A Mess of Muddled Mulberries

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A Mess of Muddled Mulberries (especially in Kentucky)

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Summary. I have assembled these notes for three reasons:
(1) The native "red" mulberry of Kentucky (*Morus rubra*) is a delicious fruit that deserves a lot more conservation, propagation and consumption, especially in human settlements.
(2) The alien "white" mulberry (*Morus alba*) has become a widespread weed, replacing *rubra* within several regions of the state, especially urban areas where humans crave better food.
(3) These two species are often confused by the general public and, unfortunately, also by some professional 'plants-people' (botanists, foresters, gardeners and other horticulturalists).

Several characters can be used to distinguish these two species. The single most useful character is the degree of hairiness on lower leaf surfaces. "Red" mulberry has dense long erect hairs (mostly 0.4–0.7 mm long), which feel distinctly soft to the touch. "White" mulberry has sparse short appressed hairs (mostly 0.2–0.5 mm long), largely restricted to major veins and providing no 'felty' feeling. There are several other general differences in the leaves. Fruits, alone, can be more difficult to distinguish: on average, red mulberries tend to be larger, with more elongated shape, deeper color and deeper flavor. Ideally, names should not involve fruit color, but native ranges instead, as indicated below. Much hybridization of the two species has been documented to the north and west of Kentucky. However, clear hybrids appear uncommon within this state, perhaps because "red" mulberry here usually flowers a few weeks later than "white". Recent research indicates that hybridization causes genes to flow between the species, with the predominant direction dependant on relative frequencies of the species. Such flow may enhance the ascendancy of "white" mulberry in less wooded landscapes. Hybrids may be difficult to distinguish without analysis of DNA. Various degrees of introgression are known.

Distinction of species

The native red mulberry (*M. rubra* L.) is common across most of Kentucky, and the East Asian white mulberry (*M. alba* L.) is also locally abundant. In addition, it is possible that the Southwest Asian black mulberry (*M. nigra* L.) occurs in the state, at least planted in gardens. Black mulberry has been cultivated since ancient times in Southwest Asia and Europe, but it has been poorly documented in North America. The following key to these three species is adapted partly from Wunderlin (1997), Wu et al. (2003) and Whittemore (2006).

1. Leaves with deeply cordate base, the overall shape reniform-triangular to suborbicular, unlobed or rarely 3-lobed; lower leaf surface softly pubescent; styles 3–5 mm long, densely hairy all over; ripe fruits elliptic to short-cylindric (Length/Width mostly 1–1.5) ..... *nigra*

1. Leaves with rounded, truncate, or shallowly cordate base, the overall shape ovate or triangular-ovate or suborbicular, unlobed or often with 3–7 lobes; lower leaf surface softly pubescent or glabrous except on veins; styles 1–2 mm long, glabrous (or rarely with a few hairs); ripe fruits short- or long-cylindric (L/W mostly 1.5–4)

    2. Lower leaf surface glabrous except for scattered short hairs (mostly 0.2–0.5 mm) on the major veins; upper surfaces glabrous or with a few hairs on the main veins, often glossy in sun, usually bright or yellowish green; blades mostly 3–8 cm wide, acute or with up to 0.5-1 cm acuminate tips; fruits short-cylindric to elliptic (L/W mostly 1.5–3) ..... *alba*

    2. Lower leaf surface with dense long hairs (mostly 0.4–0.7 mm), not restricted to the major veins; upper surfaces scabrid or with scattered appressed hairs, wrinkled with impressed veins, usually dull bluish green; blades mostly 8–22 cm wide, with 0.5–2 cm acuminate tips; fruits cylindric (L/W mostly 2.5–4) ..... *rubra*

The table below summarizes a broader suite of differences between *alba* and *rubra*, based on review of the literature and 40 years of personal experience in Kentucky. Leaves tend to differ in overall size and shape, but the degree of lobing is not a reliable character. Saar et al. (2012) indicated that *rubra* has closed ("curved brochidodromous") venation, with laterals curving distally towards the leaf apex, joining adjacent laterals. In contrast, *alba* tends to have open ("craspedodromous") venation, with laterals merely dividing into the marginal leaf teeth. This difference has been neglected in most previous literature, and it deserves more attention.

Differences in flowers and fruits often appear inconsistent, and more precise observations are needed to improve diagnostic characters. In Kentucky, *alba* usually sheds pollen and ripens fruit earlier than *rubra*, with about 2–3 weeks between peak periods. However, no phenological differences were noted by recent researchers in Texas (Maier et al. 1997), Kansas (Nepal 2008) and Ontario (Burgess et al. 2005). Fruits of *rubra* tend to be larger, and usually have a more elongated shape, with length/width = about 2.5–4 versus 2–3 in *alba* (minus the stalk). Fruits of *rubra* change color from greenish to whitish to pink to red to deep purple during the ripening process. Fruits of *alba* usually also change in this way, at least in wild populations (Nepal et al. 2012), but in some cases reddening is halted at white to pink. Although some researchers have suggested that *rubra* is largely monoecious (with bisexual trees), the survey in Kansas showed that both species are subdioecious, with about 90% of trees either male or female (Nepal 2008).

Misidentifications of *alba* as "*rubra*" are common, presumably due to inclusion of any plants with deep red fruit or with noticeable hairs on leaves. Such errors have become frequently evident on the Internet. Following are a few significant examples found during early October 2013, posted by institutions who should be concerned about such mistakes.

● Wikipedia: their front-page photo of a "*rubra*" leaf is *alba* (http://upload.wikimedia.org/wikipedia/commons/b/bf/Morus_rubra.jpg); this photo is copied below on page 38, right.

● University of Texas: their photo of a "*rubra*" leaf is *alba* http://www.sbs.utexas.edu/bio406d/images/pics/mor/morus_rubra.htm); this photo is shown on page 9, right.
● Virginia Tech University: their photo of "*rubra*" in fruit is *alba* (http://dendro.cnre.vt.edu/dendrology/images/Morus%20rubra/fruit1.jpg); this is copied here on page 36.
● University of Florida: their photo of "*rubra*" in fruit is *alba* (https://edis.ifas.ufl.edu/ pdffiles/FR/FR32600.pdf); this is copied here on page 38, left.
● Univ. of North Carolina at Chapel Hill: photos of "*rubra*" leaves and fruits are *alba* (http://www.ibiblio.org/openkey/intkey/web/MORU2.htm).
● Daves Garden: this horticultural blog is rife with errors, for example their photo #23 of "*rubra*" is *alba* (http://davesgarden.com/guides/pf/showimage/205545/); see page 37.
● The "Flora Italiana" website has a photo of "*Morus nigra*" that is *M. alba*; this photo has also been used to advertise "black mulberry" on Amazon. The error was copied in a previous version of this document, but corrected thanks to J. Rabensteiner (Univ. Graz, pers. comm.).
(http://luirig.altervista.org/photos-search/index.php?title=Morus+nigra)
(https://www.amazon.co.uk/Black-Mulberry-Purplish-Red-Berries-3fatpigs%C2%AE/dp/B00WWS4H6Q)

At the Wildflower Sanctuary in Batavia, Illinois, a potential hybrid was invoked. In 2011, a tree was identified there as *rubra* (http://thewildflower sanctuary.com/ Wildflower_Sanctuary/Mulberry_Tree_(Red).html). "A few days after this discovery, three experts at the Morton Arboretum examined our sample branch and leaves for us, and they each verified our identification—with no reservations! ... This year (late spring, 2012), we again visited Morton Arboretum with more branches and leaves from the tree in question at the top of our hill. With a very powerful little, lighted, magnifying device, they established that ours was the alien *Morus alba*, based on the existence of the very tiny hairs on the leaf's underside being concentrated along the major veins and not "evenly pubescent" as with the Red rubra! ... So OUR tree is most probably not the pure *Morus rubra*, but a quite interesting hybrid!"

Misidentification of some *alba* as *rubra* was involved in the initial decision to describe a new species, *Morus murrayana* (Galla et al. 2009, Nepal et al. 2012, Saar et al. 2012). Galla et al. compared their new taxon to a group of samples that were presumed to represent typical *rubra*. However, Nepal et al. used an expanded set of molecular data to state: "Furthermore, alignment of our [ITS] sequences of *M. alba* and *M. rubra* with sequences presented by Galla et al. (2009; as well as with additional sequences of these taxa now available on GenBank) confirms that their *M. murrayana* sequences match with *M. rubra*, while sequences of material they identified as *M. rubra* match with *M. alba* (Table 1)." Misidentifications of *rubra* as "*alba*" are much less common, presumably because *rubra* never has smooth glossy leaves as *alba* often does, and its ripe fruits never remain white or pink as in some *alba*. I could find no misidentifications of this type in Google Images.

