

A standardized photographic guide to woody plant spring phenology

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Summary

Measuring plant phenology—the timing of recurring life history events such as leafout and flowering—sounds tantalizingly simple, but is complicated by the reality that different people often interpret the same event (e.g., budburst or leafout) differently. Researchers have worked to overcome this with a series of guides that explicitly describe each phenological event in great detail. One of the most widely-used scales is the BBCH (Biologische Bundesanstalt, Bundesortenamt und CHemische Industrie), which defines several principal growth stages (see Table 1) and breaks down each stage into events within stages (e.g., first leaves separated). Yet, even with clearly described stages aimed at standardizing measurements of the same events taken by different observers, there can still be variation in observers' interpretation of events. Thus, photographs of each defined stage, for each species of interest, can help standardize observations further. Here we present a photographic guide to the BBCH stages of 31 woody species common to northeastern North American temperate forests.

Photographic guide to BBCH stages of 31 woody species

This guide shows spring phenology stages from 31 woody plant species (see Table 2) from eastern North American temperate forests following the BBCH scale.

Development was recorded from dormant cuttings forced in the springs of 2015-2016, with cuttings taken from individuals growing between Boston, Massachusetts and Saint Hippolyte, Quebec. Most cuttings were taken from either Harvard Forest LTER in Petersham, Massachusetts (USA) or Station de biologie des Laurentides in Saint Hippolyte, Quebec (Canada).

Note that stages were captured on an opportunistic basis, thus different stages are available for each species. Most species are shown on one page, while some span two pages (*Acer rubrum*, *Corylus cornuta*, *Fagus grandifolia*, *Populus grandidentata*, *Viburnum lantanoides*).

Original images have been re-sampled to fit within this PDF guide, but high-quality versions of all photos are available upon request.

Acknowledgements: Special thanks to J. Samaha and A. Ettinger for help identifying species.

BBCH Guide	
Stage	Description
Principal growth stage 0: sprouting/bud development	
00	Dormancy: buds closed and covered by scales
01	Beginning of bud swelling
03	End of bud swelling
07	Beginning of sprouting or bud breaking; shoot emergence
09	Buds show green tips
10	Green leaf tips 10 mm above the bud scales
Principal growth stage 1: leaf and needle development	
11	First leaves unfolded
15	More leaves unfolded, but not yet at full size. First leaves unfolded
17	Most leaves unfolded on majority of tree
19	Leaf expansion complete
Principal growth stage 3: stem elongation	
30	Beginning of stem elongation
31	Stem about 10% of final length
32	Stem about 20% of final length
33	Stem about 30% of final length
34	Stem about 40% of final length
35	Stem about 50% of final length
36	Stem about 60% of final length
37	Stem about 70% of final length
38	Stem about 80% of final length
39	Stem about 90% of final length
51	Inflorescence or flower buds visible
55	First individual flowers visible but still closed
59	First flower petals visible (in forms with petals)
Principal growth stage 6: flowering	
60	First flowers open
61	Beginning of flowering, 10% flowers open
62	20% of flowers open
63	30% of flowers open
64	40% of flowers open
65	50% of flowers open, full flowering: first petals may be fallen
67	Flowering finishing; majority of petals fallen or dry
69	End of flowering: fruit set visible
Principal growth stage 7: fruit/cone development	
72	Fruit/cones 20% of final size
75	Fruit/cones 50% of final size
78	Fruit/cones 80% of final size
79	Fruit/cones final size
Principal growth stage 8: fruit/cones ripening	
89	Fruit/cones fully ripe
Principal growth stage 9: senescence, beginning of dormancy	
91	Shoot growth completed; foliage still green and terminal buds developed
92	Beginning of leaf discoloration
93	Beginning of leaf fall
95	50% of leaves fallen
97	End of leaf fall

Table 1: Overview of the BBCH scale for woody species (see Finn, Straszewski & Peterson, 'A general growth stage key for describing trees and woody plants,' from *Annals of Applied Biology*, 2007).

Species name	Synonym(s)	Common name
<i>Acer pensylvanicum</i>		Striped maple
<i>Acer rubrum</i>		Red maple
<i>Acer saccharum</i>		Sugar maple
<i>Alnus incana</i>		Speckled alder
<i>Betula alleghaniensis</i>	<i>B. lutea</i>	Yellow birch
<i>Betula lenta</i>		Black birch
<i>Betula papyrifera</i>		Paper birch
<i>Cornus alternifolia</i>		Alternate-leaved dogwood
<i>Corylus cornuta</i>	<i>C. rostrata</i>	Beaked hazelnut
<i>Fagus grandifolia</i>		American beech
<i>Fraxinus americana</i>		American ash
<i>Fraxinus nigra</i>		Black ash
<i>Hamamelis virginiana</i>		Witch hazel
<i>Ilex mucronata</i>	<i>Nemopanthus mucronatus</i>	Mountain holly
<i>Kalmia angustifolia</i>		Sheep laurel
<i>Lyonia ligustrina</i>		Maleberry
<i>Myrica gale</i>		Sweet gale
<i>Nyssa sylvatica</i>		Black gum
<i>Populus grandidentata</i>		Big-toothed aspen
<i>Prunus pensylvanica</i>		Pin cherry
<i>Quercus alba</i>		White oak
<i>Quercus rubra</i>		Northern red oak
<i>Quercus velutina</i>		Black oak
<i>Rhamnus frangula</i>	<i>Frangula alnus</i>	Glossy buckthorn
<i>Rhododendron prinophyllum</i>	Many, see <i>Harvard Forest Flora</i>	Common pinkster flower
<i>Sambucus racemosa</i>		Red elderberry
<i>Spiraea alba</i>	<i>S. latifolia</i>	Meadow-sweet
<i>Tilia americana</i>		Basswood
<i>Vaccinium corymbosum</i>		Highbush blueberry
<i>Viburnum cassinoides</i>	<i>V. nudum</i> var. <i>cassinoides</i>	Wild raisin
<i>Viburnum lantanoides</i>	<i>V. alnifolium</i>	Hobblebush

Table 2: Names, synonyms and common names for the 31 species shown in this guide. Taxonomy generally follows Jenkins, Motzkin & Ward, *The Harvard Forest Flora: An Inventory, Analysis & Ecological History*, 2008, except for *Ilex mucronata*, which recent genetic tests have shown is not its own genus (i.e., *Nemopanthus*), see Haines, *Flora Novae Angliae*, 2011.

