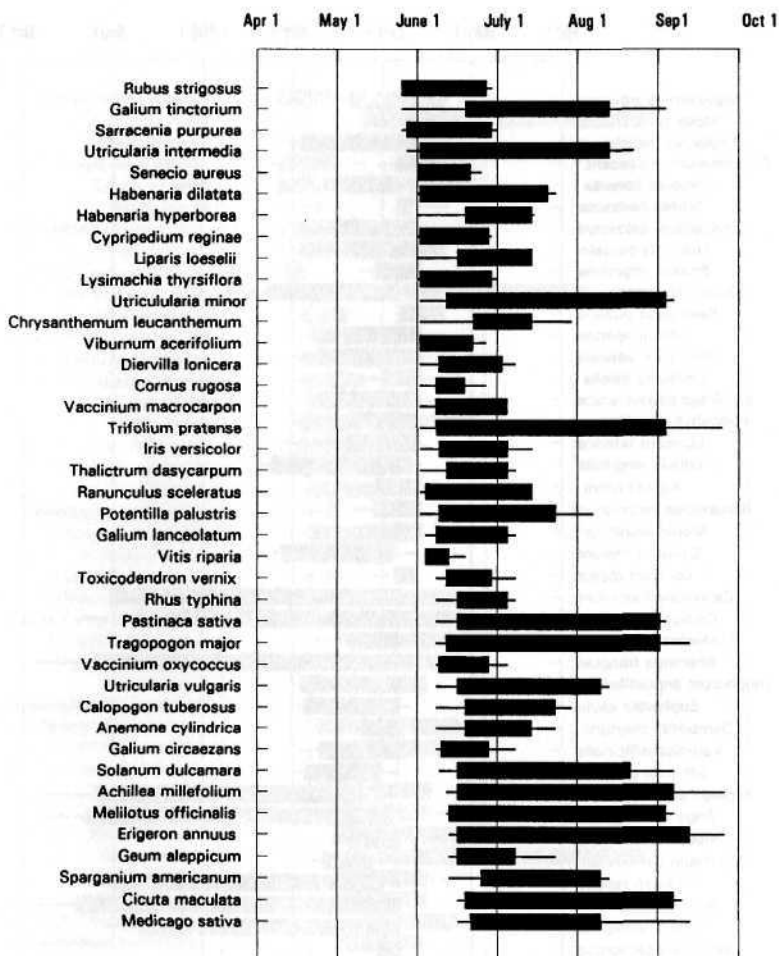


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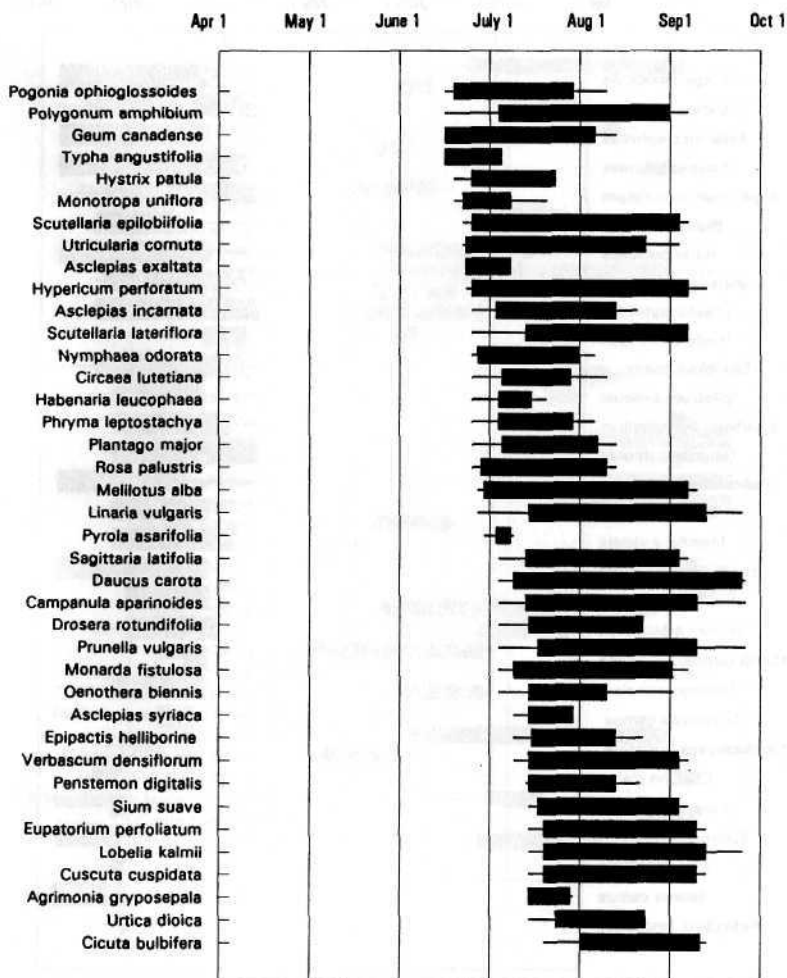