Even some authoritative sources have errors, e.g., a photo of "*rubra*" in the book by Sternberg & Wilson (2004). And it is unfortunate that misidentification often extends into the commercial arena, including material distributed for restoration of native vegetation. At the National Arboretum, A. Whittemore (pers. comm.) receives many specimens for identification, and recently noted: "The vast majority of material we've seen for sale as *M. rubra* is actually *M. alba*." In 2012/2013, the Kentucky Division of Forestry delivered a bundle of supposed "red mulberry" to W. Overbeck, graduate student at Eastern Kentucky University. But this bundle contained only *alba*, based on the characteristic differences outlined above. For several years, the state had been selling the wrong species; L. Alizadeh bought 100s of seedlings for her farm in Shelby County. I pointed out the error and they have now dumped their stock as "mulberry", and no longer sell the genus. Despite its alien status, *alba* is often knowingly promoted by wildlife enthusiasts, with birds relishing the abundant fruit in early summer—mostly June. Ripening by *rubra* is about a month later—mostly July and often tapering off into early August.

General differences between red mulberry (*rubra*) versus white mulberry (*alba*)*

Sexual Characters	***Morus rubra***	***Morus alba***
Pollination dates (typical)	**mid April to early May (east-central states)**	**late March to late April (e-c. states)**
Fruit ripening dates	**mostly in July (east-central states)**	**mostly in June (east-central states)**
Mature fruit: typical features but highly variable	**reddish- to deep purple, deeply flavored (10) 20-30 (40) × 6-8 (10) mm, L/W 2.5-4**	**pink to deep purple, often bland/insipid, (6) 8-20 (25) × 5-7 (10) mm, L/W 1.5-3**
Foliar Characters	***Morus rubra***	***Morus alba***
Leaf blade size (L × W) and overall shape [1]	**(5) 10-30 (40) × (3) 8-22 (28) cm, ovate to suborbicular, L/W mostly 1.2-1.5**	**(2) 5-15 (22) × (2) 3-8 (18) cm, ovate, L/W mostly 1.5-1.8 (often less in shade)**
Leaf blade bases	**rounded to cordate; petiole terete**	**cuneate to subcordate; petiole grooved**
Leaf apices (and lobe apices to lesser extent)	**caudate (long-tapering) to acute, elongated mostly 0.5-2 cm from inflection**	**abruptly acuminate to obtuse, elongated mostly 0-0.5 cm from inflection**
Leaf lobing and margins [2] (tentative)	**lobes uncommon, except on sprouts in sun; teeth mostly 3-4 per cm, sharper**	**lobes common, especially sprouts in sun; teeth mostly 2-3 per cm, blunter**
Upper leaf surface	**usually dense with scabrid or appressed hairs, dull bluish-green, wrinkled**	**usually glabrous or scabrid along veins, bright green to yellowish, often lustrous**
Lower leaf surface [single most useful character] [3]	**hairs dense and erect (soft to touch), spread over whole surface, mostly 0.4-0.7 mm long**	**hairs generally sparse and appressed, concentrated along major veins, mostly 0.2-0.5 mm long**
Main lateral veins: typical pattern (may vary somewhat) [4]	**laterals curved to join adjacent ones, deeply impressed on upper surface, not distinctly paler than blade above**	**laterals divided to margin, not curved, not deeply impressed, often much paler than blade above (yellowish)**
Stipules (tentative) [5]	**about 10-13 mm long, linear**	**about 5-35 mm, ovate/lanceolate/linear**

Buds, Bark & Wood	*Morus rubra*	*Morus alba*
Winter buds	**outer scales dark-brown plus blackish marginal bands, often hairy and minutely ciliate; apex acute, often oblique to twig; mostly 5-7 mm long**	**outer scales yellowish-brown or with darker submarginal bands, glabrous or with a few marginal hairs; apex acute to rounded, centered on twig; mostly 3-5 mm**
Leaf scars	**oval to irregularly semi-circular**	**more or less semi-circular**
Bark	**gray to pale brownish (inner), thin plates peeling out with age**	**gray to red/yellowish-brown (inner), developing thick solid ridges**
Mature branching	**somewhat planar, umbrella-like**	**more erect or spreading, bushy-rounded**
Sapwood (tentative) [6]	**pinkish to pale brownish white**	**yellowish white**
Heartwood (tentative) [6]	**reddish-brown**	**dark (blackish) brown**

* Sources of information include the following publications: Wunderlin (1997), Weeks (2003), Wu et al. (2003), Burgess et al. (2005), Whittemore (2006; and pers. comm.), Nepal (2008; and pers. comm.), Saar et al. (2012).

1 Leaves tend to be smaller in shade; the largest leaves are often near ends of long branches.

2 "Sprouts" with more lobed leaves can include vigorous long shoots on trees, as well as saplings and stump sprouts; trends in marginal teeth (shape, density) need further assessment.

3 Patterns in leaves of seedlings need further investigation; seedlings of *rubra* appear to have relatively dense hairs on lower surfaces but not generally as long as in mature trees.

4 Patterns in leaves of seedlings need further investigation; seedling leaves of *rubra*, especially small leaves in shade, often do not have the distinctive closed venation of mature trees.

5 Stipules are soon deciduous; descriptions vary much among cited sources.

6 See examples of images below from Internet; but more verified samples are needed.

Left: *rubra*. Right: *alba*. Note more wrinkled, dull bluish-green surface of *rubra* and up-curved lateral veins. Leaf lobing tends to be more common in *alba*, but it is not a reliable character.

Upper leaf surfaces of *rubra* (L) and *alba* (R): in *rubra*, note wrinkling with impressed veins, major lateral veins curving up to join adjacent ones, and sharper teeth. Photo by Sally Weeks.

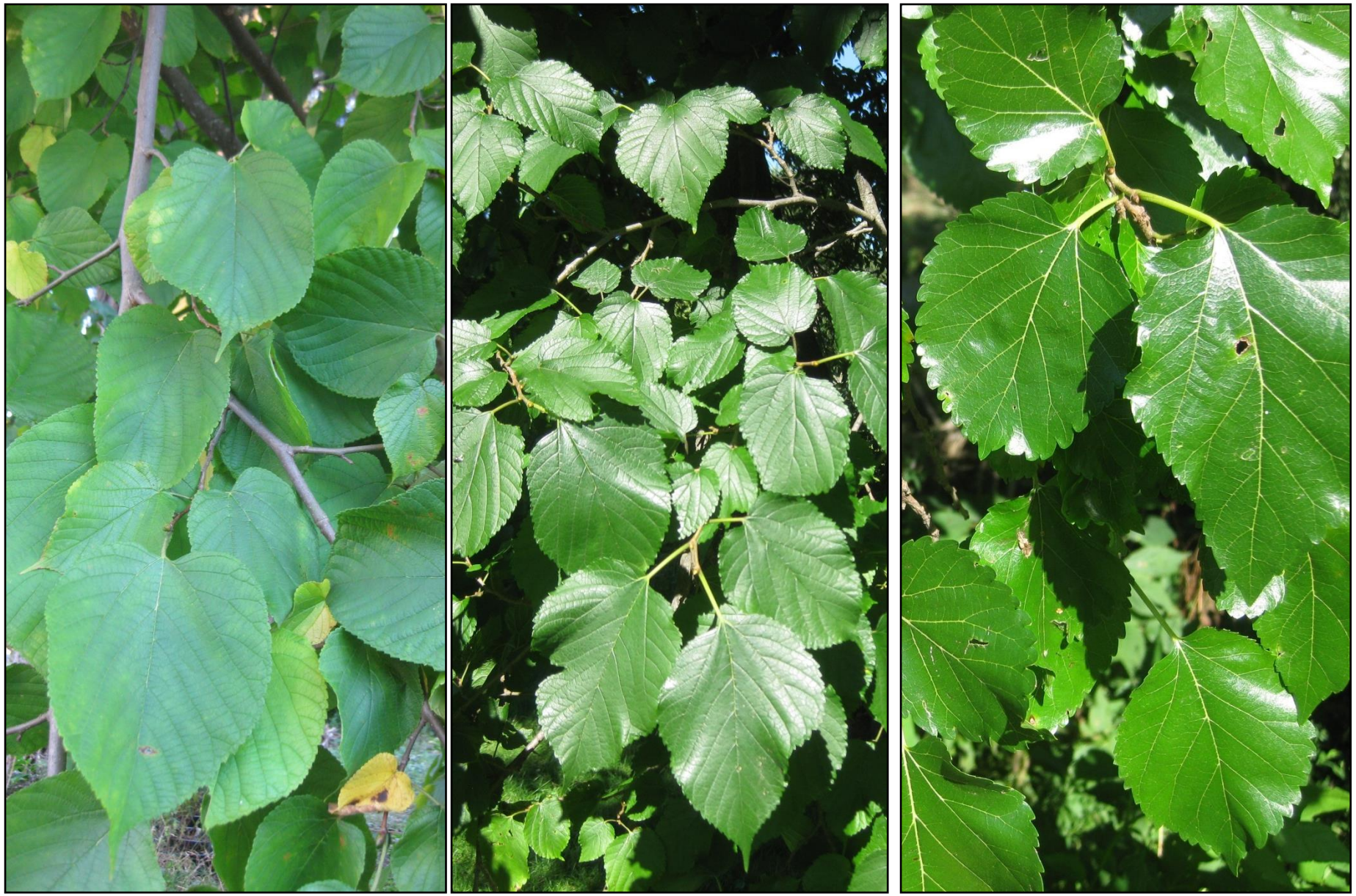
Addiional views of *rubra* (left) and *alba* (right), showing venation of leaves.

