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NEW ENGLAND NOTE

HORTICULTURAL ESCAPE AND NATURALIZATION OF *MAGNOLIA TRIPETALA* IN WESTERN MASSACHUSETTS: BIOGEOGRAPHIC CONTEXT AND POSSIBLE RELATIONSHIP TO RECENT CLIMATE CHANGE

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During the 2014 field season, eight new locations of *Magnolia tripetala* (L.) L. escape from horticulture and naturalization, were documented in Franklin and Hampshire counties in the Connecticut River Valley region of western Massachusetts (Table 1). These records constitute a substantial expansion of the documented adventive occurrence of *M. tripetala* in western Massachusetts, where only four locations had previously been reported, including only one record each in Franklin and Hampshire counties, and two in Hampden County to the south (Table 2). In addition, although most earlier reports of adventive occurrences of *M. tripetala* in New England have constituted only single, isolated individuals, and the species has been described as occurring mostly at forest edges and in thickets (Haines 2011), the new locations reported here include five sites with substantial, multi-individual populations of *M. tripetala* spreading into mature, intact forest vegetation. Based on herbarium records and our consultation with regional botanists, it appears that only four other locations with substantial naturalization by *M. tripetala* populations have been documented for New England in recent decades (Table 2). Taken together, these records suggest *M. tripetala* may become a more common exotic tree species in the region in coming years.

Magnolia tripetala is native to rich woods and ravines of the southeastern US, northward to southern Pennsylvania, as well as to portions of the Interior Highlands region in Arkansas and extreme eastern Oklahoma (Meyer 1997; Rhoades 1994; Rhoads and Block 2007). Although not native to the northeastern US, *M. tripetala* has been present in the horticultural trade since the 18th century (Dirr 1998; Rhoades 1994) and 19th century nursery catalogs document

Table 1. Newly reported locations of *Magnolia tripetala* naturalization in Franklin and Hampshire counties, Massachusetts. Naturalized population sizes, life stage composition, spatial extent, and distance to nearest horticultural specimen(s) were estimated during field surveys in the autumn of 2014. The populations are ranked from largest to smallest based on the total number of adventive individuals observed. All individuals < 1.5 m height were grouped in the "seedlings" life stage although their specific ages were not determined.

Site Name and Location	Latitude/ Longitude	Total Individuals	Reproductive Trees	Non-reproductive Saplings (> 1.5 m)	Seedlings (< 1.5 m)	Spatial Extent (ha)	Furthest Distance (m)
Amherst Woods, Amherst, Hampshire Co., MA	N 42°22.217′ W 72°30.574′	396	25	156	215	3.0	600
Mathews Rd., Deerfield, Franklin Co., MA	N 42°30.241′ W 72°38.765′	104	7	51	46	1.0	200
Titan Pier Rd., South Hadley, Hampshire Co., MA	N 42°17.151′ W 72°36.112′	59	7	42	10	0.8	100
Arcadia Sanctuary, Easthampton, Hampshire Co., MA	N 42°17.323′ W 72°38.721′	55	2	16	37	0.1	40
Bay Rd., Amherst, Hampshire Co., MA	N 42°19.176′ W 72°31.166′	46	2	18	26	0.5	400

Table 1. Continued.

Site Name and Location	Latitude/ Longitude	Total Individuals	Reproductive Trees	Non-reproductive Saplings (> 1.5 m)	Seedlings (< 1.5 m)	Spatial Extent (ha)	Furthest Distance (m)
Smith College, Northampton, Hampshire Co., MA	N 42°19.047′ W 72°38.677′	6	3	2	1	0.02	300
Wildwood Cemetery, Amherst, Hampshire Co., MA	N 42°23.414′ W 72°30.461′	1	1	–	–	single plant	unknown
Pumpkin Hollow, Conway, Franklin Co., MA	N 42°30.269′ W 72°41.864′	1	–	1	–	single plant	80

Table 2. Summary of prior records of *Magnolia tripetala* horticultural presence and adventive occurrences in New England based on specimens in regional herbaria. Records are divided between horticultural vs. adventive occurrences, both of which are ranked chronologically from oldest to most recent. Specimen # refers to bar code for herbaria with this system in place as of 2014–2015. U. = University.