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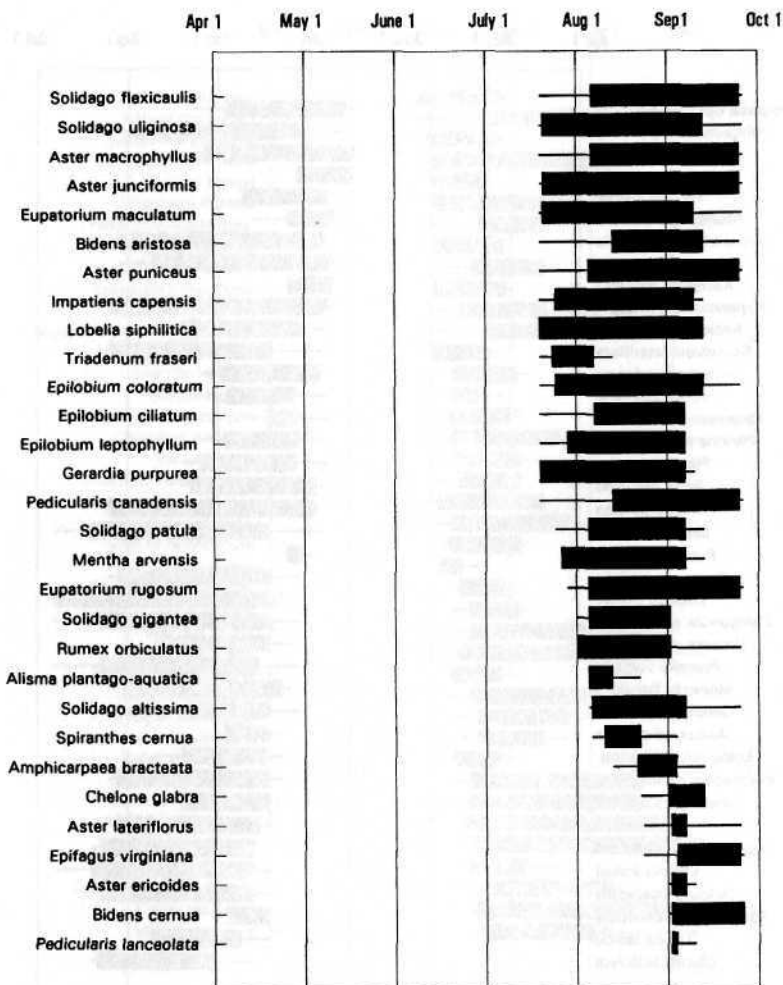


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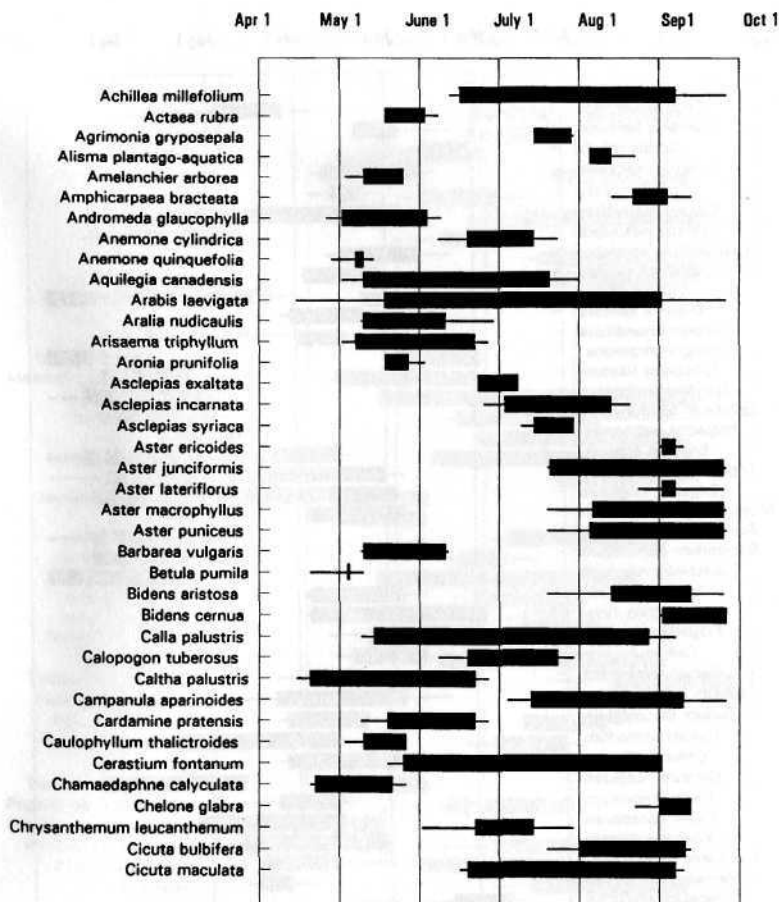


Figure 2. Blooming dates of species arranged alphabetically. Lines connect first and last observed blooming dates. Thick bars connect second and second last observed blooming dates.