Figure 1: *Acer pensylvanicum*

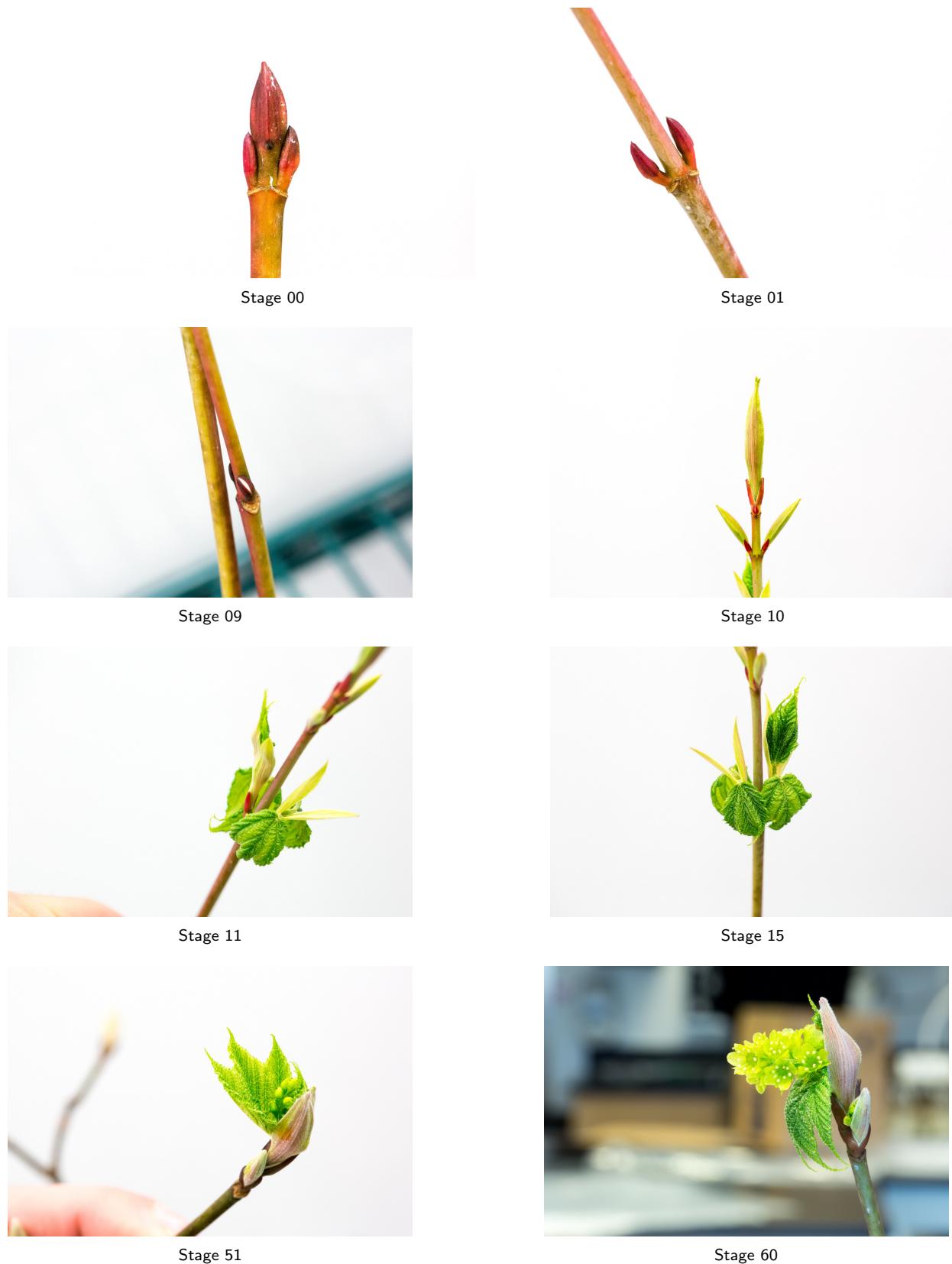


Figure 2: *Acer rubrum*



Stage 00



Stage 01



Stage 09



Stage 10



Stage 15



Stage 19



Stage 51



Stage 55

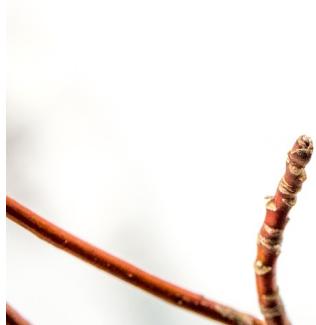
Figure 3: *Acer rubrum*



Stage 60



Stage 67



Stage 97

Figure 4: *Acer saccharum*



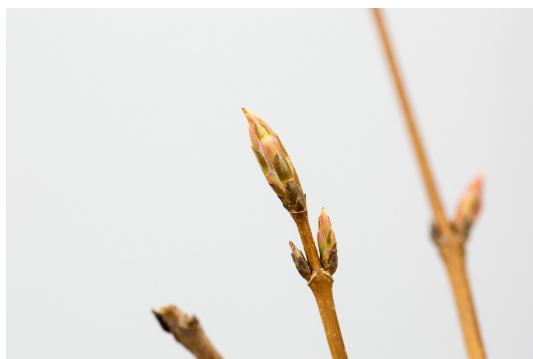
Stage 00



Stage 01



Stage 03



Stage 09

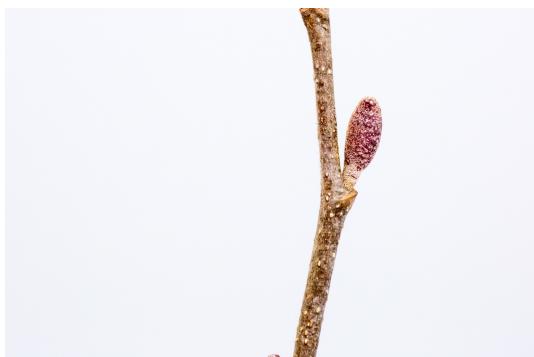


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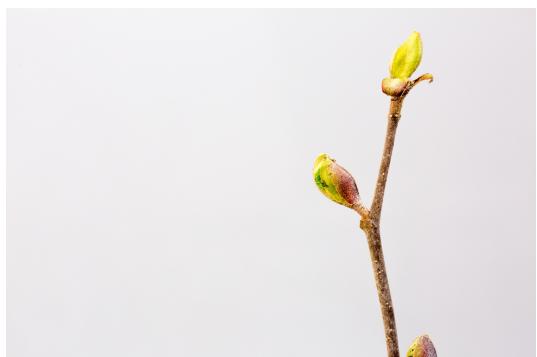