Horticultural Records			
Year	Location	Herbarium/Specimen #	Additional Information
1847	Cambridge, Middlesex Co., MA – Harvard Bot. Garden	Brown U.: BRU: PBRU00004885	Herbarium of Asa Gray, Hort. Cantab., labeled as *Magnolia umbrella* Lam.
1875	Newport, Newport Co., RI – "garden"	Brown U.: BRU: PBRU00011001	Originally labeled *M. umbrella*
18??	Hartford, Hartford Co., CT – "Culta." - cultivated	Yale U.: YU: 025824	No date, but labeled with 19th century *M. umbrella* epithet on old herbarium sheet
1911	Storrs, Tolland Co., CT – U. of Connecticut campus	U. of Connecticut: CONN00012848	—
1916 onwards	Boston, Suffolk Co., MA – Arnold Arboretum	Cultivated Herbarium of the Arnold Arboretum: multiple specimens	Collection includes 21 sheets from 20th century, earliest from 1916
1931	East Hartford, Hartford Co., CT	U. of Connecticut: CONN00012846	—
1933	Storrs, Tolland Co., CT – U. of Connecticut campus	U. of Connecticut: CONN00012849	Specimen from same location on campus, Beach Hall, also collected in 1986
1942	Concord, Merrimack Co., NH	U. of New Hampshire: NHA-529077	Referred to as "ornamental woody plant" on label
1952	Amherst, Hampshire Co., MA – U. of Massachusetts	U. of Massachusetts, Amherst: MASS 18049	Label indicates "cultivated on campus"
1954	Fairfield, Fairfield Co., CT	Yale U.: YU 025823	Planted on grounds at Fairfield Bird Sanctuary

Table 2. Continued.

Horticultural Records			
Year	Location	Herbarium/Specimen #	Additional Information
1970	Storrs, Tolland Co., CT – U. of Connecticut campus	U. of Connecticut: CONN00012844	—
1978	Northampton, Hampshire Co., MA – Smith College campus	Smith College herbarium: not numbered	—
1986	Storrs, Tolland Co., CT – U. of Connecticut campus	U. of Connecticut: CONN00012847	Specimen from this location on campus, Beach Hall, also collected in 1933
1989	Old Saybrook, Middlesex Co., CT	Yale U.: CBS.02670	Growing at Capt. William Clarke House
undated	Dunbarton, Merrimack Co., NH	U. of New Hampshire: NHA-565028	Collected as part of L.J. Mehrhoff's "Plants of Dunbarton, N.H."
ADVENTIVE RECORDS			
1910	Plymouth, Plymouth Co., MA	Harvard U. – Gray Herbarium (GH): 00217771	Label indicates "self sown + thriving on Watson Place"
1931	East Hartford, Hartford Co., CT	U. of Connecticut: CONN00012845	Label notes specimen was "growing in woods"
1973	Amherst, Hampshire Co., MA – U. of Massachusetts campus	U. of Massachusetts, Amherst: MASS 00340383	"well established in woods" on campus
1974	Concord, Middlesex Co., MA – woods off Monument St.	Harvard U.: NEBC 00217769	"3 large trees, many (flowering) saplings + seedlings (thoroughly naturalized)"
1974	Clayville, Providence Co., RI – across from Rockland Cemetery	Harvard U.: NEBC 00217772	"Spread from cultivation at rich roadside"

Table 2. Continued.