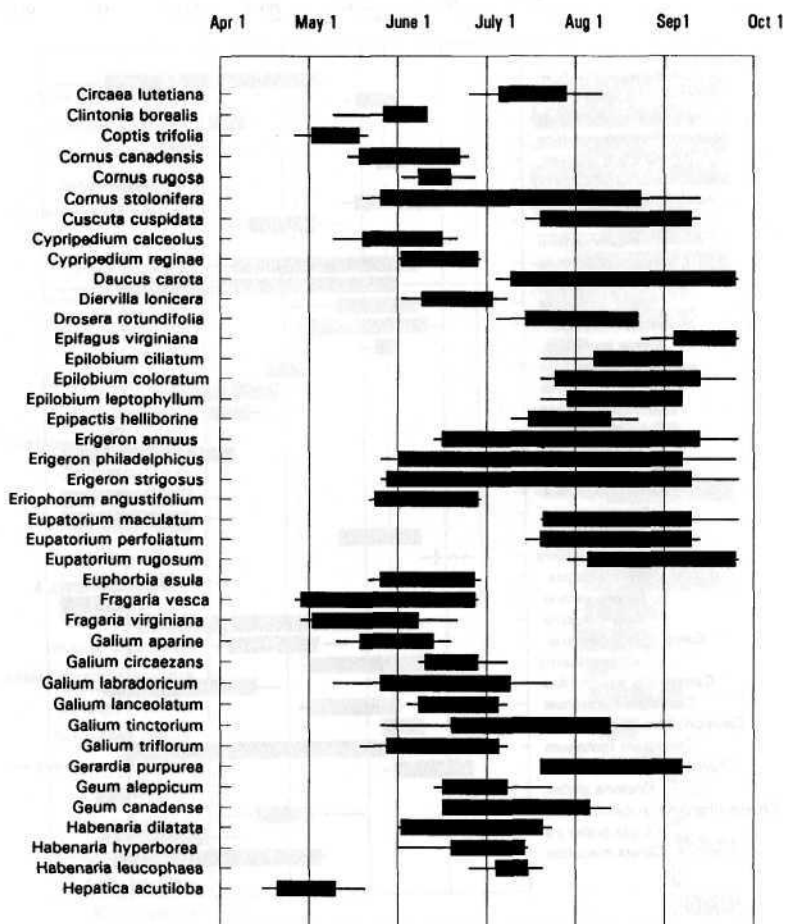


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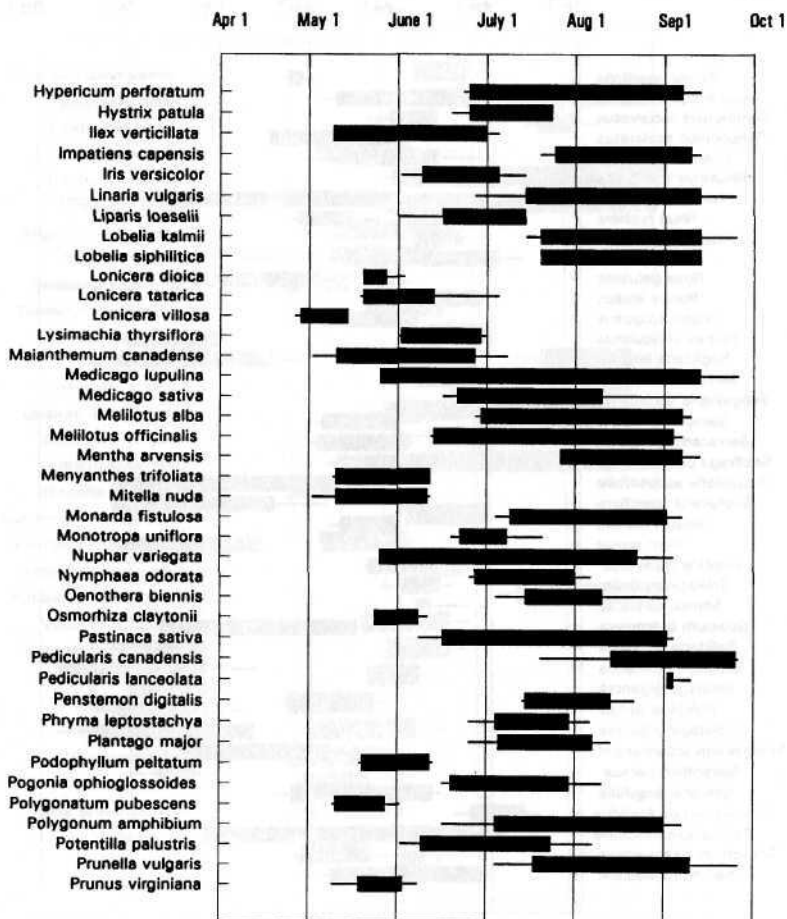