Stage 11

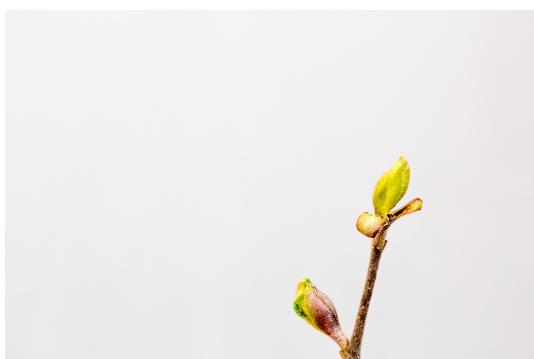
Figure 5: *Alnus incana*



Stage 00



Stage 07



Stage 10



Stage 11

Figure 6: *Betula alleghaniensis*



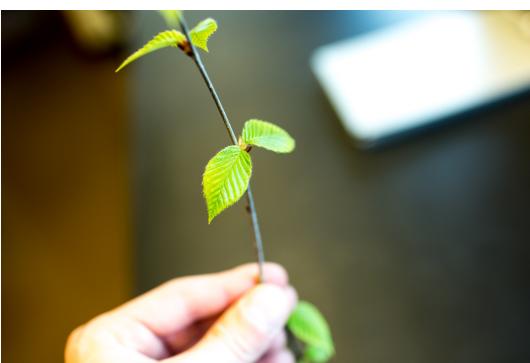
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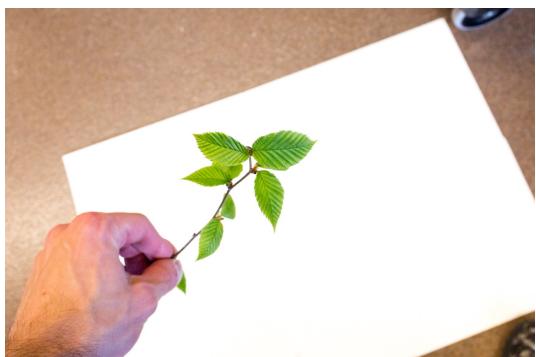
Stage 10



Stage 11



Stage 15



Stage 17



Stage 19

Figure 7: *Betula lenta*

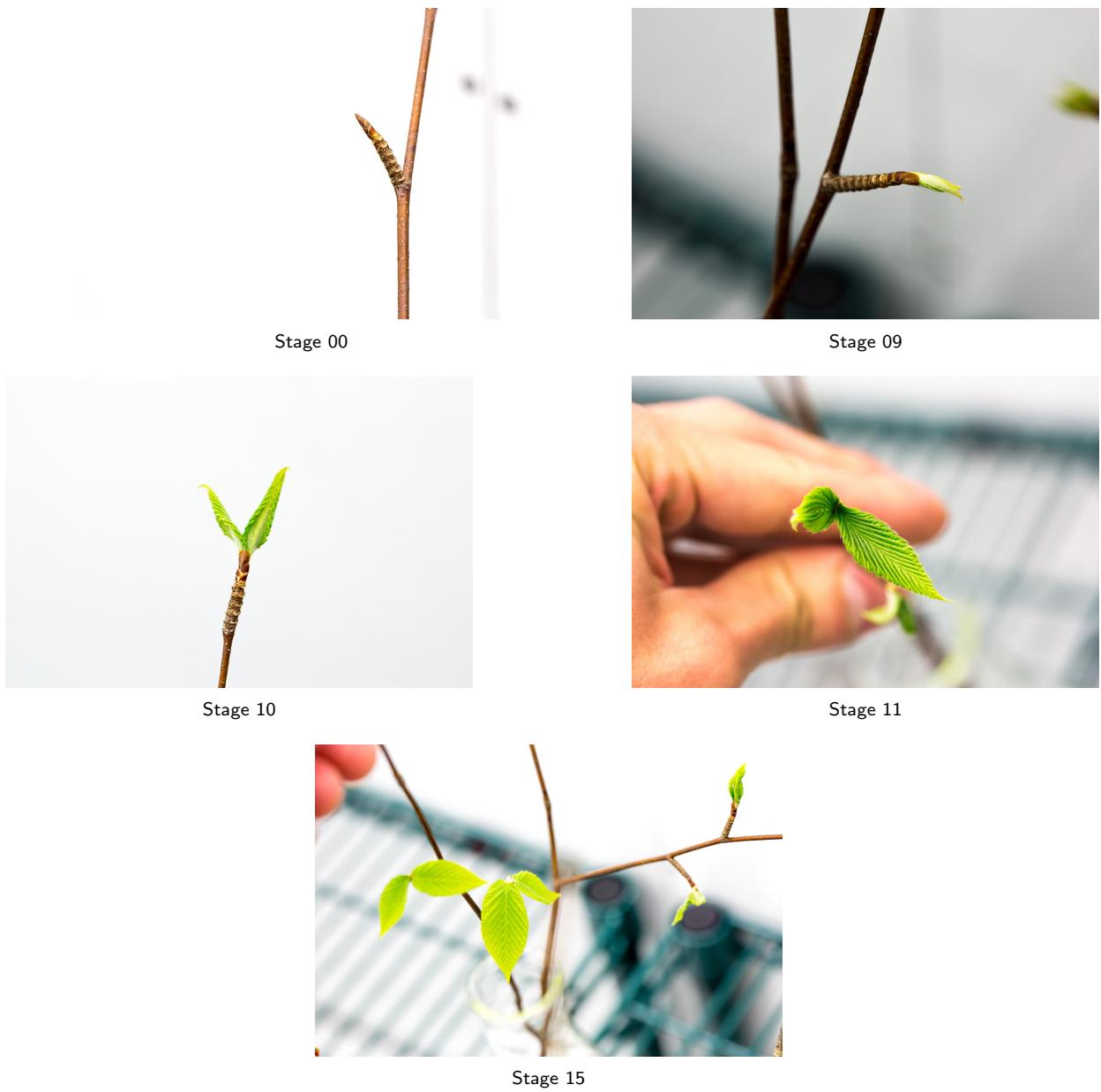
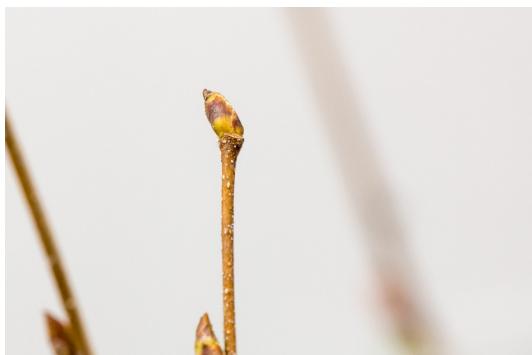
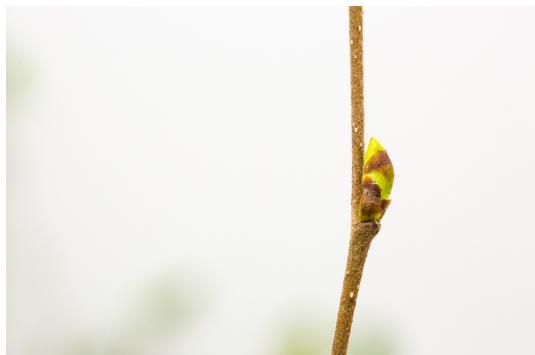


