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***Forsythia* Collection Development Plan - 2018**

This document is a concise resource considering the background, current status, and future development goals of the *Forsythia* Collection at the Arnold Arboretum. A bibliography of the references used and appendices covering collections representation (Appendix 1), landscape locations (Appendix 2), taxonomy (Appendix 3), and cultivation (Appendix 4) are also included.

Mission Statement

The Arnold Arboretum of Harvard University discovers and disseminates knowledge of the plant kingdom to foster greater understanding, appreciation, and stewardship of Earth's botanical diversity and its essential value to mankind.

The Collection

The *Forsythia* Collection at the Arnold Arboretum of Harvard University contains the most comprehensive representation of species, and historic taxa developed and/or introduced into United States cultivation by the Arboretum. The collection was developed largely by C.S. Sargent and E.H. Wilson who, through expeditions, collected and introduced new species and cultivated forms; and by Dr. Karl Sax and his students who developed new hybrids at the Arnold Arboretum. Some of these historical taxa include: *Forsythia ovata* introduced by Wilson from Korea, a chance *F. x intermedia* seedling discovered by Dr. Alfred Rehder who named it 'Primulina', and iconic hybrids *F.* 'Arnold Dwarf', *F.* 'Arnold Giant', and *F.* 'Karl Sax' developed by Dr. Karl Sax. The richness of the *Forsythia* Collection at the Arnold Arboretum ensures that the diversity of *Forsythia* and its long horticultural history will not be forgotten.

Collection Objectives

To further develop and improve upon the current collection of *Forsythia* so that the Arnold Arboretum will continue to hold the most comprehensive wild origin collection of species and Arboretum historic introductions. The aims of the Arnold Arboretum *Forsythia* Collection are:

- Represent comprehensive *taxonomic* diversity and historic Arboretum cultivars.
- Conserve wild genetics
- Maintain collection for scientific research
- Promote their use in urban landscapes

Collection Description

The *Forsythia* Collection at the Arnold Arboretum comprises of a mixture of species and historic introductions of species, cultivars, and hybrids developed and/or imported by the Arboretum. Currently the collection holds 8 out of 13 known species and all eleven historic taxa developed and/or introduced

by the Arboretum into cultivation in the United States. Of a total of 85 individuals (61 accessions), 24 (10 accessions) were obtained from wild populations making the collection 28% of known wild origin. Nine accessions (7 individuals) account for *F. giraldiana*, one accession (1 individual) for *F. koreana*, three accessions (4 individuals) for *F. ovata* (one of which is a Wilson original collection), one accession (2 individuals) for *F. suspensa*, and one accession (5 individuals) for *F. viridissima*.

Of the eleven historic taxa, six were discovered or developed at the Arnold Arboretum. These include: *F. x intermedia* 'Primulina' discovered by Dr. Alfred Rehder, and *F.* 'Arnold Dwarf', *F.* 'Arnold Giant', *F.* 'Beatrix Farrand', *F.* 'Karl Sax', and *F.* 'Meadowlark' originally bred by Dr. Karl Sax and his students. Though some of these cultivars and hybrids are no longer popular or currently in the trade, the Arnold Arboretum has made an effort to obtain and preserve all of these historic taxa. For a complete list of historic and current species representation and Arboretum introductions representation, please see Appendix 1.

The bulk of the collection, 68 individuals, lies on the eastern side of Bussey Hill; south of Rehder Pond along Bussey Hill Road and on State Labs Slope, and extending south along Beech Patch west of South Street. One individual is planted near the Hunnewell Visitor Center, five individuals in the Leventritt Garden, one at the Forest Hills Gate entrance, two individuals in the northwest corner of Peter's Hill, and one individual in the far southwest corner of Weld Hill. For a map, please see Appendix 2.

***Forsythia* and Collection Background**

Forsythia is a genus of deciduous shrubs grown for their tough constitution and bold display of yellow flowers. Grown all over the United States, except for the warmest or coldest areas, this iconic shrub is synonymous with the passing of winter and arrival of spring. Whether it is due to its unapologetic yellow hue, ubiquity, or both, few other garden shrubs elicit such strong reactions and opinions. The first species introduced to Europe from Japan, in 1833, was *Forsythia suspensa* var. *sieboldii*, a second species, *Forsythia viridissima*, came from China in 1844. The first forsythias were introduced to the United States a little over 180 years ago, but they were not widely grown until the 1850s, and prior to that *F. viridissima* was the only species available in the trade.