Horticultural Records			
Year	Location	Herbarium/Specimen #	Additional Information
1974	West Greenwich, Kent Co., RI	Harvard U.: NEBC 00217773	"Shaded north-facing roadside"
1984	New London, New London Co., CT – Connecticut College Arboretum	Dreyer (1984), published report	Single tree - "Multi-stemmed… approximately 5 m tall" in wetland
1987	Marshfield, Plymouth Co., MA – Old Ocean St.	U. of Massachusetts, Amherst: MASS 00340384	"One tree and one sapling, associated with large mature tree"
1994	East Longmeadow, Hampden Co., MA – Pine Quarry Cons. Area	U. of Massachusetts, Amherst: MASS 00322485	Label indicates "rare", specimen material from 15' sapling
2000	Stratford, Fairfield Co., CT – Pecks Mill Pond Park	U. of Connecticut: CONN00039250	Label indicates "30' tree; apparently naturalized… wet woods"
2002	Quincy, Norfolk Co., MA – Blue Hills Reservation	Harvard U.: NEBC 00518962	"Small tree in shady deciduous woods"
2002	Springfield, Hampden Co., MA – Forest Park	Westfield State U.: WSCH 3840	"A single individual 3-feet tall"
2007	Storrs, Tolland Co., CT – west of U. of Connecticut campus	U. of Connecticut: CONN00189996	"tree ca. 6 m tall. Completely naturalized"
2007	Springfield, Hampden Co., MA – Hubbard Park	Westfield State U.: WSCH 17369	"about a dozen trees up to 20 feet tall"
2009	Hartford, Hartford Co., CT – Keney Park	U. of Connecticut: CONN00128833	"Apparently well established; numerous individuals of different ages"
2012	Erving – Millers Falls, Franklin Co., MA – adj. to town organic waste dump area	U. of Massachusetts, Amherst: MASS 00321417	"one individual in thicket at edge of dump"

its availability in the region. For example, an 1822 catalog from William Prince's nursery on Long Island, NY, offered the species for sale at $ 0.50 per plant (D. Stiefel, Bailey Hortorium, pers. comm.). Herbarium specimens also document the presence of *M. tripetala* in New England gardens since the mid-19th century (Table 2), coinciding with landscape architects' promotion of the species for estate gardens (Downing 1852; Rhoads 1994; Scott 1881) and its inclusion among a list of woody species for "June effects on the lawn" (Parsons 1895). By the turn of the 20th century, Sargent (1905) noted that *M. tripetala* was "often cultivated as an ornamental tree in the northern States." As with the establishment of many other non-native plant species (Mack and Erneberg 2002), the majority of the new *M. tripetala* naturalization sites reported here (seven of eight locations) are associated with nearby horticultural specimens in botanical gardens, college campus plantings, and at private residences, providing clear evidence of horticulture as the local source of introduction.

Of particular note, five of the eight new *Magnolia tripetala* records in Franklin and Hampshire counties represent sites with vigorous naturalized populations, including numerous seedlings, saplings, and reproductively active trees established in intact forest vegetation (Table 1). For example, both the naturalized populations in Deerfield (Franklin County) and near Amherst College (Hampshire County) comprised over 100 individuals, including mature trees with associated seedlings, and extended over more than a hectare (Table 1). Prior to the documentation of these new sites, only two herbarium records had documented naturalized, multi-individual occurrences of *M. tripetala* in western Massachusetts. A specimen from 1973, collected by H. E. Ahles at the University of Massachusetts, Amherst, in Hampshire County, was annotated that the species was "well-established in woods" on campus (University of Massachusetts, Amherst Herbarium specimen barcode MASS00340383). The exact location where this specimen was collected on campus is not known, and it is possible that the site has since been developed. More recently, in 2007, D. Lovejoy documented a population of about a dozen *M. tripetala* naturalizing in a city park in Springfield in Hampden County, MA (Westfield State University Herbarium: WSCH17369; D. Lovejoy, Westfield State University, pers. comm.). Besides these two previously reported populations, records of a few isolated adventive individuals have also been logged in the area. In 2012, R. Bertin

(College of the Holy Cross, Worcester, MA) collected material from a single individual adjacent to a town dump in Erving in Franklin Co., MA (MASS00321417), the first record of *M. tripetala* as an adventive in the county and, apparently, the northernmost record of the species as an adventive anywhere in New England. In Hampden Co., to the south, two isolated individuals have been documented in Springfield and East Longmeadow since the 1990s (Table 2). Together with a 2009 report of *M. tripetala* naturalized at a park in Hartford, CT (CONN00128833; Table 2), and the new sites reported here, it appears that this southern tree species might have the potential to become a more common naturalized element of forests in the Connecticut River Valley region.