Buds of *alba* (left) and *rubra* (right): in *rubra*, note oblique angle and blackish marginal bands on outer scales, versus less dark submarginal bands in *alba*. Photo by Sally Weeks.

Hybridization of red and white mulberry

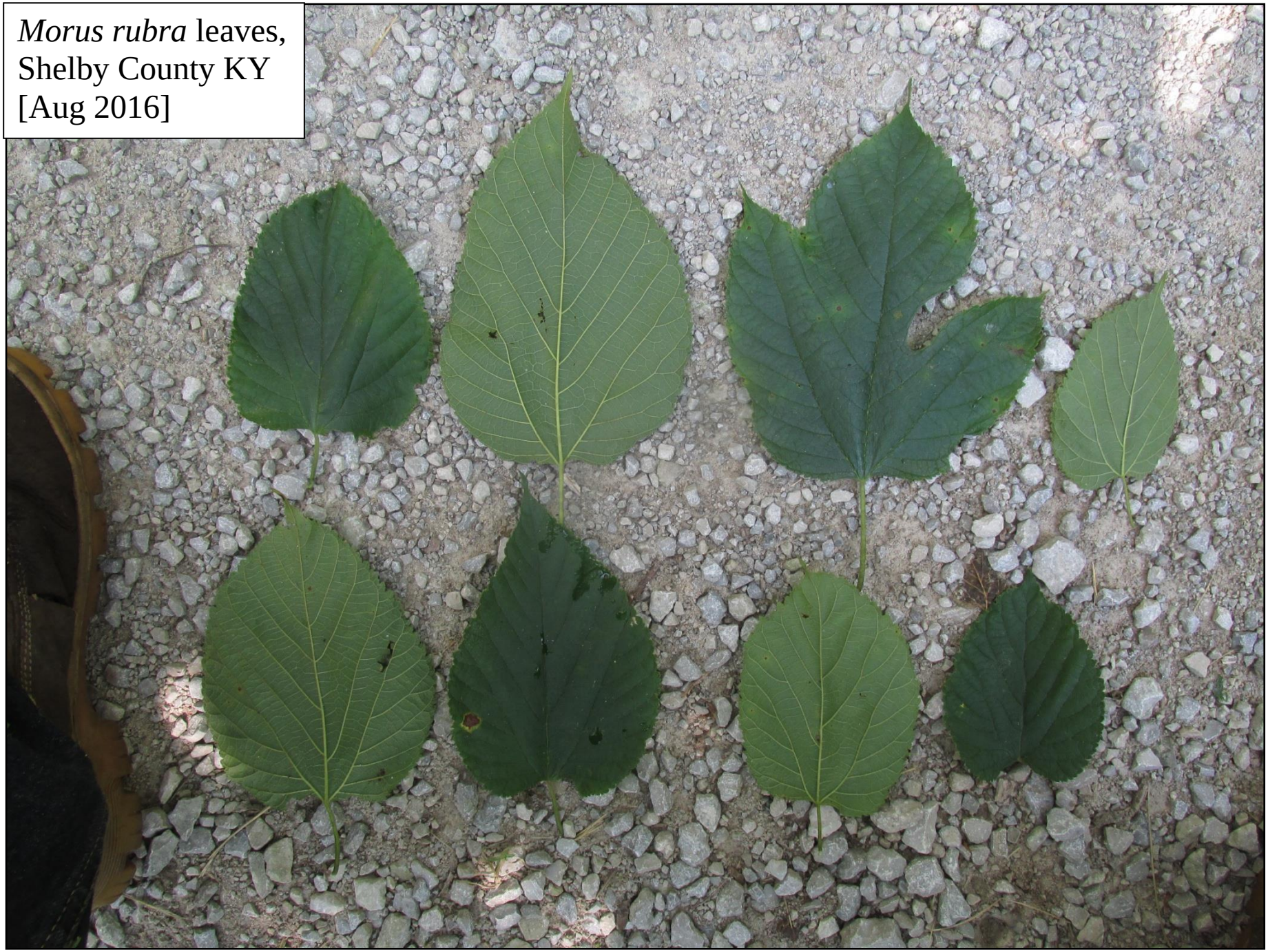
Hybrids have been proven to occur in the wild, using genetic markers. In southern Ontario, *rubra* is now rare and there appears to be a net flow of its genes into the expanding *alba* population, including numerous backcrosses of hybrids with *alba* (Burgess et al. 2005). Hybrids and backcrosses comprise 54% of all mulberry trees sampled in the region. They tend to have intermediate overall leaf size, but their degree of pubescence on lower leaf surfaces is not significantly different from pure *alba*. However, this pubescence in individual plants is the character most closely related to a DNA-based index of *rubra*-versus-*alba* position along the hybrid spectrum. At the Konza Prairie in eastern Kansas, *rubra* remains more common than *alba*; hybrids and backcrosses comprise 37% of the whole mulberry population. Moreover, there appears to be a net flow of genes from *alba* to *rubra* (Nepal 2008).

