A standardized photographic guide to woody plant spring phenology

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Summary

This guide shows spring phenology stages from 28 woody plant species from eastern North America.

Problem: different groups measure phenology different ways. First date of leaf out is often used for cross-study comparisons, but even assessing what is "leaf out" is not straight forward. Project Budburst of the National Phenology Network, an intiatitave of academic and governmental agencies in the United States (https://www.usanpn.org), uses a scale based on both date and intensity of bud burst, leaf out, flowerering and senescence. The measures of intensity may be challenging to assess.

Solution: BBCH for woody plants.

This guide facilitates the use of the BBCH scale for woody plants. The BBCH (Biologische Bundesanstalt, Bundessortenamt, Chemische Industrie) was developed byt the German federal agencies of Biological Research Centre for Agriculture and Forestry, the Federal Office of Plant Varieties, and the Federal Office of Chemical Industry, and uses a numeric scale to quantify phenophases for many kinds of plants and animals. An extended BBCH scale for woody plants [1] was developed to expand the BBCH approach beyond crop species, and serves as the bases for this guide.

The use of the BBCH scale as a standardized measure of phenological stages has facilitated cross-species analysis of how phenology tracks climate at the continental scale [2].

List of species...

Comparison of different phenological stages

This table compares the BBCH and NPN phenostages.

Table 1: BBCH and NPN phenostage scales

BBCH Stage	BBCH Description	NPN Stage	NPN 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	Leaf budburst	In at least 3 locations on the plant, an emerging leaf is visible. A leaf is considered "emerging" once the green tip is visible at the end of the leaf bud, but before it has fully unfolded to expose the petiole (leaf stalk) or leaf base.
10	Green leaf tips 10 mm above the bud scales		
Principal growth stage 1: leaf and needle development			
11	First leaves unfolded	First leaf	
15	More leaves unfolded, but not yet at full size. First leaves unfolded		
17	Most leaves unfolded on majority of tree	75% of full leaf size	In at least 3 locations on the plant, an unfolded leaf is visible. A leaf is considered "unfolded" when the petiole (leaf stalk) or leaf base is visible. The leaf may need to be bent backwards to see whether the petiole or leaf base is visible.
19	Leaf expansion complete	All leaves unfolded	
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		

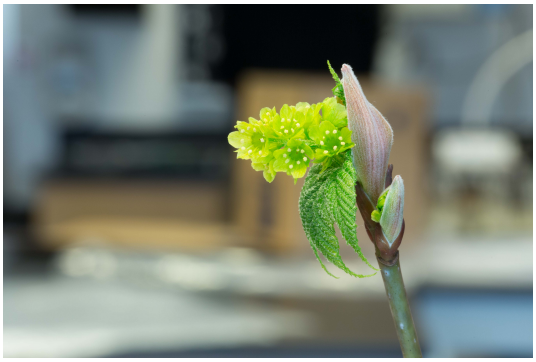
59	First flower petals visible (in forms with petals)		
Principal growth stage 6: flowering			
60	First flowers open	First flowers	In at least 3 locations on the plant, an open fresh flower is visible. Flowers are considered "open" when the reproductive parts are visible between unfolded or open flower parts. Do not include spent (wilted) flowers that remain on the plant.
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	full flower or peak flowering	For the whole plant, at least half (50%) of the flowers are open and still fresh.
67	Flowering finishing; majority of petals fallen or dry		
69	End of flowering: fruit set visible	end of flowering	
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	50% of leaves colored	For the whole plant, at least half (50%) of the leaves (including any that have fallen to the ground) have changed to their late-season colors.
93	Beginning of leaf fall		
95	50% of leaves fallen	50% of leaves fallen	For the whole plant, at least half (50%) of the leaves have fallen.
97	End of leaf fall		

Photographic guide to BBCH stages

Figure 1: *Acer pensylvanicum*

Stage 0

Stage 1



Stage 2

Stage 3

Stage 4

Stage 5

Figure 2: *Acer rubrum*

Stage 0 Stage 1

Stage 2 Stage 3

Stage 4 Stage 5

References Cited

References

[1] Finn, G. A., Straszewski, A. E. & Peterson, V. A general growth stage key for describing trees and woody plants. *Annals of Applied Biology* **151**, 127–131 (2007).

[2] Menzel, A. *et al.* European phenological response to climate change matches the warming pattern. *Global change biology* **12**, 1969–1976 (2006).