Beyond western New England, herbarium records and published reports document occasional cases of adventive *Magnolia tripetala* individuals in eastern Massachusetts, Connecticut, and Rhode Island during the 20th century (Table 2). The earliest record of adventive *M. tripetala* in New England appears to be a 1910 collection from Plymouth, MA, where the species was described as "self sown" and "thriving," but the habitat context and number of plants involved was not reported on the specimen label (Harvard University Herbaria, GH00217771; Table 2). This 1910 record seems to supersede description of *M. tripetala* as probably naturalized (i.e., six or fewer records) in Massachusetts from 1952 onwards (Sorrie 2005). However, it was not until a 1974 record from Concord in Middlesex Co. that substantial spread of a naturalized population into forest vegetation was well documented for eastern Massachusetts. At that time, the Concord site included "3 large trees, many (flowering) saplings + seedlings (thoroughly naturalized)" (Harvard University Herbaria, NEBC00217769; Table 2). This site in Concord, MA was re-located in June 2015 with help from Jennifer Garrett (Trustees of Reservations) and it now includes a dense population of several 100 *M. tripetala* individuals, many of which are large (~15–25 cm DBH) and reproductive, across a 1–2 ha wetland forest area. In central Massachusetts, *M. tripetala* has been reported as introduced (Cullina et al. 2011; Fernald 1950), but this has not been confirmed by recent, more detailed investigations of the Worcester County flora (R. Bertin, pers. comm.; Bertin and Rawinski 2012).

It is also notable that the new *Magnolia tripetala* naturalization sites reported here for western Massachusetts occurred across a broad range of forest types and environmental settings. For

example, two naturalization sites in Amherst were situated in wet, *Acer rubrum* L.-dominated woods, whereas the site in South Hadley occurred on a steep, conifer-dominated slope under *Tsuga canadensis* (Carrière) L. and *Pinus strobus* L. In Easthampton, *M. tripetala* was naturalizing in a post-agricultural *Pinus strobus* stand, whereas the naturalized population in Deerfield occurred in the understory of a forest dominated by *Acer saccharum* Marshall. These locations showed evidence of on-site reproduction and seedling establishment even under relatively closed canopy conditions—characteristics that will likely facilitate further spread of this species into intact forest habitats in the region (Martin et al. 2009). The ecological breadth evident among the sites also suggests that the niche requirements of *M. tripetala* may be broadly met in forested habitats in the region. That being said, limited seed dispersal appears to have allowed only localized spread to date, mostly in the vicinity of reproductively-active horticultural trees (e.g., within 10s to a few 100 meters; Table 1), rather than scattered widely across the landscape. Although this type of slow spread does not fit the stereotypical model of rapid biological invasions by short-lived weedy species, it nevertheless represents an important and underappreciated mode of invasion by shade-tolerant forest plants (Martin et al. 2009).

The reasons for only localized spread of *Magnolia tripetala* to date are not entirely clear. It is possible that the number of seeds produced by naturalized individuals in shaded forest settings is relatively low and that the naturalized populations have only recently established, as discussed below (J. Bellemare, pers. obs.). Further, although the seeds of *M. tripetala* exhibit a fleshy, reddish-orange seed coat that is likely attractive to birds and small mammals (Martin et al. 1951; Stiles 1980), these dispersal vectors might not move seeds especially long distances: the gut retention times for seeds consumed by birds tends to be short, particularly for larger seeds (Cousens et al. 2008). Taken together, these factors may limit the potential for *M. tripetala* to move rapidly through the landscape.

Consistent with local evidence of dispersal limitation, it is noteworthy that the native range of *Magnolia tripetala* is entirely restricted to areas south of the formerly glaciated portions of the eastern US. This type of distribution pattern is quite common among many small-ranged forest plant species and is suggestive of large-scale dispersal limitation (Bellemare and Moeller 2014). Despite its more southerly native distribution, *M. tripetala* performs quite vigorously in horticulture in the northeastern US,

~ 300–400 km beyond its native range-edge in Pennsylvania (Cullina 2002). Indeed, the escape and naturalization of *M. tripetala* in the region might be viewed as evidence that its fundamental niche requirements are met in New England, even though it is not native to the region (Sax et al. 2013). Similar escape and naturalization events in New England by woody plants native to areas to the south have been noted in the past [for example, *Isotrema tomentosum* (Sims) Huber (Burk 1984) and *Aralia spinosa* L. (Zebryk 2003)], further underscoring this biogeographic trend.