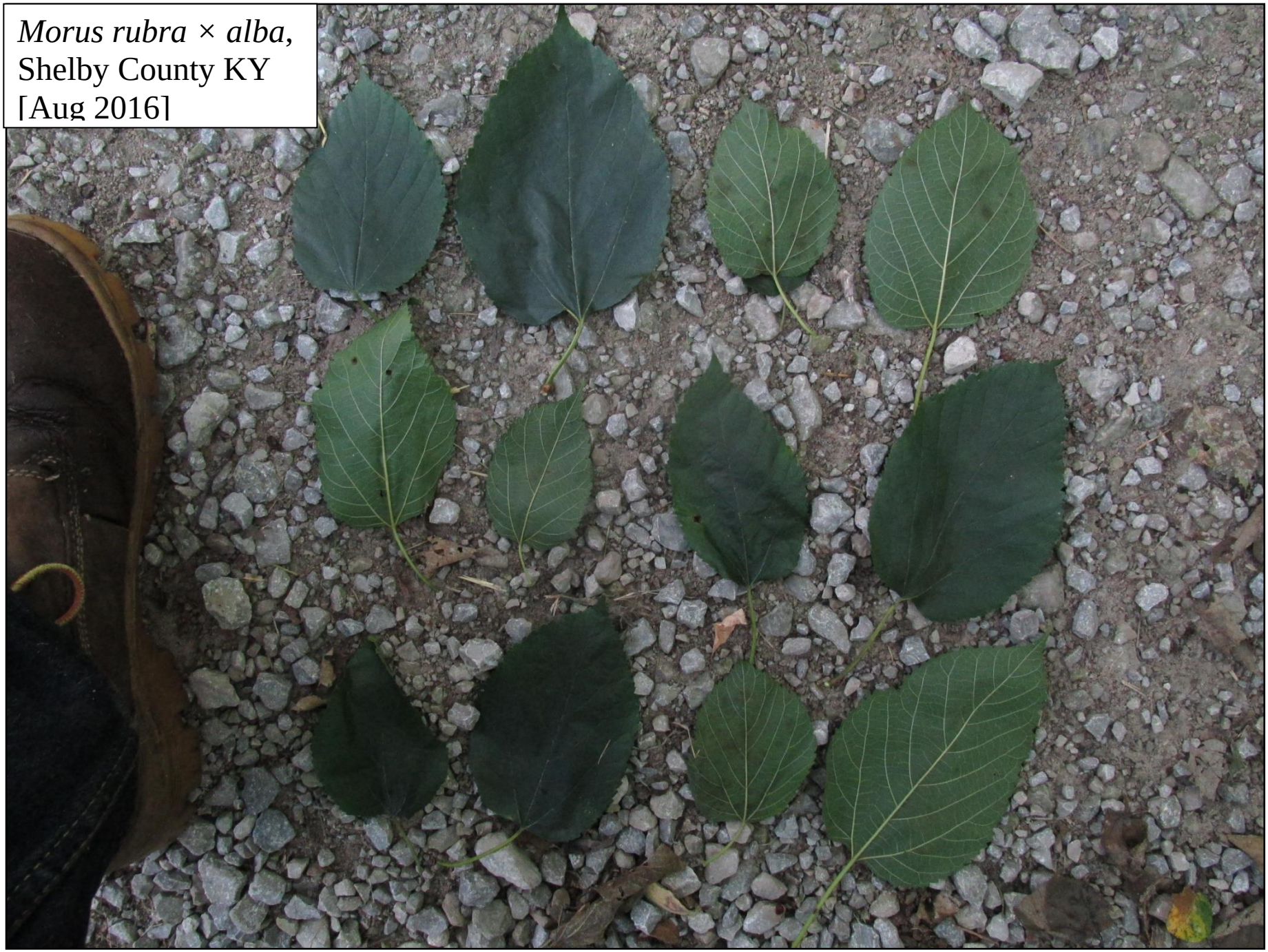
Morus rubra is imperiled in southern Ontario not just due to habitat loss, but also due to being overwhelmed from hybridization by *alba* (Ambrose & Kirk 2011). Burgess et al. (2008) found that 77% of seeds produced by *rubra* mothers have *alba* or *alba-rubra* fathers. Experimental removal of neighboring *alba* and *alba-rubra* trees within plots of about 2000 m^2, caused a 14% reduction in this hybridization rate at one site, but no change in total numbers of seed set. Maternal effects on initial fitness (seed set, germination, seedling growth) were much more significant than paternal, presumably due to non-nuclear inheritance (Burgess & Husband 2004). *M. rubra* generally had lower growth rates than *alba* or hybrids, even in naturally shaded habitat (Burgess & Husband 2006). Hybrids were about as vigorous as *alba*, except that hybrids with *rubra* mothers were less vigorous in full sun. These results were surprising, since *rubra* appears to be more shade tolerant than *alba* (at least in Kentucky). More comparative trials are needed.



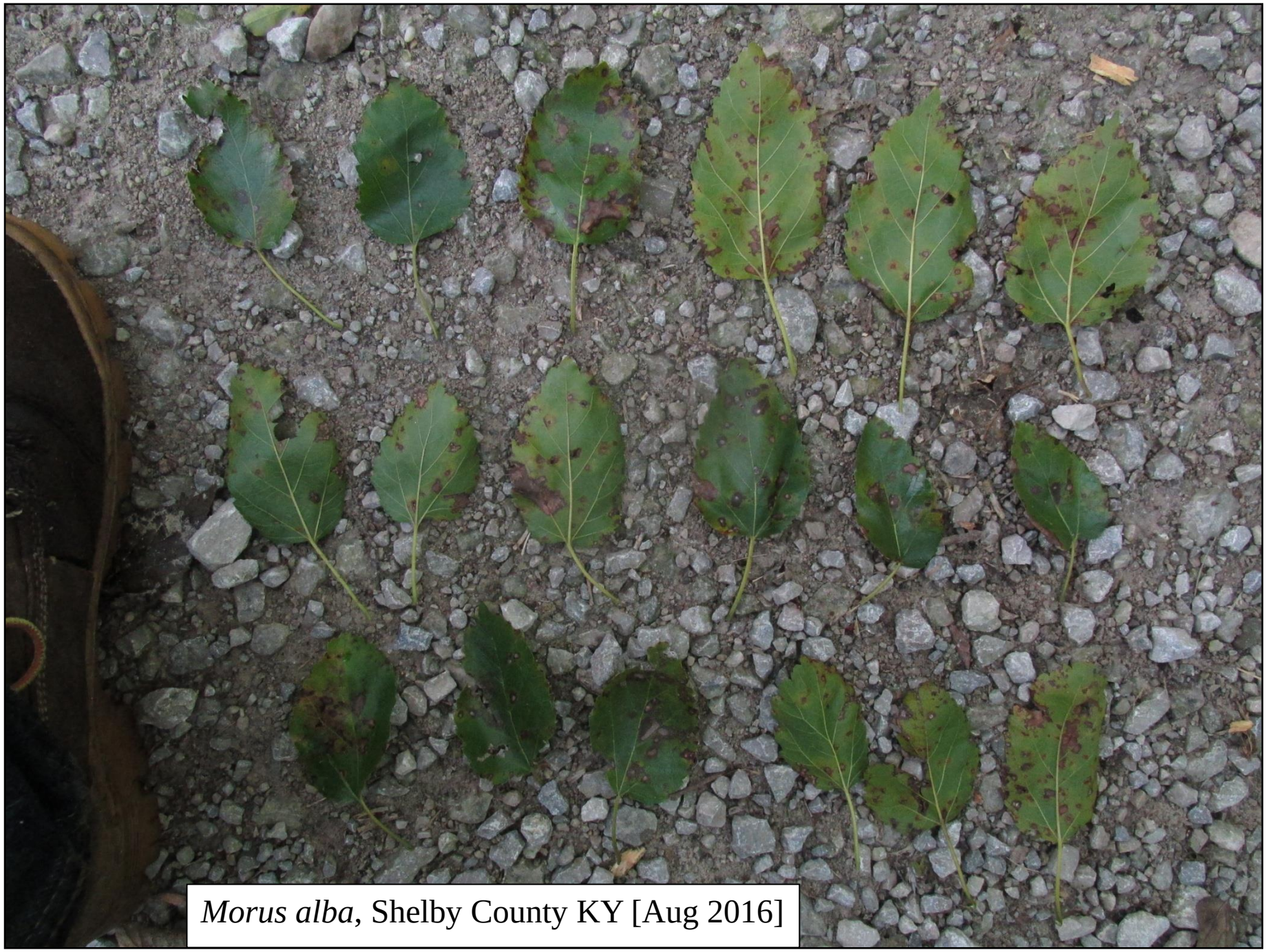
Left: *rubra*. Center: probable F1 hybrid. Right: *alba*.
The central plant is the first convincing F1 hybrid discovered by the author in Kentucky.

Morus rubra leaves, Shelby County KY [Aug 2016]





Morus rubra × *alba*,
Shelby County KY
[Aug 2016]



Morus alba, Shelby County KY [Aug 2016]