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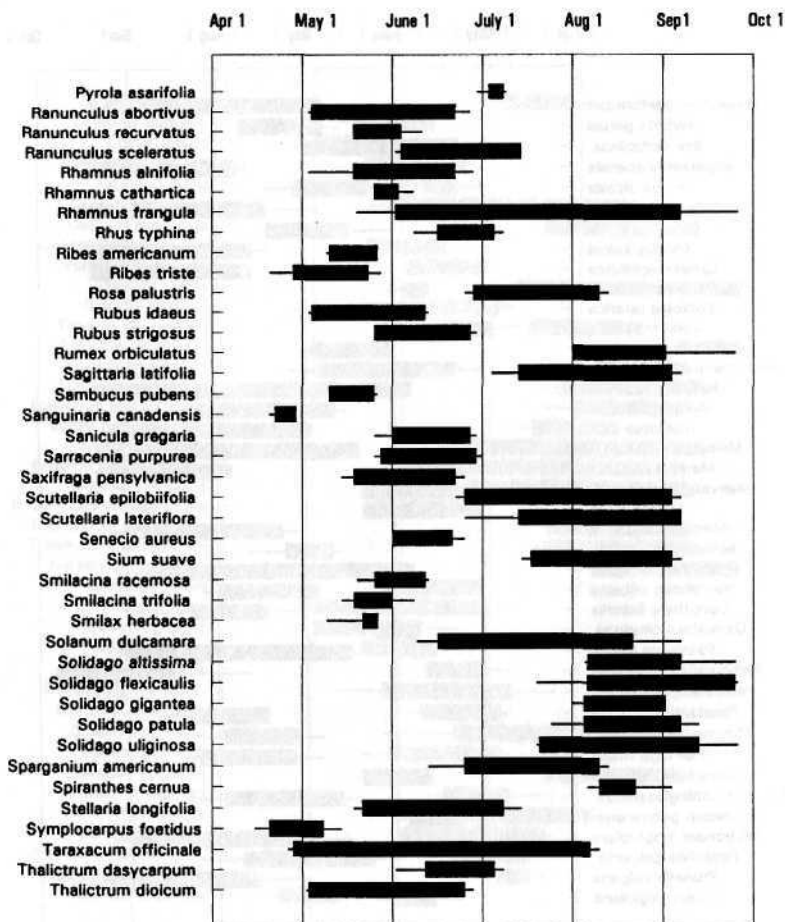


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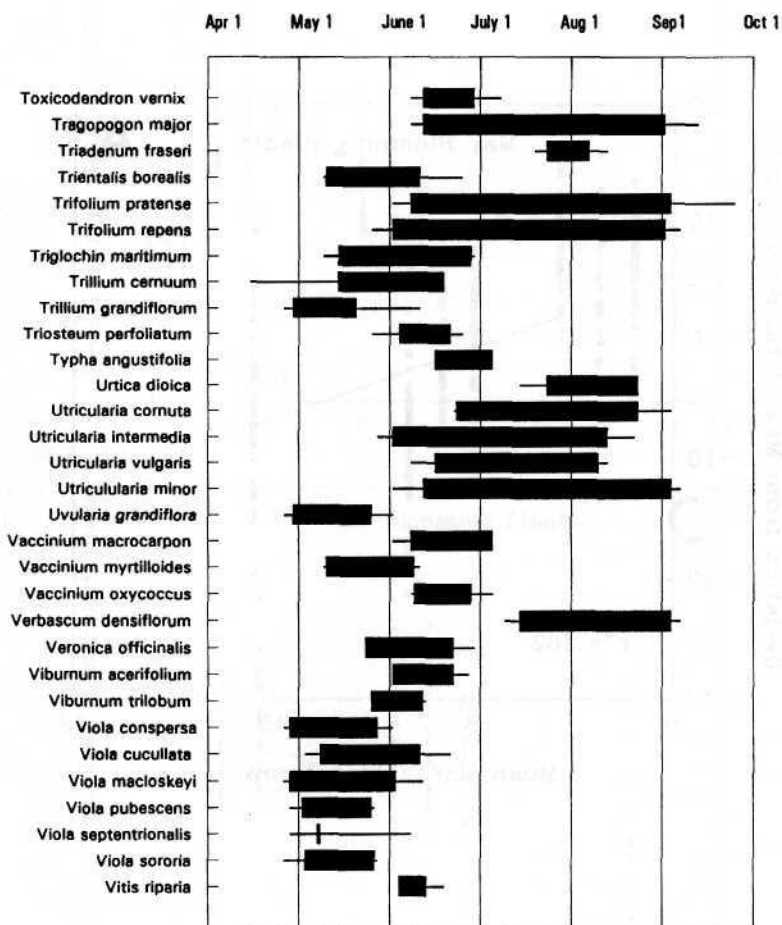