The Arnold Arboretum has played a major role introducing forsythias into cultivation in the United States, particularly in the 1900s during the height of popularity for *Forsythia*. During a period of 108 years, the Arnold Arboretum had introduced four species, one cultivar, and eight hybrids into cultivation in the United States with many of these historic introductions the parents of many hybrids available in the trade today. The Arboretum obtained its first species – *F. viridissima* and *F. suspensa* – in the late 19th century. As interest grew during the ensuing years the Arboretum attempted to grow all *Forsythia* taxa available in the United States. Between 1963 and 2003 the Arnold Arboretum undertook the role of international cultivar registration authority for eleven genera, one of which was *Forsythia*.

In 1912, a chance seedling with pale yellow flowers was discovered by taxonomist Dr. Alfred Rehder at the Arboretum. This chance cross of *F. suspensa* and *F. viridissima* was introduced as 'Primulina' and has since proved to be one of the most popular cultivars in the trade in the United States. Twenty-three years later a sport of *Forsythia x intermedia* 'Primulina' was discovered in a garden in Mentor, Ohio with

larger flowers produced in higher density. It was introduced into the trade as 'Spring Glory' in 1942 by Wayside Gardens and its popularity surpassed that of 'Primulina'.

E.H. Wilson is accredited with introducing two forsythias, the first introduction being *F. suspensa* var. *atrocaulis* in 1908 when he collected on his 1907-1909 expedition through China. (Since then it has been reduced from variety level to cultivar level, i.e., *F. suspensa* 'Atrocaulis'.) Returning from his 1917-1919 expedition through Korea, Japan, and Taiwan, E.H. Wilson brought back seeds of his second forsythia, *Forsythia ovata* from the Diamond Mountains of North Korea. (Repropagated accessions of Wilson's *F. ovata* continue to grow in the arboretum today.)

Around this time another cultivar was introduced via the Arboretum's collection efforts. Soon after Wilson's return from his expedition in the early 1920s, seed of *F. ovata* was shared with French's Nursery in Lebanon, New Hampshire. A seedling resulted with cold hardy buds and pale yellow flowers in 1930. In 1940, this seedling was named *F. ovata* 'French's Florence' and was introduced to the trade by French's Nursery.

During the late 1930s - 1940s, Dr. Karl Sax took an interest in breeding plants at the Arboretum. He and his students experimented with *Forsythia* by crossing different species and using the chemical colchicine to produce polyploidy plants, which were then crossed back with non-polyploid plants. These colchicine and crossing experiments resulted in the cultivars *Forsythia* 'Arnold Giant' (1939), *Forsythia* 'Arnold Dwarf' (1941), *Forsythia* 'Beatrix Farrand' (1944) named after the Arboretum landscape consultant, and *Forsythia* 'Karl Sax' later selected and named by Joab L. Thomas in 1960.

Dr. Karl Sax and Haig Derman made a cross of *F. ovata* and *Forsythia europaea* in 1935, but the resulting plants were deemed unworthy of introduction and were largely forgotten. However, in the winter of 1966-67 Dr. Harrison Flint spotted a plant in full bloom unaffected by the harsh conditions that year and as it turned out it was one of the seedlings from the original cross in 1935. This seedling was trialed at North and South Dakota State University for ten years and proved to be plant and bud hardy. It was named 'Meadowlark' and introduced into the trade in 1984 expanding the cultivation the range of forsythias to USDA Zone 3.

Today the collection contains seven out of eight species ever grown at the Arboretum and eleven out of thirteen Arboretum introductions into cultivation in the United States. (Please see Appendix 1 for full list.) Further developing and maintaining this living collection of *Forsythia* would honor the work of C.S. Sargent, E.H. Wilson, and Dr. Karl Sax, and the Arboretum's rich past of exploration and forefront of plant introductions.

For more information on *Forsythia* taxonomy and cultivation, please see Appendices 3 and 4.