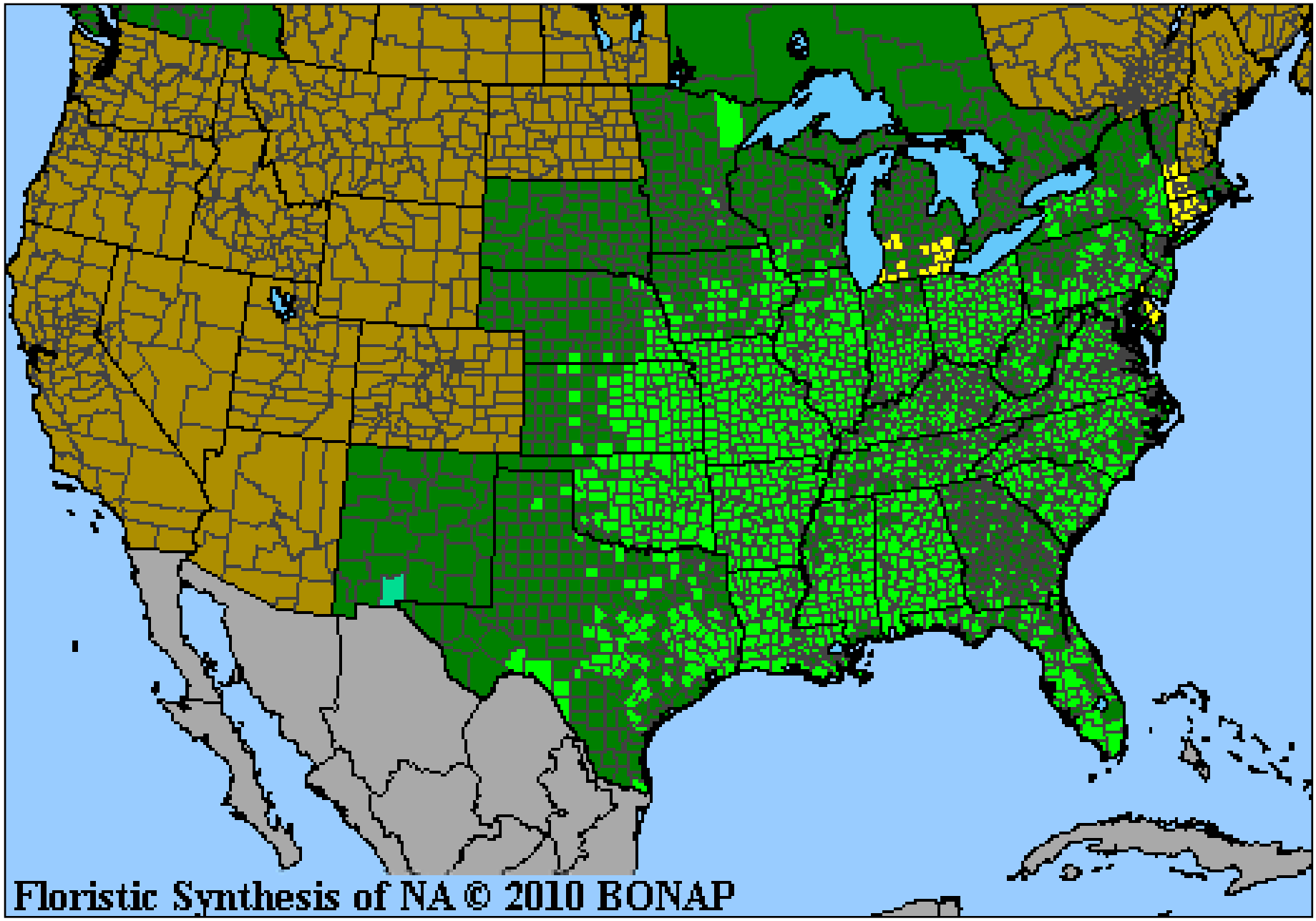
Cultivar “Illinois Everbearing”—a supposed hybrid of *alba* and *rubra* but similar to *alba*.

Some named cultivars of mulberries are reported to have been developed from hybrids of *alba* and *rubra* (CRFG 1997). These include “Collier” and “Illinois Everbearing.” However, there is little documentation for Collier, and photos labeled Illinois Everbearing from the Internet indicate that this plant may just be *alba*; for example, see preceding page.

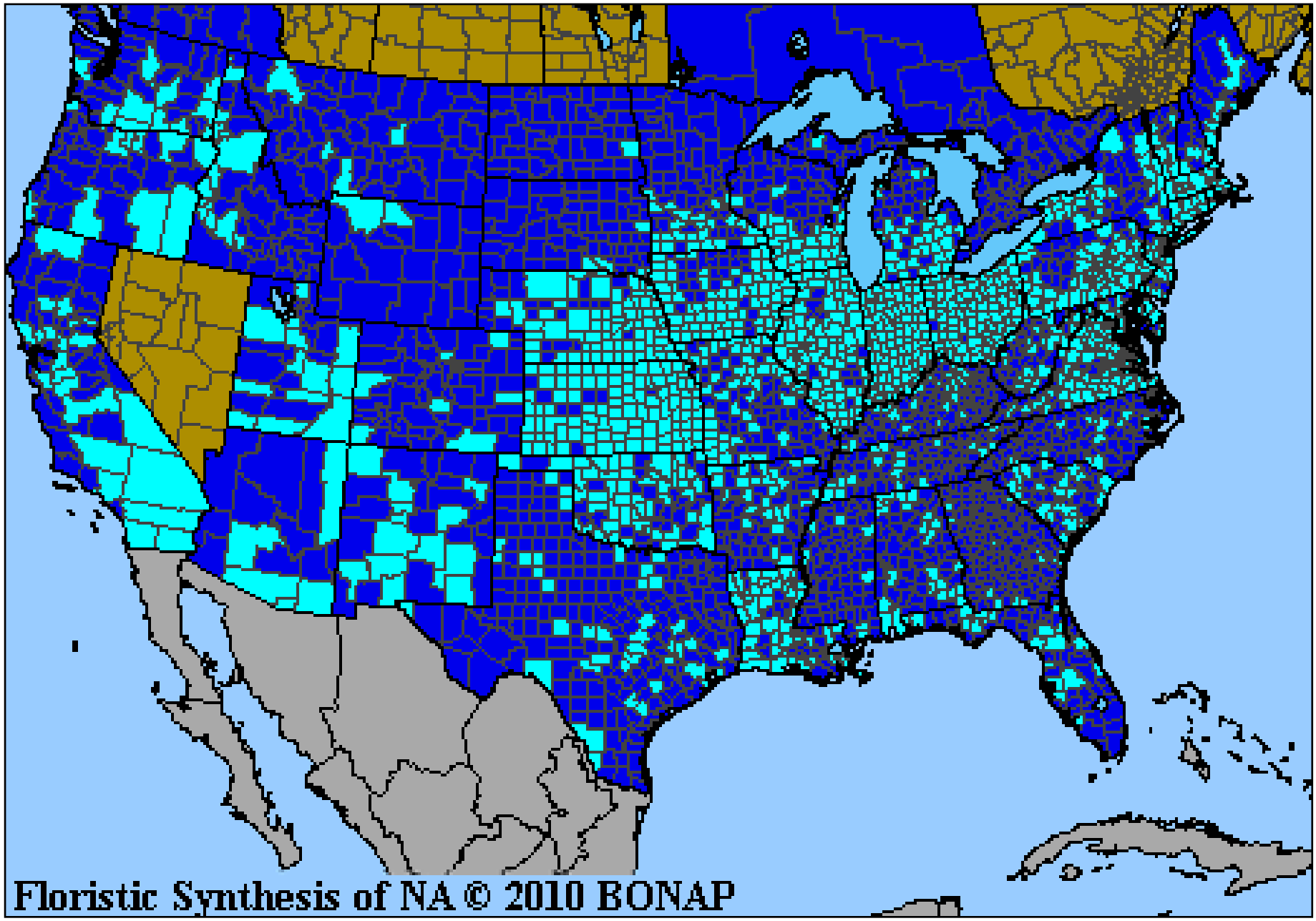
Differences in ranges within eastern North America

Morus rubra occurs mostly in current Hardiness Zones 5b to 10b, with average extreme mininum temperatures of about -10 to 35 deg. F (Kartesz 2010, Daly et al. 2012). *M. alba* has a similar range, but shifted slightly to the north, mostly in Hardiness Zones 5a to 9b, with average minimums of about -15 to 30 deg. F. There is also a concentrated abundance of *alba* records in the mid-western region from Ohio to Kansas and Nebraska. This mid-western concentration reflects the general conversion here of woodland into farmland, where *alba* is able to prosper. Moreover, much planting of *alba* has occurred in this region, due to promotion of various cultivars for silk (Parker & Jeffrey 1993) or fruit (CRFG 1997).

The western limit of *rubra*, in Nebraska to Texas, corresponds with the transition from woodland to grassland on uplands. The more extensive western spread of *alba*, across the Great Plains and Rockies to the Pacific Coast, has been promoted by much human planting. Also, *alba* has become naturalized in riparian zones of western states, where uplands are generally much too dry to support the species (Stone 1992). Yet, although definitive evidence is lacking, it is likely that *alba* is more tolerant of droughts than *rubra*. Stone stated: “White mulberry is drought tolerant ... which may be attributed to its well-developed root system. In the southern high plains of Oklahoma, 32.8% of planted white mulberry survived 7 years of drought...”



Documented distribution of *Morus rubra* in the U.S.A. (Kartesz 2013); green indicates native.



Documented distribution of *Morus alba* in the U.S.A. (Kartesz 2013); blue indicates alien.