It is also interesting to note the apparent time lag between the 19th century horticultural presence of *Magnolia tripetala* in New England and its more frequent observation as a naturalized plant near horticultural sites in the late 20th and early 21st centuries. For example, several of the *M. tripetala* horticultural specimens associated with the naturalized populations described in this report are old, large-diameter trees (e.g., 56 cm DBH in Amherst), likely tracing to 19th century plantings (J. Bellemare, pers. obs.), and yet the naturalization of *M. tripetala* in western Massachusetts seems to be a fairly recent phenomenon. For example, herbarium records first documented the species as adventive in 1973, then not again until 1994, followed by several more-recent 21st century observations (Table 2). Consistent with these herbarium records, tree-core age data from an ongoing survey in our lab at Smith College indicate a late 20th century timeframe for *M. tripetala* naturalization at the sites reported here. For example, although the largest adventive tree at the site in Deerfield is about 45 y old (established ~ 1969), another nine of the larger individuals at the site averaged only 22 y of age (established ~ 1992; range 1986–2000; J. Bellemare, unpubl. data). Likewise, 10 of the largest adventive trees at the site in South Hadley averaged 23 y in age (established ~ 1991; range 1978–2001), and 10 trees at a site in Amherst averaged 24 y in age (established ~ 1990; range 1980–1995; J. Bellemare, unpubl. data). These patterns suggest a time lag of several decades, to a century or more, between the horticultural presence of *M. tripetala* in the area and its naturalization.

Although time lags in escape and naturalization have often been reported in the invasion biology literature (Lockwood et al. 2013), the pattern of relatively synchronous escape and establishment of this southern tree species in the last 20–30 years seems most consistent with a link to recent climatic warming in the northeastern US (e.g., Hayhoe et al. 2007). Other causes of invasion time lags have been

proposed in the literature (e.g., rapid evolution to adapt to a new environment, self-incompatibility in isolated individuals, slow maturation) but the particular details of this case seem to limit their applicability. For example, the horticultural specimens involved as seed sources are old individuals, not populations undergoing rapid evolutionary change. Likewise, self-incompatibility does not appear to be a substantial problem for *Magnolia tripetala*, as germination experiments conducted with seed from the single horticultural specimen at Smith College have indicated high viability (~ 78% germination in a 2012–2013 trial with 128 seeds; J. Bellemare, unpubl. data). Further, among the adventive individuals cored, we found shade-grown trees that were reproductively active at ~ 15–20 y of age. Instead, we hypothesize that recent climate change may have allowed for the newly successful recruitment of adventive seedlings from otherwise long-established horticultural specimens of *M. tripetala*. Investigation by Greller et al. (2011) of *Magnolia* spp. naturalizations on Long Island, NY, has also suggested that climate warming in the past two decades has been a key factor related to the recent establishment and spread of *M. acuminata* (L.) L., *M. macrophylla* Michx., and *M. tripetala* in that region.

Overall, these patterns highlight the possibility that the practice of native plant horticulture may inadvertently facilitate the northward spread of some southern species in the wake of climate change (Van der Veken 2008). Given that the current native distribution of *Magnolia tripetala* is situated substantially south of New England, it seems very unlikely that the species would have reached the New York and New England areas by means of natural dispersal in the near future, even if climatic conditions have now become suitable for its establishment and spread in the region. Such cases present an interesting situation for management: should these "exotic" species be considered differently from other southern plant species that are likely to shift northward into the region under their own dispersal capacity in coming years?

Research on the escape and naturalization of *Magnolia tripetala* and other plant species that are native to the US, but exotic in New England, is continuing at Smith College, and the corresponding author would appreciate hearing of any new field observations. Voucher specimens of *M. tripetala* collected for this project are being deposited in the herbaria of Smith College and the University of Massachusetts, Amherst.

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