Collection Development Goals

The collection's goal is to obtain and maintain a comprehensive collection of species and historical taxa of Arnold Arboretum introductions to be used as an educational tool to promote conservation, future research, and preservation of the history of *Forsythia* at the Arboretum. The collection contains 34 taxa of which 24 are cultivars or hybrids. There are 61 accessions (85 individuals) total, and of those 9

accessions (24 individuals) were collected from wild populations making the collection 28% of documented known wild origin. These species of wild known origin include: *F. giraldiana*, *F. koreana*, *F. ovata*, *F. suspensa*, and *F. viridissima*.

In addition, the collection currently holds all eleven historic taxa that the Arnold Arboretum developed and/or introduced into cultivation in the United States. These include: *F. koreana*, *F. ovata*, *F. suspensa* 'Atrocaulis', *F. x intermedia* 'Primulina', *F. x intermedia* 'Spectabilis', *F. x intermedia* 'Tremonia', *F. 'Arnold Dwarf'*, *F. 'Arnold Giant'*, *F. 'Beatrix Farrand'*, *F. 'Karl Sax'*, and *F. 'Meadowlark'*. As the collection holds all the historic cultivars and hybrids developed at the Arnold Arboretum, the focus of development will be on obtaining wild germplasm of all species absent from the collection (*F. likiangensis*, *F. mira*, *F. saxatilis*, *F. velutina*, and *F. togashii*), and on represented species that currently lack accessions of known wild origin (*F. europaea*, *F. japonica*, and *F. mandschurica*).

Opportunistic collections of *F. giraldiana*, *F. suspensa*, and *F. viridissima* to supplement their wild representation in the collection will be welcomed, but acquiring them will not be of highest priority. For details on current and historical representation of *Forsythia* taxa, please see Appendix 1.

For more information please refer to our Living Collections Policy.

Acquisition Criteria

First priority:

- Obtain at least three accessions of wild origin of each species currently not represented in the collection.
- Obtain at least one accession of wild origin of species currently represented in the collection but lack accessions of wild origin.

Second priority:

- Determine if *F. koreana* (8392-39-1949*A) at the Montreal Botanical Garden is clonal material of the first introduction of *F. koreana* in 1919. If this is the case, obtain clonal material to repatriate this original lineage.

Third priority:

- As the collection holds all historically associated taxa, adding new cultivars or hybrids is of lowest priority. However, choice cultivars and/or hybrids of unusual characteristics or of ornamental value may be added to the collections to showcase variation in cultivated forms and promote their use in gardens.

Documentation

To supplement detailed records on BG-Base, all accessions will have a complete set of herbarium vouchers collected and stored in the Arnold Arboretum Herbarium. A complete voucher set will include one vegetative specimen, one flowering specimen, and one fruiting specimen (if taxon is not sterile). Collecting priority will be given to accessions currently without vouchers. Single individuals will be

collected to represent clonal accessions, however a set of vouchers will be collected for each lineage per taxon.

For more information please refer to our Herbarium Collections Policy.

Verification

Verification of the *Forsythia* Collection will be done through comparing living plants, photographs, and published reference materials – such as Floras, keys, cultivar registration lists – if available. This process will be done on all botanical species and cultivars in the collection until completed.

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Appendix

1. Collection Representation

For a complete inventory of the *Forsythia* Collection, please refer to the attached Excel spreadsheet 'Forsythia Inventory_2018'.