Figure 8: *Betula papyrifera*



Stage 00



Stage 01



Stage 09

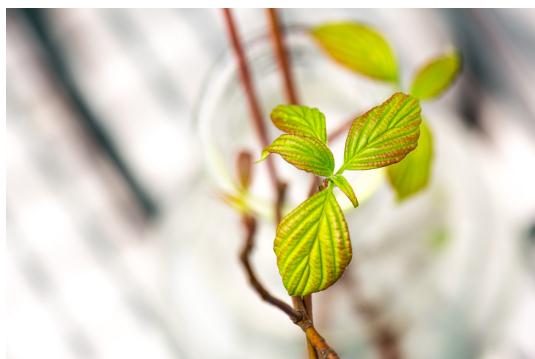
Figure 9: *Cornus alternifolia*



Stage 00



Stage 11



Stage 15



Stage 92

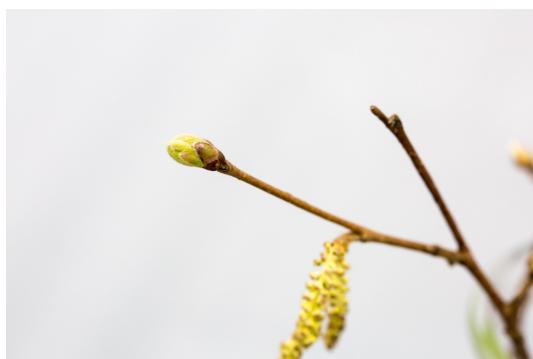
Figure 10: *Corylus cornuta*



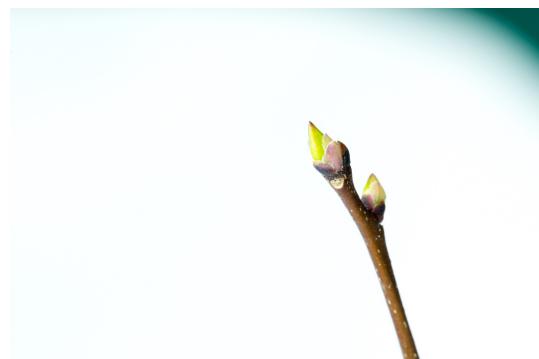
Stage 00



Stage 01



Stage 07



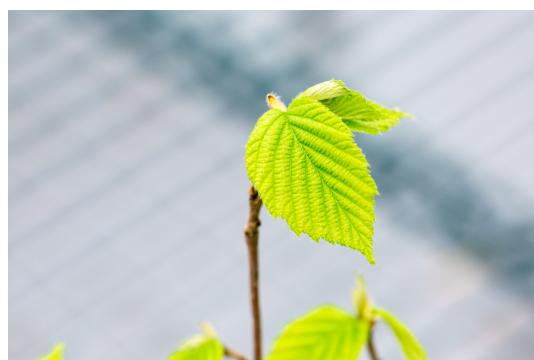
Stage 09



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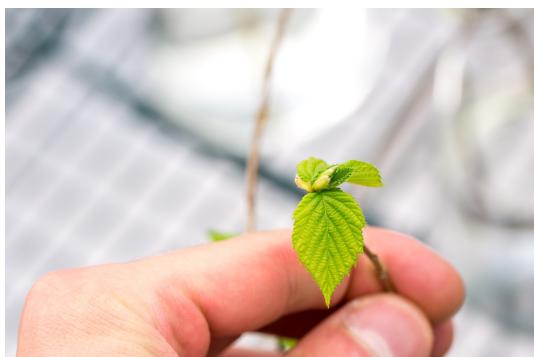


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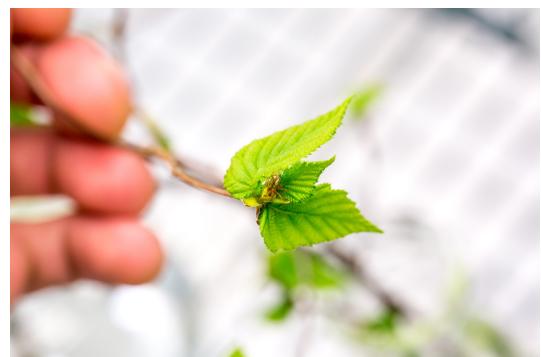