Differences in habitat, herbivory and diseases

Morus rubra occurs in a wide range of forest or woodland types across eastern North America (Burns & Honkala 1990, Sullivan 1993, Nepal 2008, Ambrose & Kirk 2011, NatureServe 2013, VegBank 2013). It is not, however, a typical species in grassland. The species is generally concentrated on mesic to submesic sites, especially in thin woods, edges or upper shorelines. It is rare to absent on truly hydric or xeric sites. Typical soils appear to be moderately or highly fertile, in terms of overall nutrients and base-status.

For *Morus rubra*, the optimal degree of disturbance or opening in the woods appears to be moderate, between deeper shade with dominant *Tilia americana* (sensu lato), *Acer saccharum* (sensu lato) or *Fagus grandifolia* (sensu lato), and more open grassy woods with abundant *Quercus* spp., *Juglans* spp., *Robinia pseudoacacia*, *Maclura pomifera,Pinus* spp., *Juniperus virginiana* or other sun-loving trees. It is sensitive to fire but may be moderately tolerant of browsing. Yet, probably due to its efficient long-distance dispersal, *Morus rubra* is often the most shade-tolerant broad-leaved deciduous tree to occur in successional woods that are intermediate between open and closed conditions. It occupies a similar niche to hackberry (*Celtis occidentalis*), but becomes concentrated in the subcanopy rather than the canopy.

Morus alba occurs in a similar range of woodland types within eastern North America, but tends to be concentrated in more disturbed or open woods (Nepal 2008, Stone 2009, NatureServe 2013, VegBank 2013). It is generally absent from deeper woods dominated by *Tilia*, *Acer* or *Fagus*. It can sometimes invade grassland, especially along forest edges and fencerows where browsing by deer and livestock is reduced. Also, *alba* often occurs in riparian woods with more frequent flooding and scouring than is typical for *rubra*.

More subtle differences in habitat-preferences deserve further exploration. Seedlings of *rubra* do appear able to establish in moderately shady sites, much more so than *alba*. However, there has been little analysis of forest surveys or experimental work to measure differences in shade tolerance. Although *alba* has been well established in central Kentucky for 200 years, it does not generally invade the understories of native woodland, where scattered seedlings and saplings of *rubra* do occur. For southeastern states in general, Stone (2009) listed several examples of *alba* growing in largely native vegetation. However, NatureServe (2013) has provided no listings of *alba* as a typical constituent of more natural vegetation types in southeastern states; the complete text of their descriptions was searched.

Differences in herbivores and pathogens are poorly documented but may be significant (Sullivan 1993, Stone 2009, Ambrose & Kirk 2011). Both species, but perhaps especially *alba*, are browsed by herbivorous mammals in North America: livestock, elk (Schneider et al. 2006), deer, rabbits and beaver. There is much traditional use of *alba* as fodder for livestock in Asia, Europe and Africa (e.g. Kandylis et al. 2009, Tan et al. 2011). There may be relatively few reports of intensive feeding on *rubra* (Atwood 1941). However, in central Kentucky, Short (1828-29) noted: "*Morus rubra* (Common Mulberry). Owing to the depradations of stock upon this valuable tree, whose bark is a favourite food with horses and sheep, it is becoming rare in this quarter where it once abounded; young trees are never met with in exposed situations, and the old ones have generally a decaying aspect. The sexes are sometimes together on the same plant and again seperate, so that trees are occasionally found which never bear fruit. The wood of the mulberry is more durable when exposed to the vicissitudes of weather than any other timber of this region, except the red-cedar and black-locust; hence, in those parts of the country where those trees are not found, this is much used as posts for fencing. It blooms about the last of April..."

Declines of *rubra* populations have been attributed to pathogens in some cases, but definitive research is lacking (Sullivan 1993). In the central Bluegrass region of Kentucky, Van Shipp (a long-time resident of Versailles) has stated that trees in this region used to grow much larger than they do today. Indeed, most botanical manuals state that its maximum height is about 60 ft [18 m], but no trees are currently reported to exceed 30 ft [9 m] in this region. [Further west, a tree of about 50 ft [15 m] and 18 inches [45 cm] dbh was recently noted in Louisville behind the Nature Center on Illinois Avenue.] Swearingen et al. (2002) noted, without cited evidence, that *alba* might cause "the transmittal of a harmful root disease to red mulberry" in North Carolina.

Ambrose & Kirk (2011) summarized the situation in Canada: "Red Mulberry is known to suffer from twig blight, twig dieback, cankers, and root rot (Ambrose et al. 1998). Health assessments of four populations of Red Mulberry indicate that some populations are in very poor health, suffering population-level declines described as a "gradual, general deterioration" (McLaughlin and Greifenhagen 2002; Spisani et al. 2004). The former study concluded that no single pathogen was responsible for the disease symptoms. Rather, several opportunistic, canker-causing pathogens and two opportunistic root disease pathogens affected the diseased trees. These pathogens are not known to infect healthy tissues, but can successfully cause damage to stressed and weakened hosts. Probable factors causing such stress include drought, low soil fertility and/or poor or suppressed canopy position." They also indicated potential problems due to snails (feeding on seedlings), changes in soil microbes, and ozone pollution.

A definitive comparison of such problems in *alba* versus *rubra* would be useful. It does seem likely that *alba* is generally more tolerant of disturbances and stresses, leading to less pests and pathogens. Moreover, it is possible that natural enemies are lacking in North America.

Morus alba, test-planted but intensively browsed by deer and smaller mammals at Griffith Woods (Kentucky), where there is little invasion [May 2014].

Discussion

Morus alba has become naturalized in eastern North America during the past 300-400 years, after it was introduced especially for production of silk (Hatch 1957). When it first became established around human settlements, there would have been an overwhelming amount of hybridizing pollination from native *rubra*. It is likely that some early introgression occurred from *rubra* into the *alba* population. Such introgression might have enhanced the ability of *alba* to invade eastern North America. Later, along the northern edge of *rubra*'s range, *alba* became much planted and it has spread into open farmed landscapes. Currently, *alba* is much more common than *rubra* in some of these regions, and its pollen may now overwhelm the fertilization of *rubra*. But in more southern regions, *rubra* tends to flower later than *alba*, and there appears to be little or no hybridization (Weakley 2012). In some cases, it is possible that hybrid seed is less fit than both parental species. This is suggested by results of Burgess & Husband (2004) for the percentage of seed set, but their differences were not statistically significant. It would clearly be useful to extend the work of Burgess et al. (2008) and Nepal (2008) into southeastern states, so that these hypotheses can be tested.

While *Morus rubra* may survive at low density in more shady habitats, its former local abundance in more open habitats seems to be doomed without human intervention. It is crucially important that woody species like this be clearly prioritized for assistance, through careful selection of material to propagate and promotion for uses in suitable plantings. There are numerous historical references to native people having used mulberries around their settlements. It would be entirely reasonable—and relatively easy—to replant this species into urban environments, so that its pollen and fruit can make a recovery. The species is easy to propagate from seed—so long as we collect from correctly identified trees!

Supplementary notes & photographs: North American or "red" mulberry (*Morus rubra*)
This species ranges across central and eastern states but it is rarely abundant. Garman (1913) noted: "moderately common in Kentucky, but generally occurs singly or a few in a place, never constituting any large proportion of the woody growth." It often grows into subcanopies of fencerows, thickets and woodland pastures. Browsing may limit it, and trees usually die at 2-4 dm dbh due to diseased bark (Burns & Honkala 1990); yet trees of 10 dm dbh or more have been reported. It varies greatly in leaves and fruits, but there appear to be no distinct segregates. Rafinesque (1836, 3:46-47) listed five additional species; none of these names were used by other authors. Plants in the central Mississippi and lower Ohio Valleys, including much of Kentucky, tend to have relatively large fruits (often 3–4 cm long minus stalks), and relatively large leaves (blades often 15–30 cm long). Such plants have been recently described as *M. murrayana* D.E. Saar & S.J. Galla (Galla et al. 2009), but Nepal et al. (2012) showed that they are not clearly distinct from typical *rubra*.