History of Species Representation					
Species	First Accession Year	Source	Provenance	Original Accession	Status
<i>F. suspensa</i>	1876	Francis Parkman; Jamaica Plain, Massachusetts.	cultivated	930	Lost
<i>F. suspensa</i> var. <i>fortunei</i>	1878	Benjamin Maston Watson; Plymouth, Massachusetts.	uncertain	14607	Lost
<i>F. europaea</i>	1900	A.K. Bulley; Cheshire, England.	uncertain	1100-84*A; propagated from original lineage (4742)	Alive
<i>F. ovata</i>	1917	E.H. Wilson; Diamond Mountains, North Korea.	wild	219-2005*A, B; propagated from original lineage (10566)	Alive
<i>F. koreana</i>	1919	Department of Forestry, Korea; Korea.	uncertain	11721; living clonal material of this accession may be alive at Montreal Botanical Gardens.	Lost
<i>F. saxatilis</i>	1924	Unspecified botanical garden in Tokyo; Japan.	uncertain	18822	Lost
<i>F. viridissima</i>	1924	Mount Arbor Nurseries; Shenandoah, Iowa.	cultivated	18274; Note - The first accession of <i>F. viridissima</i> (1031) was shared with the Arnold Arboretum by C.S. Sargent in 1874, but was later identified to be <i>F. suspensa</i> 'Atrocaulis'.	Lost
<i>F. girdiana</i>	1938	RHS Garden, Wisley; Surrey, England.	wild	12-38*D, E, F, G, H	Alive
<i>F. suspensa</i> var. <i>sieboldii</i>	1953	Morton Arboretum; Lisle, Illinois.	uncertain	32-53*A	Alive
<i>F. mandschurica</i>	1968	Forest Tree Breeding Station of the Forest Research Institute; Maisala, Finland.	uncertain	93-68*B	Alive
<i>F. japonica</i>	1950	The Acclimatization Garden; Kyoku, Japan.	uncertain	898-50	Lost

Current Representation of Species			
Species	Accession	Provenance	General Locality
<i>F. europaea</i>	1100-84*A	cultivated	
	12-38*D, E, F, G, H	wild	China
<i>F. giraldiana</i>	129-93*B	wild	Sichuan, Muli County; China
	208-2007*B	wild	Guan Shan, Hubei; China
<i>F. japonica</i>	101-2005*A	uncertain	
<i>F. koreana</i>	1241-68*A	wild	Suwon; South Korea
<i>F. mandschurica</i>	93-68*B	uncertain	
	261-2005*B	uncertain	
	204-2007*A	cultivated	
<i>F. ovata</i>	219-2005*A, B	wild	Diamond Mountains; North Korea
	320-2005*A	wild	Kangwan Do; South Korea
	1062-86*A	wild	Kangwan Do; South Korea
<i>F. suspensa</i>	224-2005*A, B	wild	Mt. Maiji, Gansu; China
<i>F. suspensa</i> var. <i>fortunei</i>	277-2005*A	cultivated	
	968-71*B	cultivated	
<i>F. suspensa</i> var. <i>sieboldii</i>	32-53*A	uncertain	
<i>F. viridissima</i>	1223-85*MASS	uncertain	
	597-84*A, B, C, D, E	wild	Western Zhejiang, Chang-hua; China

History of Arnold Arboretum's Introductions			
Species	Year	Source	Historical Notes
<i>F. suspensa</i> 'Atrocaulis'	1908	E.H. Wilson; Hubei, China.	Collected on his 1907-1909 expedition through China.
<i>F. ovata</i>	1917	E.H. Wilson; Diamond Mountains, North Korea.	Collected on his 1917-1919 expedition through Korea, Japan, and Taiwan.
<i>F. koreana</i>	1919	Department of Forestry, Korea; Korea.	Received as seeds. Very few notes.
<i>F. x intermedia</i> 'Spectabilis'	1906	Späth Nurseries; Berlin, Germany.	Imported and introduced to US cultivation. Most popular cultivar due to its vigor, deep yellow flowers, and free flowering habit.
<i>F. x intermedia</i> 'Tremonia'	1966	Botanischer Garten Rombergpark; Dortmund, Germany.	Imported and introduced to US cultivation. Cultivar known for its cut, lacy leaves.
<i>F. x intermedia</i> 'Primulina'	1912	Dr. Alfred Rehder; Arnold Arboretum.	Chance seedling discovered by A. Rehder at the Arnold Arboretum.
<i>F.</i> 'Arnold Giant'	1939	Dr. Karl Sax and George Skirm; Arnold Arboretum.	Developed by Dr. Karl Sax and students. A <i>F. x intermedia</i> seedling was treated with colchicine to double chromosomes. Stiff form and difficult to root.
<i>F.</i> 'Arnold Dwarf'	1941	Dr. Karl Sax; Arnold Arboretum.	A seedling from a cross of <i>F. x intermedia</i> with <i>F. saxatilis</i> (syn. <i>japonica</i>). Low growing, but slow and reluctant to bloom.
<i>F.</i> 'Beatrix Farrand'	1959	Dr. Karl Sax; Arnold Arboretum.	A seedling from backcrossing <i>F.</i> 'Arnold Giant' with <i>F. x intermedia</i> 'Spectabilis'. Selected and named by Dr. Karl Sax in honor of landscape architect Beatrix Farrand. Triploid.
<i>F.</i> 'Karl Sax'	1960	Dr. Karl Sax; Arnold Arboretum.	A seedling from backcrossing <i>F.</i> 'Arnold Giant' with <i>F. x intermedia</i> 'Spectabilis'. Selected and named by Joab L. Thomas. Mysteriously tetraploid.
<i>F.</i> 'Meadowlark'	1984	Dr. Karl Sax and Haig Derman; Arnold Arboretum.	Cross of <i>F. ovata</i> and <i>F. europaea</i> done in 1935. Overlooked until Dr. Harrison Flint observed the seedling in full bloom and unaffected by the cold winter of 1966-67. Seedling was trialed for 10 years at North and South Dakota State University and proved to be plant and bud hardy to USDA Zone 3.