Stage 19

Figure 11: *Corylus cornuta*



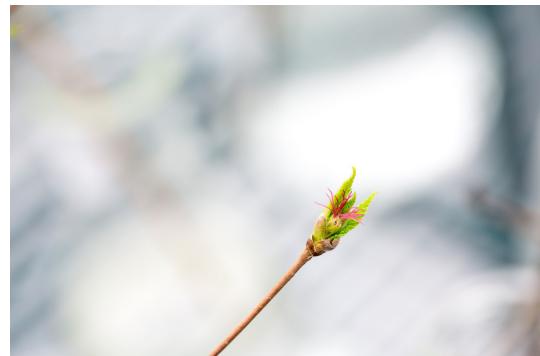
Stage 11



Stage 15



Stage 51



Stage 60

Figure 12: *Fagus grandifolia*



Stage 00



Stage 01



Stage 03



Stage 07



Stage 09



Stage 10



Stage 11



Stage 15

Figure 13: *Fagus grandifolia*

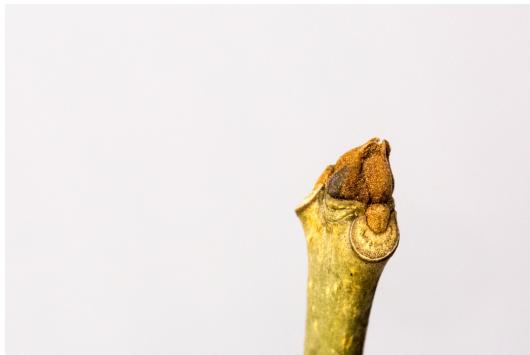


Stage 17



Stage 19

Figure 14: *Fraxinus americana*



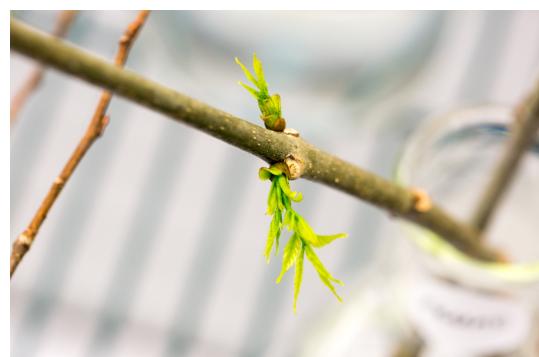
Stage 00



Stage 01



Stage 07



Stage 10



Stage 11



Stage 19

Figure 15: *Fraxinus nigra*



Stage 00



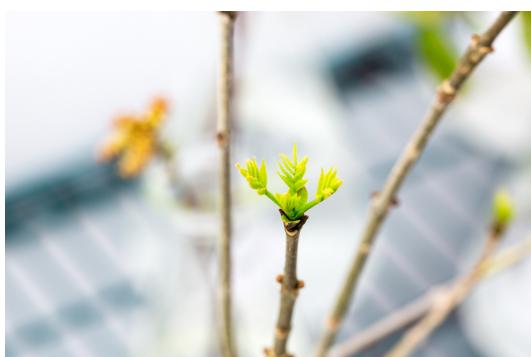
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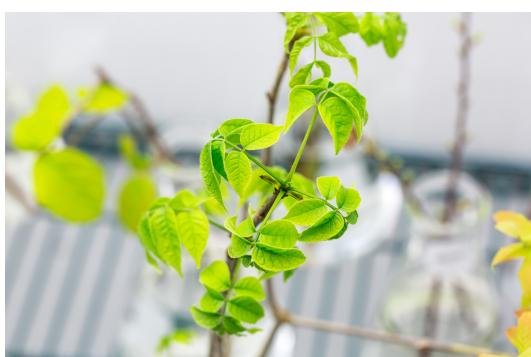
Stage 10



Stage 11



Stage 15



Stage 17



Stage 19

Figure 16: *Hamamelis virginiana*



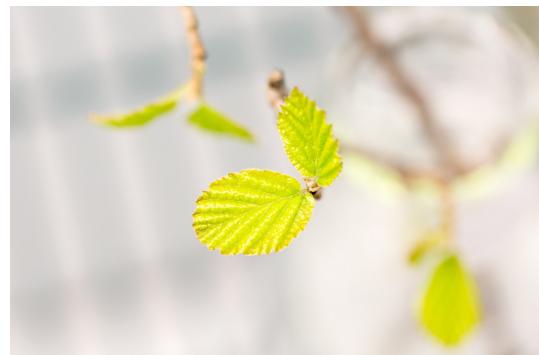
Stage 00



Stage 07



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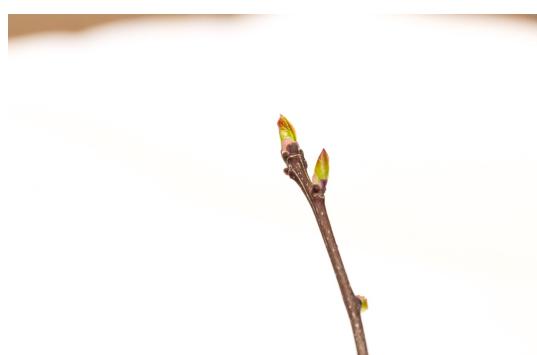
Figure 17: *Ilex mucronata*



Stage 00



Stage 09



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Figure 18: *Kalmia angustifolia*



Stage 00



Stage 01

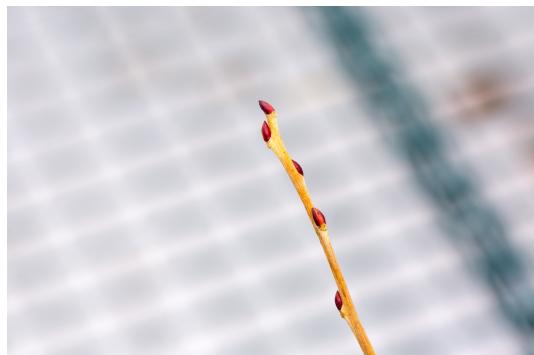


Stage 51



Stage 55

Figure 19: *Lyonia ligustrina*



Stage 00

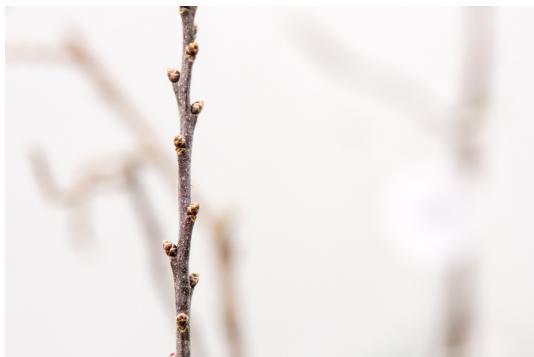


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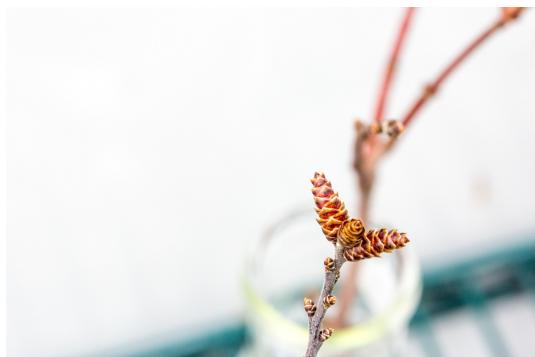


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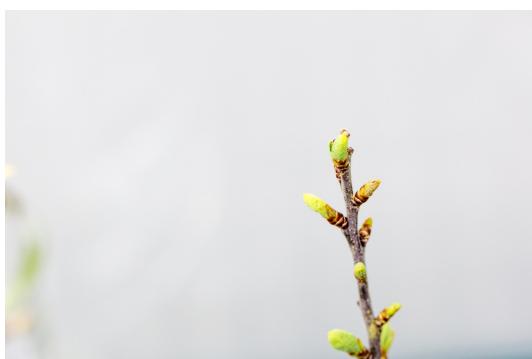
Figure 20: *Myrica gale*