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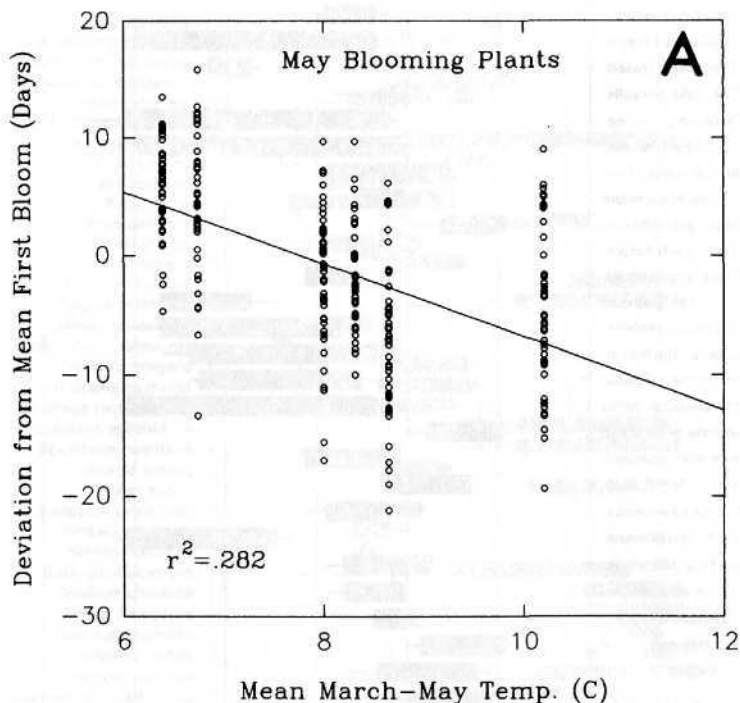


Figure 3. The effects of mean spring (March through May) temperatures in six years on deviations from mean first blooming dates. Lines are regression lines drawn through the points. A) Plants with a mean first blooming date in May. B) Plants with a mean first blooming date in June. C) Plants with a mean first blooming date in July.

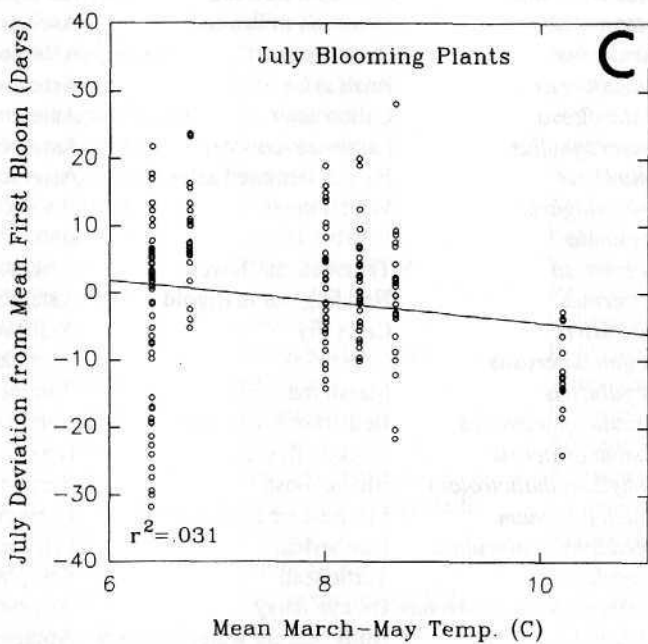
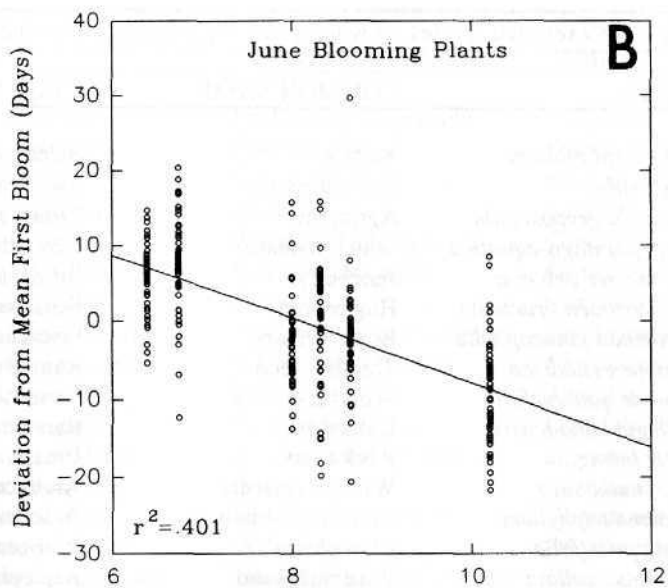


Figure 3 (cont.)

Table 1. 189 selected species for which phenological data is reported.