Current Representation of Historical Introductions into Cultivation (US)

<i>Species</i>						
Taxon	Original Introduction Year	Accession	Original Lineage	Source	Provenance	Locality
<i>F. koreana</i>	1919	1241-68*A	No	USDA, Washington, D.C.; US Plant Introduction Station; Glenn Dale, Maryland.	wild	Suwon; South Korea
		204-2007*A	No	Royal Botanic Gardens, Kew; Richmond, England.	cultivated	
		219-2005*A, B	Yes	E.H. Wilson	wild	Diamond Mountains; North Korea
<i>F. ovata</i>	1917	320-2005*A	No	USDA, Washington, D.C.; US Plant Introduction Station; Glenn Dale, Maryland.	wild	Kangwan Do; South Korea
		1062-86*A	No	USDA, Washington, D.C.; US Plant Introduction Station; Glenn Dale, Maryland.	wild	Kangwan Do; South Korea
<i>Cultivars & Hybrids</i>						
Taxon	Original Introduction Year	Accession	Original Accession	Source		
<i>F. suspensa</i> 'Atrocaulis'	1908	278-2005*A	No	Hillier Nurseries; Winchester, England.		
<i>F. x intermedia</i> 'Spectabilis'	1906	146-40*MASS	No	Wyman's Framingham Nursery, Inc.; Framingham, Massachusetts.		
		348-2005*B	No	Wyman's Framingham Nursery, Inc.; Framingham, Massachusetts.		
		20657*A	No	Jackson & Perkins Nursery; Newark, New Jersey.		
<i>F. x intermedia</i> 'Tremonia'	1966	21123*A	No	Bay State Nursery; North Abington, Massachusetts.		
		216-2005*A, B	Yes	Botanischer Garten Rombergpark; Dortmund, Germany.		
<i>F. x intermedia</i> 'Primulina'	1912	1190-71*A, B	No	C.R. Burr & Co.; Manchester, Connecticut.		
<i>F.</i> 'Arnold Giant'	1939	206-2007*A	Yes	Dr. Karl Sax; Arnold Arboretum.		
		967-71*D	No	Cherry Hill Nurseries; West Newbury, Massachusetts.		
<i>F.</i> 'Arnold Dwarf'	1941	218-2005*A, B		Al Johnson; Bussey Institute.		
		520-70*MASS	No	Weston Nurseries, Inc.; Hopkinton, Massachusetts.		
<i>F.</i> 'Beatrix Farrand'	1959	1250-50*A	Yes	Arnold Arboretum.		
		55-2007*D	Yes	Dr. Karl Sax, Arnold Arboretum; via University of Connecticut, Storrs, Connecticut.		
		150-2008*MASS	Yes	Dr. Karl Sax, Arnold Arboretum; via University of Connecticut, Storrs, Connecticut.		
<i>F.</i> 'Karl Sax'	1960	785-81*A, B, C	No	Sheridan Nurseries, Ltd.; Oakville, Ontario, Canada.		
		1504-66*A	Yes	Dr. Karl Sax, Arnold Arboretum; via University of Connecticut, Storrs, Connecticut.		
<i>F.</i> 'Meadowlark'	1984	154-2008*MASS	Yes	Dr. Karl Sax; Arnold Arboretum.		
		253-2005*A, B	No	Al Johnson; Bussey Institute.		
		198-2007*MASS-A	No	Bailey Nurseries, Inc.; St. Paul, Minnesota.		
<i>F.</i> 'Meadowlark'	1984	273-2002*A, B, C	Yes	Haig Dermen, Arnold Arboretum; via University of North Dakota, Grand Forks, North Dakota.		
		1192-83*MASS	Yes	Haig Dermen, Arnold Arboretum; via University of North Dakota, Grand Forks, North Dakota.		