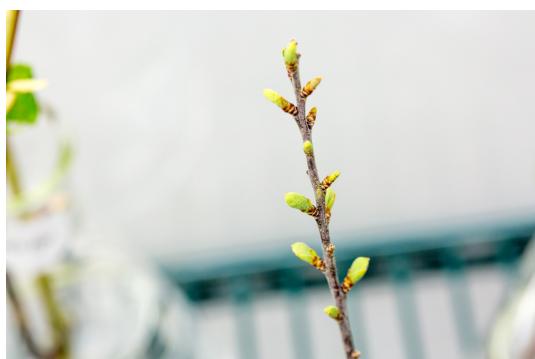
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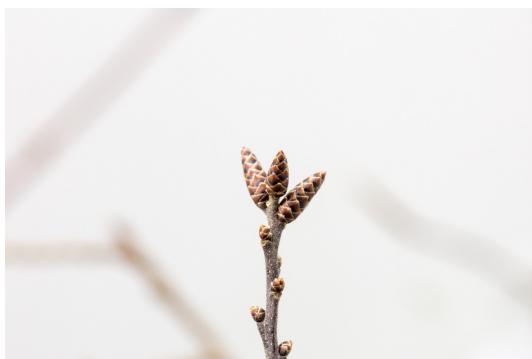
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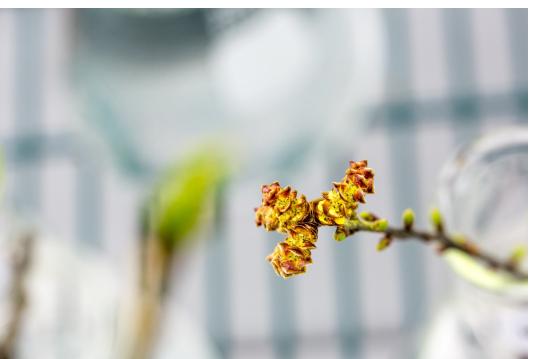
Stage 09