Pages with photographs are as follows; for sources of photos, see list after Literature Cited.
24: flowering shoot, with male catkins.
25: flowering shoot, with female catkins
26: fruiting shoot, showing unripe fruit (white) and ripe fruit (red).
27: more fruit, with range of ripeness.
28: leafy shoot, with unlobed leaves.
29: leafy shoot, with lobed leaves.
30: bark of young trunk (left) and older trunk (right).
31: bark of large old trunk.
32: views of whole trees in summer (left) and winter (right).
33: cross-section of trunk, with labelled sections.
34: longitudinal sections, showing mostly heartwood.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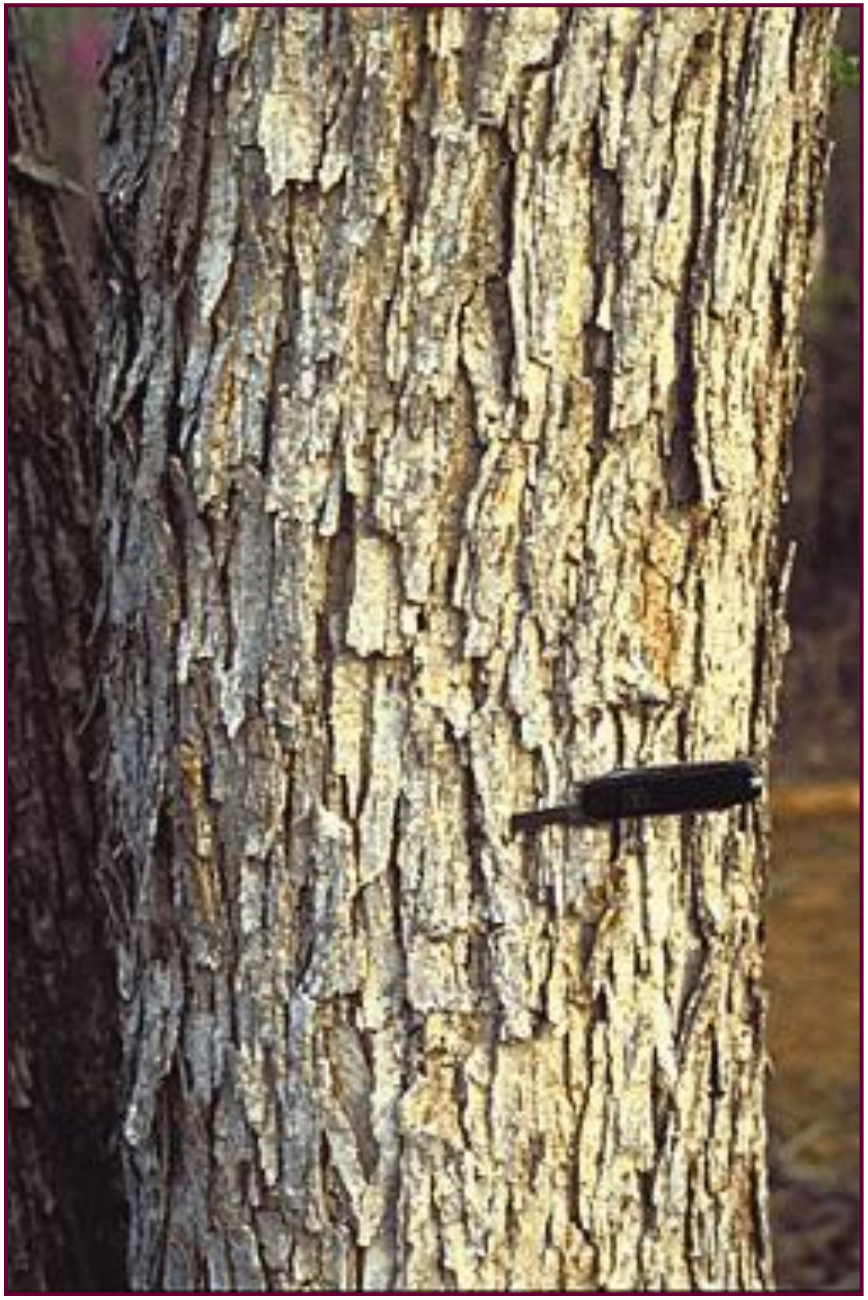