2. Landscape Map



The *Forsythia* Collection is planted in the following areas from North to South and West to East:

1. Near the Hunnewell Visitor Center (1 individual)
2. The Leventritt Shrub and Vine Garden (5 individuals)
3. The Forest Hills Gate (1 individual)
4. Bussey Hill (3 individuals)
5. The east side of Bussey Hill; south of Rehder Pond along Bussey Hill Road and on State Labs Slope, then extending south along Beech Path west of South Street (68 individuals)
6. The western corner of the Arboretum north of the intersection of Centre and Bussey Streets (4 individuals)
7. The northwest corner of Peter's Hill south of Bussey Streets (2 individuals)
8. The far southwest corner of Weld Hill (1 individual)

3. Taxonomy

3.1 Taxonomy

The genus *Forsythia* comprises 13 species, all endemic to East Asia aside from a single species – *F. europaea* – which is endemic to Albania and Kosovo in southeastern Europe. Six species are native to China (*F. giraldiana*, *F. mandschurica*, *F. likiangensis*, *F. mira*, *F. suspensa*, and *F. viridissima*), four in Korea (*F. koreana*, *F. ovata*, *F. saxatilis*, and *F. velutina*), and two in Japan (*F. japonica* and *F. togashii*). The majority of species were described and introduced to cultivation before 1930, however *F. togashii* (1973), *F. likiangensis* (1983), and *F. mira* (1987) were recently described in the latter portion of the 20th century (Kim, 1999).

Historically the circumscription of *Forsythia* has been in flux and still in flux to an extent today. A wide variety of characters have been used to delineate species, such as leaf hairiness, leaf shape, leaf margin, pollen structure, flavonoids, cytology, and geographical distribution. However, due to the homogenous nature of the characteristics of this genus, these studies have not produced conclusive treatments (Kim, 1999). Leaf, flower, and fruit characters can vary in the wild and in cultivation, and sometimes more so within species than between species (Kim, 1999). Species with overlapping ranges – e.g., *F. koreana*, *F. ovata*, and *F. saxatilis* in Korea – can make identification difficult and taxonomic work complex as cases of hybridization may occur (Kim, 1999; Suh et al., 2011; Chung et al., 2013).

The validity of a few species have been debated throughout history and some uncertainty still exists today. These species include: *F. koreana*, *F. ovata*, *F. saxatilis*, and *F. velutina*. Currently both names are still used as no taxonomic authority has stepped in to make a determination. The other three species – *F. ovata*, *F. saxatilis*, and *F. velutina* – were all considered at one point to be a variety or form of *F. japonica*. To further complicate matters, a genetic study found that *F. ovata* and *F. saxatilis* may be a single species. Traditionally, morphological traits based on leaf hairiness and leaf margin shape desalinated these two species (Lee, 2011). However, these characters are often control by a single gene, so they do not make strong characters (Chung et al., 2013).

Luckily with development of new techniques genetic studies focused on DNA may help clear up some of these taxonomic questions (Kim, 1999; Tae et al., 2005; Kim and Kim, 2011; Suh et al., 2011; Chung et al., 2013; Fu et al., 2016; and Ha et al., 2018). By developing the *Forsythia* Collection to hold complete species representation, this will give researchers the ability to comprehensively study the taxonomy of *Forsythia* through DNA and morphological techniques.