SPECIES	COMMON NAME	FAMILY
<i>Achillea millefolium</i>	Yarrow	Asteraceae
<i>Actaea rubra</i>	Red baneberry	Ranunculaceae
<i>Agrimonia gryposepala</i>	Agrimony	Rosaceae
<i>Alisma plantago-aquatica</i>	Water plantain	Alismataceae
<i>Amelanchier arborea</i>	Juneberry	Rosaceae
<i>Amphicarpaea bracteata</i>	Hog peanut	Fabaceae
<i>Andromeda glaucophylla</i>	Bog rosemary	Ericaceae
<i>Anemone cylindrica</i>	Thimbleweed	Ranunculaceae
<i>Anemone quinquefolia</i>	Wood anemone	Ranunculaceae
<i>Aquilegia canadensis</i>	Columbine	Ranunculaceae
<i>Arabis laevigata</i>	Rock cress	Brassicaceae
<i>Aralia nudicaulis</i>	Wild sarsaparilla	Araliaceae
<i>Arisaema triphyllum</i>	Jack in the Pulpit	Araceae
<i>Aronia prunifolia</i>	Chokeberry	Rosaceae
<i>Asclepias exaltata</i>	Poke milkweed	Asclepiadaceae
<i>Asclepias incarnata</i>	Swamp milkweed	Asclepiadaceae
<i>Asclepias syriaca</i>	Common milkweed	Asclepiadaceae
<i>Aster ericoides</i>	Heath aster	Asteraceae
<i>Aster junciformis</i>	Rush aster	Asteraceae
<i>Aster lateriflorus</i>	Calico aster	Asteraceae
<i>Aster macrophyllus</i>	Large-leaved aster	Asteraceae
<i>Aster puniceus</i>	Purple-stemmed aster	Asteraceae
<i>Barbarea vulgaris</i>	Winter cress	Brassicaceae
<i>Betula pumila</i>	Bog birch	Betulaceae
<i>Bidens aristosa</i>	Tickseed sunflower	Asteraceae
<i>Bidens cernua</i>	Nodding bur marigold	Asteraceae
<i>Calla palustris</i>	Calla lily	Araceae
<i>Calopogon tuberosus</i>	Grass pink	Orchidaceae
<i>Caltha palustris</i>	Marsh marigold	Ranunculaceae
<i>Campanula aparinoides</i>	Bedstraw bellflower	Campanulaceae
<i>Cardamine pratensis</i>	Cuckoo flower	Brassicaceae
<i>Caulophyllum thalictroides</i>	Blue cohosh	Berberidaceae
<i>Cerastium fontanum</i>	Mouse-eared chickweed	Caryophyllaceae
<i>Chamaedaphne calyculata</i>	Leatherleaf	Ericaceae
<i>Chelone glabra</i>	Turtlehead	Scrophularia
<i>Chrysanthemum leucanthemum</i>	Ox eye daisy	Asteraceae
<i>Cicuta bulbifera</i>	Bulb-bearing water hemlock	Apiaceae
<i>Cicuta maculata</i>	Water hemlock	Apiaceae

SPECIES	COMMON NAME	FAMILY
<i>Circaea lutetiana</i>	Enchanter's nightshade	Onagraceae
<i>Clintonia borealis</i>	Blue bead lily	Liliaceae
<i>Coptis trifolia</i>	Goldthread	Ranunculaceae
<i>Cornus canadensis</i>	Bunchberry	Cornaceae
<i>Cornus rugosa</i>	Round-leaved dogwood	Cornaceae
<i>Cornus stolonifera</i>	Red osier dogwood	Cornaceae
<i>Cuscuta cuspidata</i>	Dodder	Convolvulaceae
<i>Cypripedium calceolus</i>	Small yellow lady's slipper	Orchidaceae
<i>Cypripedium reginae</i>	Showy lady's slipper	Orchidaceae
<i>Daucus carota</i>	Wild carrot	Apiaceae
<i>Diervilla lonicera</i>	Bush honeysuckle	Caprifoliaceae
<i>Drosera rotundifolia</i>	Round-leaved sundew	Droseraceae
<i>Epifagus virginiana</i>	Beechdrops	Orobanchaceae
<i>Epilobium ciliatum</i>	Northern willow herb	Onagraceae
<i>Epilobium coloratum</i>	Willow herb	Onagraceae
<i>Epilobium leptophyllum</i>	Narrow-leaved willow herb	Onagraceae
<i>Epipactis helliborine</i>	Helliborine	Orchidaceae
<i>Erigeron annuus</i>	Daisy fleabane	Asteraceae
<i>Erigeron philadelphicus</i>	Philadelphia daisy	Asteraceae
<i>Erigeron strigosus</i>	Daisy fleabane	Asteraceae
<i>Eriophorum angustifolium</i>	Cottongrass	Cyperaceae
<i>Eupatorium maculatum</i>	Joe-pye weed	Asteraceae
<i>Eupatorium perfoliatum</i>	Boneset	Asteraceae
<i>Eupatorium rugosum</i>	White snakeroot	Asteraceae
<i>Euphorbia esula</i>	Leafy spurge	Euphorbiaceae
<i>Fragaria vesca</i>	Wood strawberry	Rosaceae
<i>Fragaria virginiana</i>	Wild strawberry	Rosaceae
<i>Galium aparine</i>	Cleavers	Rubiaceae
<i>Galium circaezans</i>	White wild licorice	Rubiaceae
<i>Galium labradoricum</i>	Bedstraw	Rubiaceae
<i>Galium lanceolatum</i>	Bedstraw	Rubiaceae
<i>Galium tinctorium</i>	Bedstraw	Rubiaceae
<i>Galium triflorum</i>	Fragrant bedstraw	Rubiaceae
<i>Gerardia purpurea</i>	Small-flowered gerardia	Scrophulariaceae
<i>Geum aleppicum</i>	Avens	Rosaceae
<i>Geum canadense</i>	White avens	Rosaceae
<i>Habenaria dilatata</i>	Tall white bog orchid	Orchidaceae
<i>Habenaria hyperborea</i>	Northern green orchid	Orchidaceae
<i>Habenaria leucophaea</i>	Prairie wht-fringed orchid	Orchidaceae