Stage 10



Stage 51



Stage 65

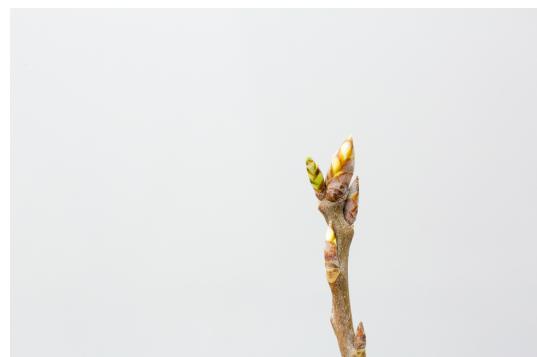
Figure 21: *Nyssa sylvatica*



Figure 22: *Populus grandidentata*



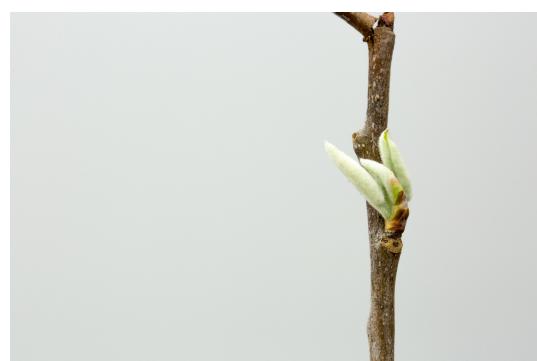
Stage 00



Stage 01



Stage 04



Stage 10



Stage 11



Stage 17



Stage 55

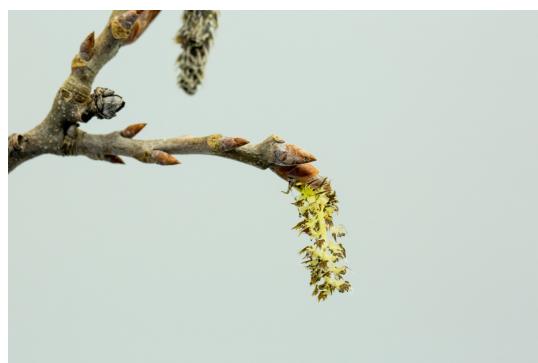


Stage 60

Figure 23: *Populus grandidentata*



Stage 67



Stage 67

Figure 24: *Prunus pensylvanica*



Figure 25: *Quercus alba*



Stage 00



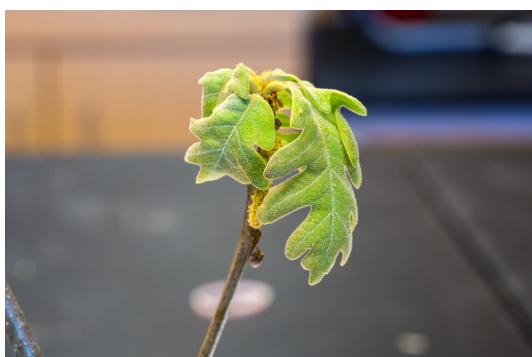
Stage 01



Stage 10



Stage 11



Stage 15



Stage 51

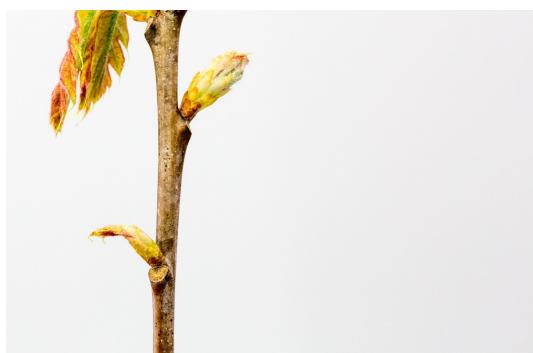
Figure 26: *Quercus rubra*



Stage 00



Stage 01



Stage 10



Stage 11



Stage 15



Stage 19

Figure 27: *Quercus velutina*



Stage 00



Stage 01



Stage 07



Stage 15

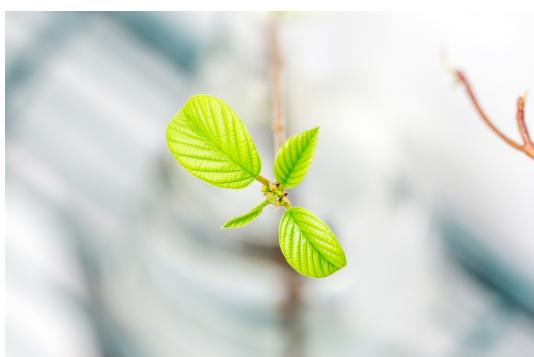
Figure 28: *Rhamnus frangula*



Stage 00



Stage 10



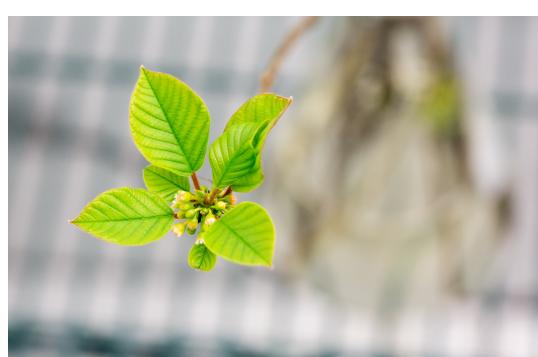
Stage 11



Stage 15

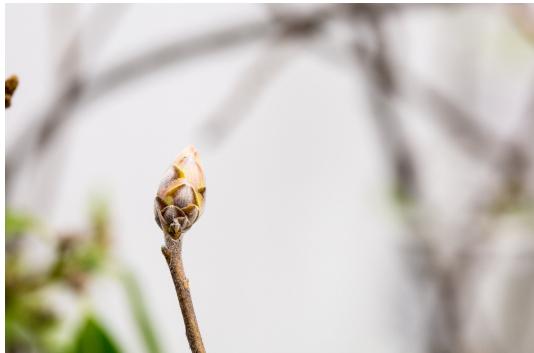


Stage 51



Stage 60

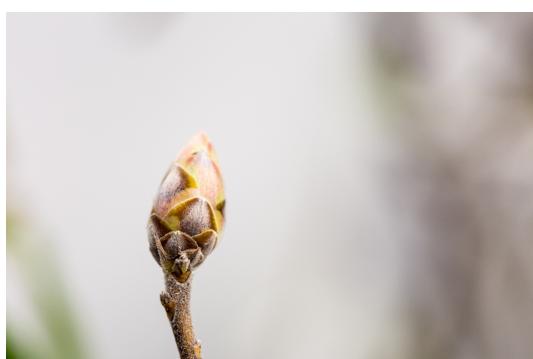
Figure 29: *Rhododendron prinophyllum*



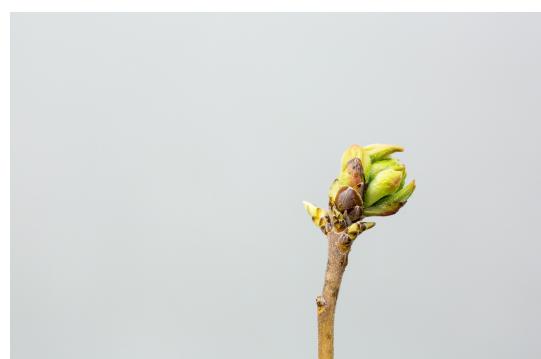
Stage 00



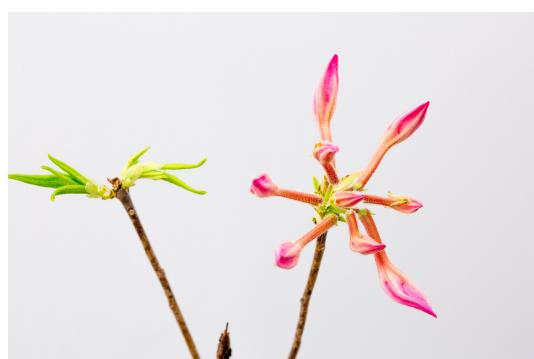
Stage 10



Stage 51

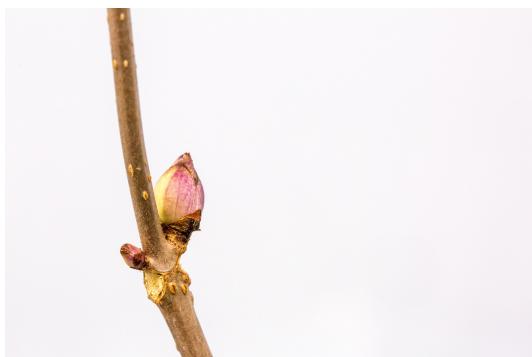


Stage 55



Stage 59

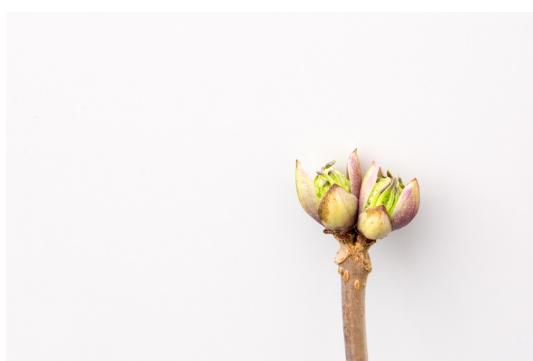
Figure 30: *Sambucus racemosa*



Stage 00



Stage 01