3.2 Phylogeny

The first study on the phylogenetics of *Forsythia* – the most comprehensive at the time – was done by examining the chloroplast DNA of wild species and cultivated forms (Kim, 1999). Kim found that the genus could be split into three clades: 1. *F. suspensa* Complex, 2. *F. koreana-saxatilis* Clade, and 3. *F. europaea-viridissima* Complex (Kim, 1999). The first clade was the most basal of the three and contained just *F. suspensa*. The second clade contained the species *F. koreana*, *F. mandschurica*, and *F. saxatilis*. The third clade could be further divided into two more with a basal clade containing the species *F. europaea* and *F. giraldiana*, and the derived clade containing *F. ovata*, *F. japonica*, and *F. viridissima*.

Subsequent genetic studies have suggested varying relationships and this may be due to the lack of complete species representation and/or the misidentification of samples (Kim and Kim, 2011; Lee, 2011;

Suh et al., 2011). The study completed by Kim and Kim (2011) produced low resolution in the phylogeny of *Forsythia* from gene sequence analysis, however three monophyletic clades could still be made out. The basal clade, sister to the other two, contained species *F. koreana*, *F. saxatilis*, and *F. suspensa*. The second clade has species *F. europaea* sister to *F. giraldiana* and *F. viridissima*. The third clade placed *F. japonica* as the basal species with *F. ovata* and *F. velutina* as sister species.

The most recent phylogenetic study conducted by Ha et al. (2018) is the most species comprehensive analysis to date. All species except *F. mandshurica*, *F. mira* and *F. togashii* were sampled, and the first time *F. likiangensis* was included in a genetic study. This study found that chloroplast and nuclear genomes produced conflicting results when it came to the placement of *F. ovata* and *F. viridissima*. Following the more conservative chloroplast genome, the current phylogeny of *Forsythia* has *F. giraldiana* and *F. likiangensis* as a clade at the base of the tree. Next, *F. europaea* is sister to two clades: 1. *F. ovata* sister to *F. japonica* and *F. velutina*, and 2. *F. suspensa* is basal with *F. saxatilis* sister to *F. koreana* and *F. viridissima*. Image below taken from Ha et al. (2018).