SPECIES	COMMON NAME	FAMILY
<i>Hepatica acutiloba</i>	Sharp-lobed hepatica	Ranunculaceae
<i>Hypericum perforatum</i>	Common St. John's wort	Guttiferae
<i>Hystrix patula</i>	Bottle brush grass	Poaceae
<i>Ilex verticillata</i>	Winterberry	Aquifoliaceae
<i>Impatiens capensis</i>	Jewel weed	Balsaminaceae
<i>Iris versicolor</i>	Blue flag iris	Iridaceae
<i>Linaria vulgaris</i>	Butter and eggs	Scrophulariaceae
<i>Liparis loeselii</i>	Green twayblade	Orchidaceae
<i>Lobelia kalmii</i>	Bog lobelia	Campanulaceae
<i>Lobelia siphilitica</i>	Great lobelia	Campanulaceae
<i>Lonicera dioica</i>	Wild honeysuckle	Caprifoliaceae
<i>Lonicera tatarica</i>	Tartarian honeysuckle	Caprifoliaceae
<i>Lonicera villosa</i>	Mountain fly honeysuckle	Caprifoliaceae
<i>Lysimachia thyrsiflora</i>	Tufted loosestrife	Primulaceae
<i>Maianthemum canadense</i>	Canada mayflower	Liliaceae
<i>Medicago lupulina</i>	Black medick	Fabaceae
<i>Medicago sativa</i>	Alfalfa	Fabaceae
<i>Melilotus alba</i>	White sweet clover	Fabaceae
<i>Melilotus officinalis</i>	Yellow sweet clover	Fabaceae
<i>Mentha arvensis</i>	Wild mint	Lamiaceae
<i>Menyanthes trifoliata</i>	Buckbean	Gentianaceae
<i>Mitella nuda</i>	Miterwort	Saxifragaceae
<i>Monarda fistulosa</i>	Wild bergamot	Lamiaceae
<i>Monotropa uniflora</i>	Indian pipe	Pyrolaceae
<i>Nuphar variegata</i>	Bullhead lily	Nymphaeaceae
<i>Nymphaea odorata</i>	Water lily	Nymphaeaceae
<i>Oenothera biennis</i>	Common evening primrose	Onagraceae
<i>Osmorhiza claytonii</i>	Sweet cicely	Apiaceae
<i>Pastinaca sativa</i>	Wild parsnip	Apiaceae
<i>Pedicularis canadensis</i>	Common lousewort	Scrophylariaceae
<i>Pedicularis lanceolata</i>	Swamp lousewort	Scrophulariaceae
<i>Penstemon digitalis</i>	Foxglove beardtongue	Scrophulariaceae
<i>Phryma leptostachya</i>	Lopseed	Phrymaceae
<i>Plantago major</i>	Common plantain	Plantaginaceae
<i>Podophyllum peltatum</i>	Mayapple	Berberidaceae
<i>Pogonia ophioglossoides</i>	Rose pogonia	Orchidaceae
<i>Polygonatum pubescens</i>	Hairy Solomon's seal	Liliaceae
<i>Polygonum amphibium</i>	Water smartweed	Polygonaceae
<i>Potentilla palustris</i>	Marsh cinquefoil	Rosaceae
<i>Prunella vulgaris</i>	Heal all	Lamiaceae