Stage 09



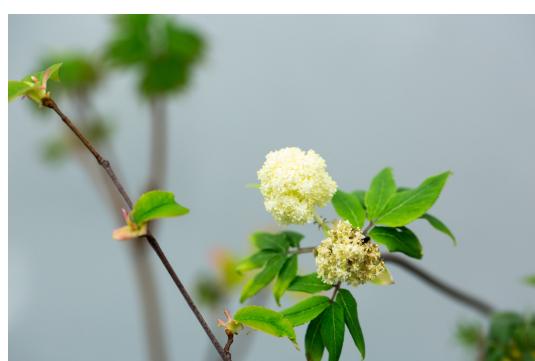
Stage 11



Stage 15



Stage 60



Stage 67

Figure 31: *Spiraea alba*



Stage 00



Stage 01



Stage 10



Stage 11



Stage 15



Stage 17

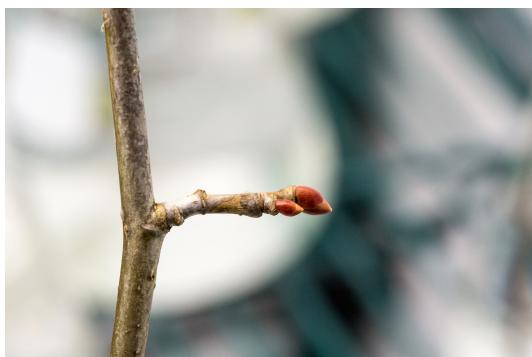
Figure 32: *Tilia americana*



Stage 09



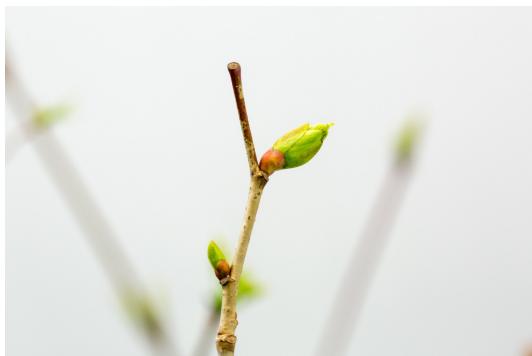
Stage 00



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Stage 07



Stage 10



Stage 11

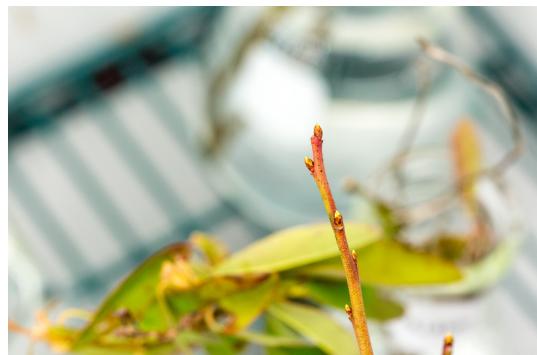


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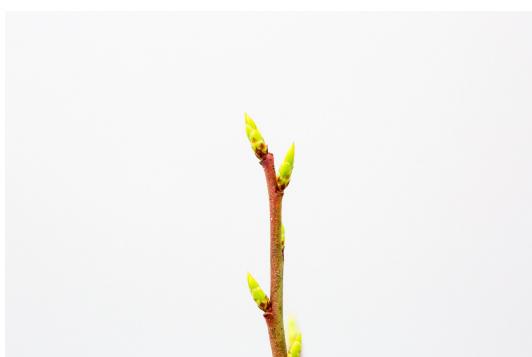
Figure 33: *Vaccinium corymbosum*



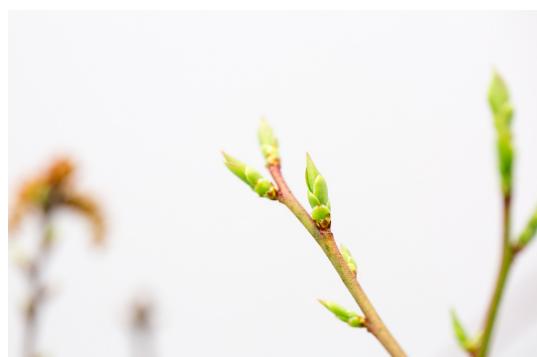
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Stage 01



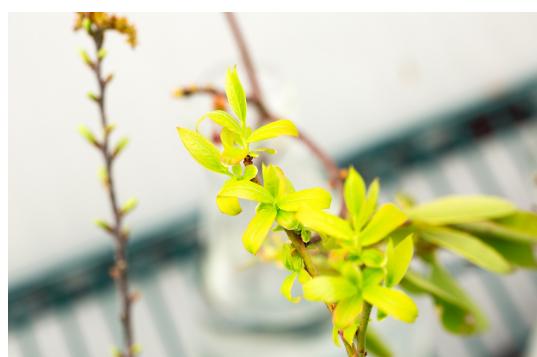
Stage 09



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Stage 11



Stage 17



Stage 92

Figure 34: *Viburnum cassinoides*



Figure 35: *Viburnum lantanoides*



Stage 00



Stage 01



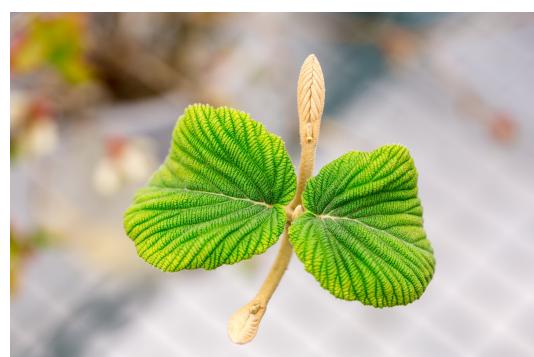
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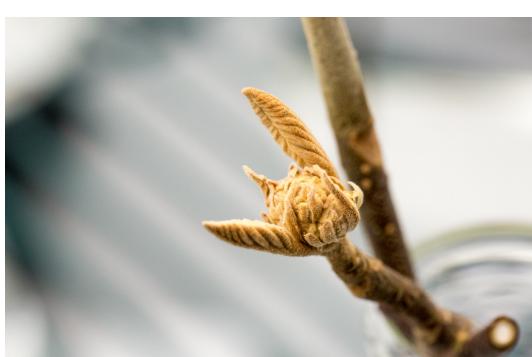
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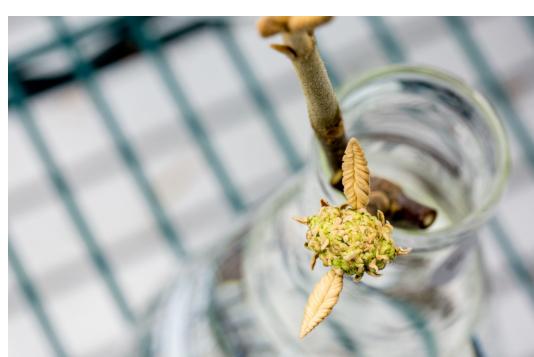
Stage 17



Stage 19



Stage 51



Stage 55

Figure 36: *Viburnum lantanoides*



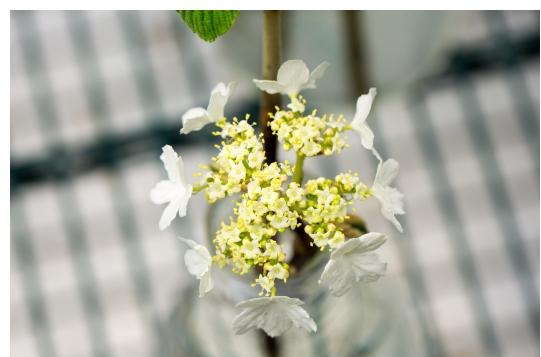
Stage 59



Stage 60



Stage 61



Stage 63



Stage 65



Stage 67



Stage 69