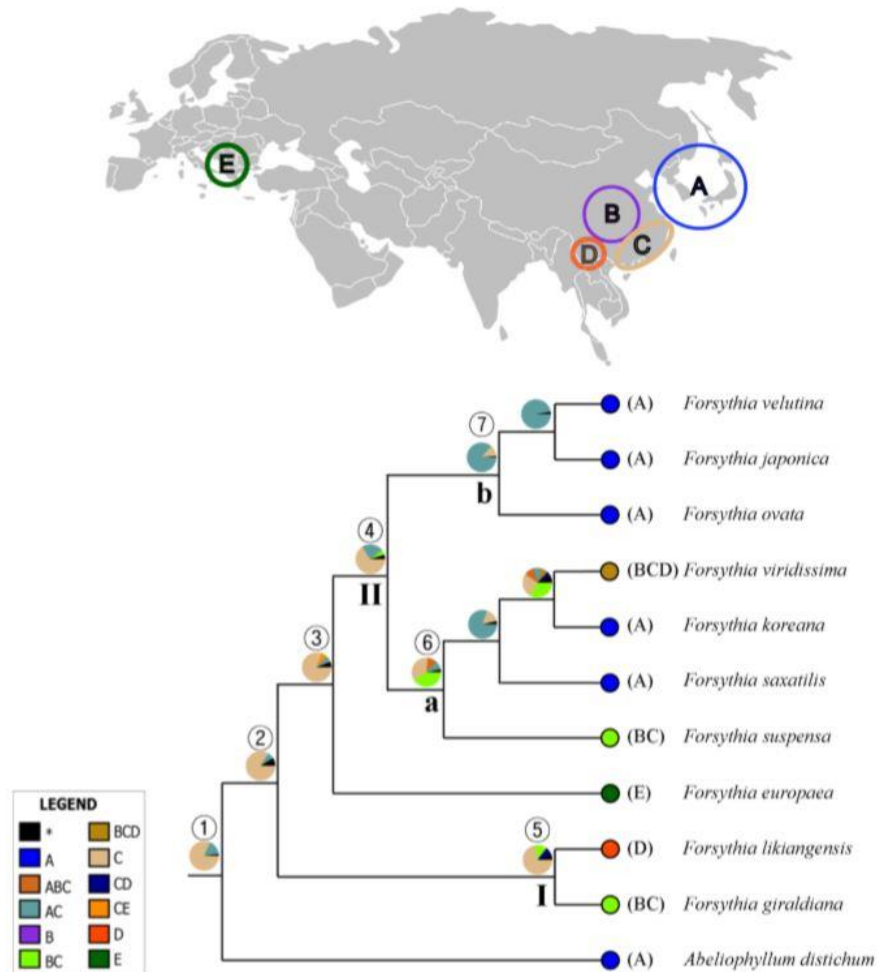


FIGURE 7 | Summary of the Bayesian Binary Method (BBM) model of ancestral area reconstruction in Forsythieae based on a reduced BEAST combined-gene chronogram. The BBM ancestral area reconstructions with the highest likelihood are shown as pies for each clade of Forsythieae. Biogeographic regions used in BBM: A, Korea and Japan; B, Central China; C, East China; D, Sikang-Yuennan; E, West Europe. The clades (I and II) and subclades (a and b) correspond to those in **Figure 4**. Numbers 1–7 indicate nodes of interest (for details, see **Table 4**).

It is clear that the taxonomic and phylogenetic work of *Forsythia* has had a long and shifting history and is far from complete. In order to fully assess this genus, species need to be correctly identified first, then studies on the range of genetic variation within each species need to be completed (Lee, 2011; Suh et al., 2011). By achieving complete species representation in the *Forsythia* Collection at the Arnold Arboretum, the collection can be used for phylogenetic research for more conclusive results.

4. Cultivation

Forsythias are adaptable plants performing well in a wide range of conditions, such as: poor soil, acidic and alkaline conditions, drought, and light shade (Wyman 1937 and 1950; DeWolf and Hebb, 1971; Dirr, 2009). Their ease of cultivation, dependability, and lack of serious pests and diseases have made them popular shrubs for gardens and urban plantings (Jack, 1931; Wyman, 1937, 1950, and 1961; Sax, 1955; DeWolf and Hebb, 1971; Dirr, 2009). However, forsythias will look and perform their best when planted in sunny sites with well-drained fertile soil and given plenty of space to grow (Wilson, 1928; Wyman, 1937, 1950, and 1961; DeWolf and Hebb, 1971; Dirr, 2009).

Their tolerant disposition also allows them to be propagated easily. This can be done by division, taking both green and hardwood cuttings, and layering; however the easiest methods are propagating from ripe wood cuttings and layering (Jack, 1931; Wyman, 1961; Green, 1965). Ripe wood cuttings should be taken between autumn and early spring, and in the following autumn cuttings should be well rooted (Jack, 1931).

Forsythias require minimal pruning except to thin out weak, unproductive, or dead stems (Wilson, 1928; Jack, 1931; Wyman, 1950; Dirr, 2009). Shrubs can be cut to six inches of the ground to refresh and reinvigorate them, however this should be done before late spring to allow plants plenty of recovery time before winter (Wyman, 1950). Pruning should be done immediately after flowering as flower buds are developed during the previous summer; any later, the floral display in the following spring will be affected (Wilson, 1928; Jack, 1931; Wyman, 1950).

Dirr (2009) states that cold hardy forsythias can be grown in USDA Zone (3)4, but the average cold hardiness for all species, cultivars, and hybrids available in the trade do best in USDA Zones 5-8. In more continental areas of the United States forsythias can die back to the ground, but here in the Boston area they are fully hardy (Jack, 1931; Wyman, 1937; DeWolf and Hebb, 1971). Plants can handle the conditions of severe winters, but flower buds will suffer if temperatures fall below -15 to -20°F (Jack, 1931; Wyman, 1937; DeWolf and Hebb, 1971; Dirr, 2009). It has been found that *F. mandshurica*, *F. ovata*, *F. europaea*, and their cultivars and hybrids are more bud-hardy than their central Chinese counterparts (Wilson, 1928; Jack, 1931; Wyman, 1937; Wyman, 1950; DeWolf and Hebb, 1971; Dirr, 2009). The most bud and plant-hardy forsythia is *F. 'Meadowlark'* (a cross between *F. ovata* and *F. europaea*) as it reliably grows and flowers well in USDA Zone 3 (Arnoldia, 1938; Herman and Evers, 1984).