SPECIES	COMMON NAME	FAMILY
<i>Prunus virginiana</i>	Choke cherry	Rosaceae
<i>Pyrola asarifolia</i>	Pink pyrola	Pyrolaceae
<i>Ranunculus abortivus</i>	Kidney leaf buttercup	Ranunculaceae
<i>Ranunculus recurvatus</i>	Hooked crowfoot	Ranunculaceae
<i>Ranunculus sceleratus</i>	Cursed crowfoot	Ranunculaceae
<i>Ratibida pinnata</i>	Gray-headed coneflow	Asteraceae
<i>Rhamnus alnifolia</i>	Alder-leaved buckthorn	Rhamnaceae
<i>Rhamnus cathartica</i>	Common buckthorn	Rhamnaceae
<i>Rhamnus frangula</i>	Glossy buckthorn	Rhamnaceae
<i>Rhus typhina</i>	Staghorn sumac	Anacardiaceae
<i>Ribes americanum</i>	Wild black currant	Grossulariaceae
<i>Ribes triste</i>	Swamp red currant	Grossulariaceae
<i>Rosa palustris</i>	Swamp rose	Rosaceae
<i>Rubus idaeus</i>	Swamp dewberry	Rosaceae
<i>Rubus strigosus</i>	Red raspberry	Rosaceae
<i>Rumex orbiculatus</i>	Great water dock	Polygonaceae
<i>Sagittaria latifolia</i>	Arrowhead	Alismataceae
<i>Sambucus pubens</i>	Red elderberry	Caprifoliaceae
<i>Sanguinaria canadensis</i>	Bloodroot	Papaveraceae
<i>Sanicula gregaria</i>	Black snakeroot	Apiaceae
<i>Sarracenia purpurea</i>	Pitcher plant	Sarraceniaceae
<i>Saxifraga pensylvanica</i>	Swamp saxifrage	Saxifragaceae
<i>Scutellaria epilobiifolia</i>	Marsh skullcap	Lamiaceae
<i>Scutellaria lateriflora</i>	Mad dog skullcap	Lamiaceae
<i>Senecio aureus</i>	Golden ragwort	Asteraceae
<i>Sium suave</i>	Water parsnip	Apiaceae
<i>Smilacina racemosa</i>	False Solomon's seal	Liliaceae
<i>Smilacina trifolia</i>	3-lvd False Solomon's seal	Liliaceae
<i>Smilax herbacea</i>	Carriion flower	Liliaceae
<i>Solanum dulcamara</i>	Purple nightshade	Solanaceae
<i>Solidago flexicaulis</i>	Zigzag goldenrod	Asteraceae
<i>Solidago gigantea</i>	Late goldenrod	Asteraceae
<i>Solidago patula</i>	Rough-leaved goldenrod	Asteraceae
<i>Solidago uliginosa</i>	Bog goldenrod	Asteraceae
<i>Sparganium americanum</i>	Bur reed	Sparganiaceae
<i>Spiranthes cernua</i>	Ladies' tresses	Orchidaceae
<i>Stellaria longifolia</i>	Long-leaved chickweed	Caryophyllaceae
<i>Symplocarpus foetidus</i>	Skunk cabbage	Araceae
<i>Taraxacum officinale</i>	Dandelion	Asteraceae
<i>Thalictrum dasycarpum</i>	Purple meadow rue	Ranunculaceae

SPECIES	COMMON NAME	FAMILY
<i>Thalictrum dioicum</i>	Early meadow rue	Ranunculaceae
<i>Toxicodendron vernix</i>	Poison sumac	Anacardiaceae
<i>Tragopogon major</i>	Yellow goats beard	Asteraceae
<i>Triadenum fraseri</i>	Marsh St. John's wort	Guttiferae
<i>Trientalis borealis</i>	Starflower	Primulaceae
<i>Trifolium pratense</i>	Red clover	Fabaceae
<i>Trifolium repens</i>	White clover	Fabaceae
<i>Triglochin maritimum</i>	Arrowgrass	Juncaginaceae
<i>Trillium cernuum</i>	Nodding trillium	Liliaceae
<i>Trillium grandiflorum</i>	Common trillium	Liliaceae
<i>Triosteum perfoliatum</i>	Tinker's weed	Caprifoliaceae
<i>Typha angustifolia</i>	Narrow-leaved cattail	Typhaceae
<i>Urtica dioica</i>	Stinging nettle	Urticaceae
<i>Utricularia cornuta</i>	Horned bladderwort	Lentibulariaceae
<i>Utricularia intermedia</i>	Bladderwort	Lentibulariaceae
<i>Utricularia vulgaris</i>	Greater bladderwort	Lentibulariaceae
<i>Utricularia minor</i>	Lesser Bladderwort	Campanulacea
<i>Uvularia grandiflora</i>	Large-flowered bellwort	Liliaceae
<i>Vaccinium macrocarpon</i>	Large cranberry	Ericaceae
<i>Vaccinium myrtilloides</i>	Velvet leaf bilberry	Ericaceae
<i>Vaccinium oxycoccus</i>	Small cranberry	Ericaceae
<i>Verbascum densiflorum</i>	Mullein	Scrophulariaceae
<i>Veronica officinalis</i>	Common speedwell	Scrophulariaceae
<i>Viburnum acerifolium</i>	Maple-leaved viburnum	Caprifoliaceae
<i>Viburnum trilobum</i>	High bush cranberry	Caprifoliaceae
<i>Viola conspersa</i>	American dog violet	Violaceae
<i>Viola cucullata</i>	Blue marsh violet	Violaceae
<i>Viola macloskeyi</i>	Smooth white violet	Violaceae
<i>Viola pubescens</i>	Yellow violet	Violaceae
<i>Viola septentrionalis</i>	Violet	Violaceae
<i>Viola sororia</i>	Common blue violet	Violaceae
<i>Vitis riparia</i>	River grape	Vitaceae

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