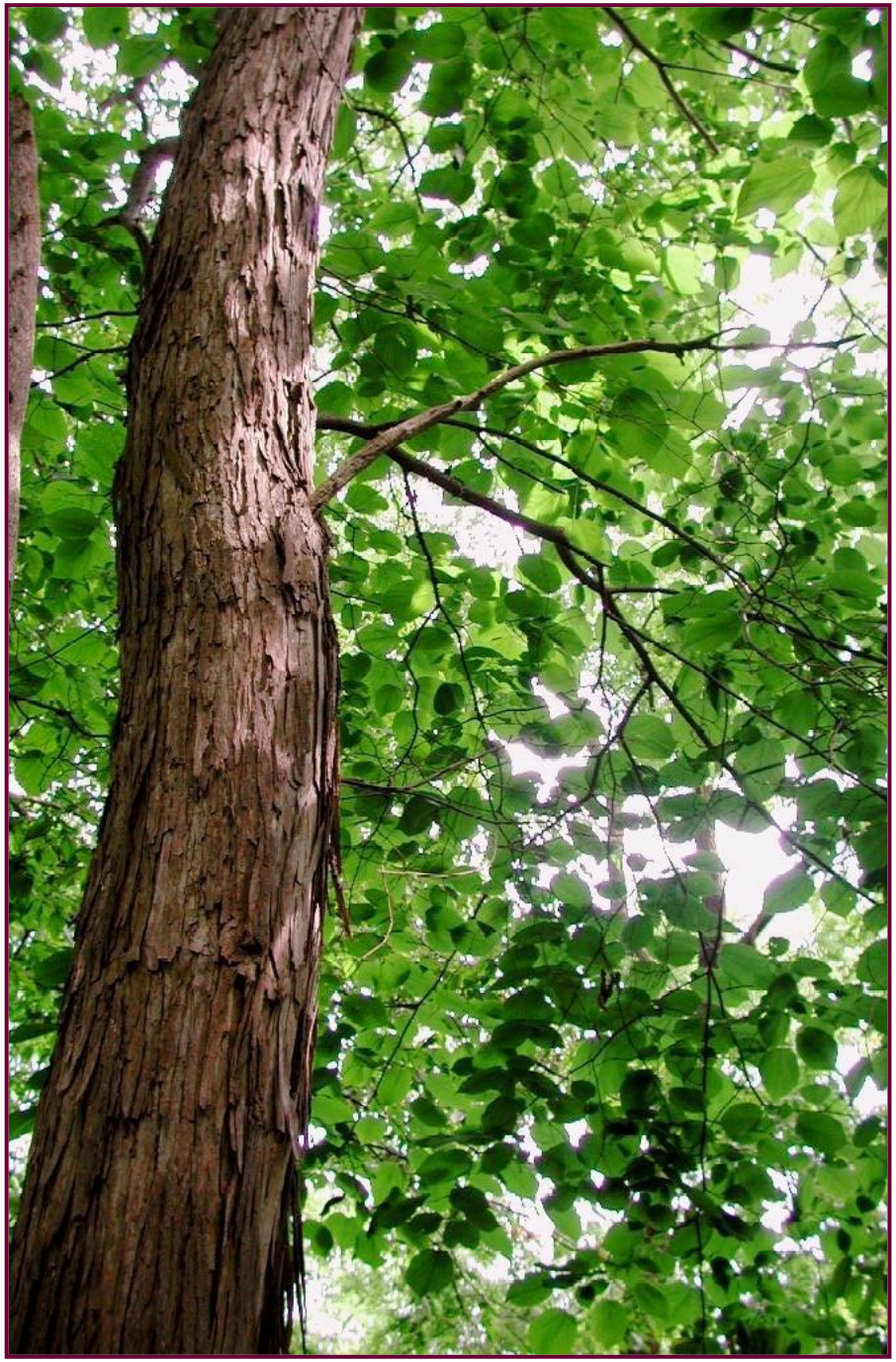

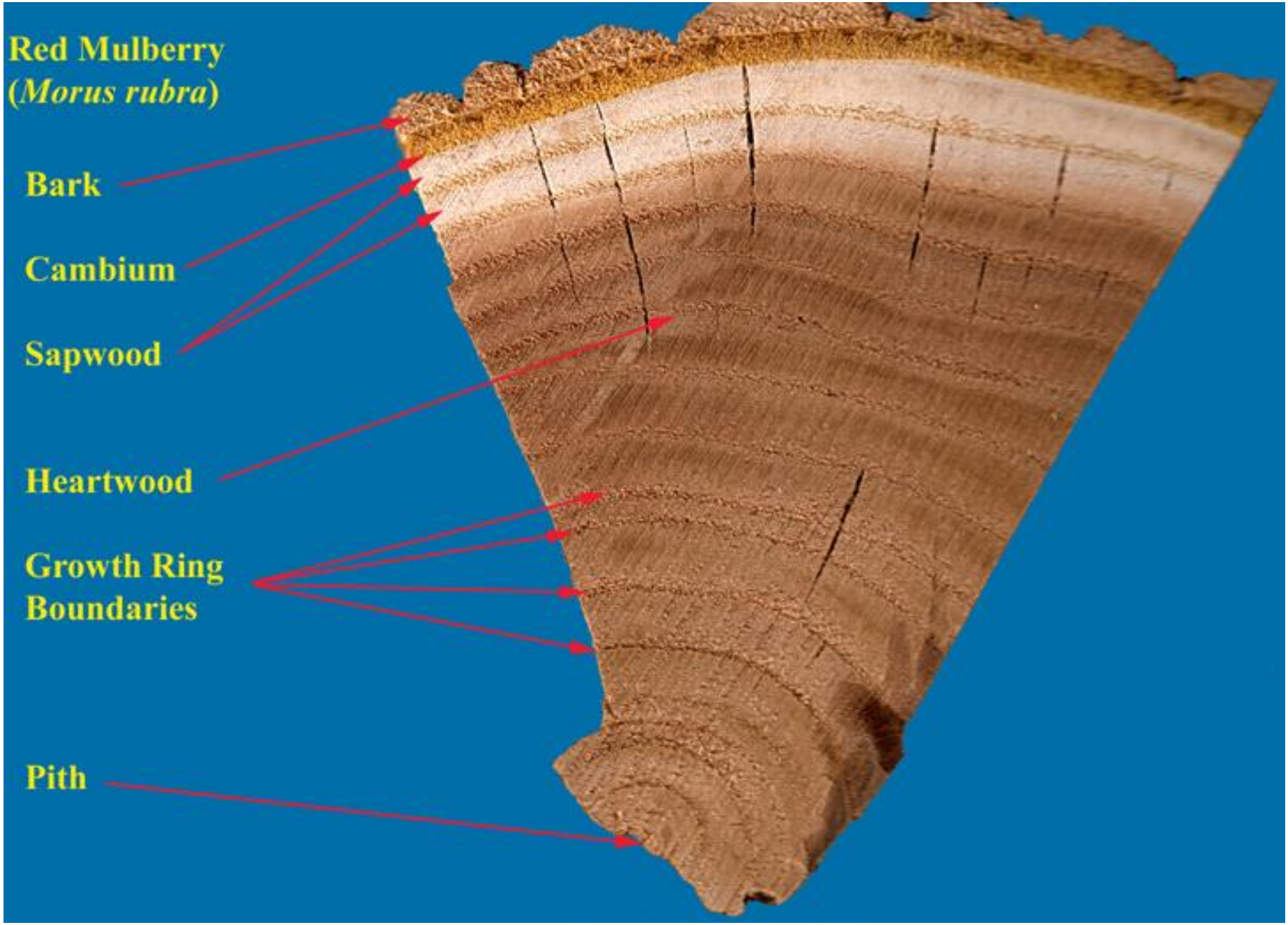
Red Mulberry
(*Morus rubra*)
Bark
Cambium
Sapwood
Heartwood
Growth Ring
Boundaries
Pith


5"

Supplementary notes and photographs: Chinese or "white" mulberry (*Morus alba*)
This Northeast Asian species was first cultivated for silkworms in North America over 300 years ago. It has now become widely naturalized across warm- and mid-temperate regions. In the Bluegrass Region of Kentucky, Short (1828-9) noted: "The White mulberry, lately introduced by seeds from France, seems to thrive well in this climate, so far at least as four or five year's experience can show." Rafinesque (1836, 3:46) noted: "a well known tree, now widely grown with us, almost wild in some localities." It is now locally common on base-rich soils of Kentucky in mature riparian woods (reaching 8 dm or more in dbh), as well as being a common weed in most urban areas.

Pages with photographs are as follows; for sources of photos, see list after Literature Cited.
40: flowering shoot, with male catkins.
41: flowering shoot, with female catkin
42 & 43: fruting shoots, showing stages in ripening (both labelled "red mulberry" in sources).
44L: close up of fruit (also labelled "red mulberry" in source).
44R: lobed leaf; lobing is most common on vigorous sprouts and absent from fertile shoots.
45: shoot with immature fruit.
46: shoot with lobed leaves.
47. shoot with unusualy pronounced lobing
48: bark of younger trunk (left) and older trunk
49: bark of large old trunk.
50 & 51: views of whole trees, showing range of form; 51R is 'weeping' cultivar.
52: cross-section of large trunk.
53: longitudinal section, showing heartwood and sapwood.
54: exposed root (exposed near streambank)


Morus alba
Moraceae
© G. D. Carr


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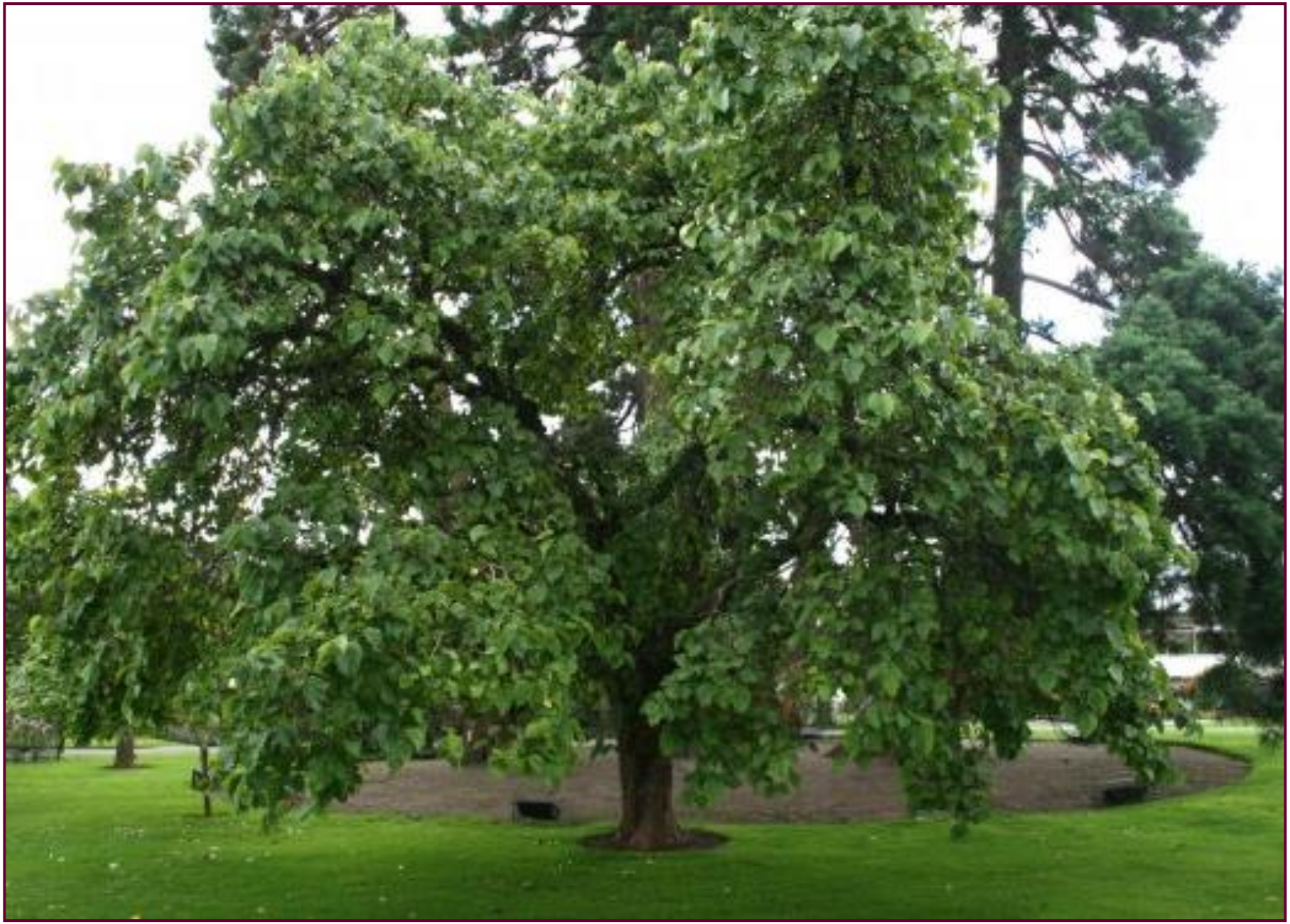
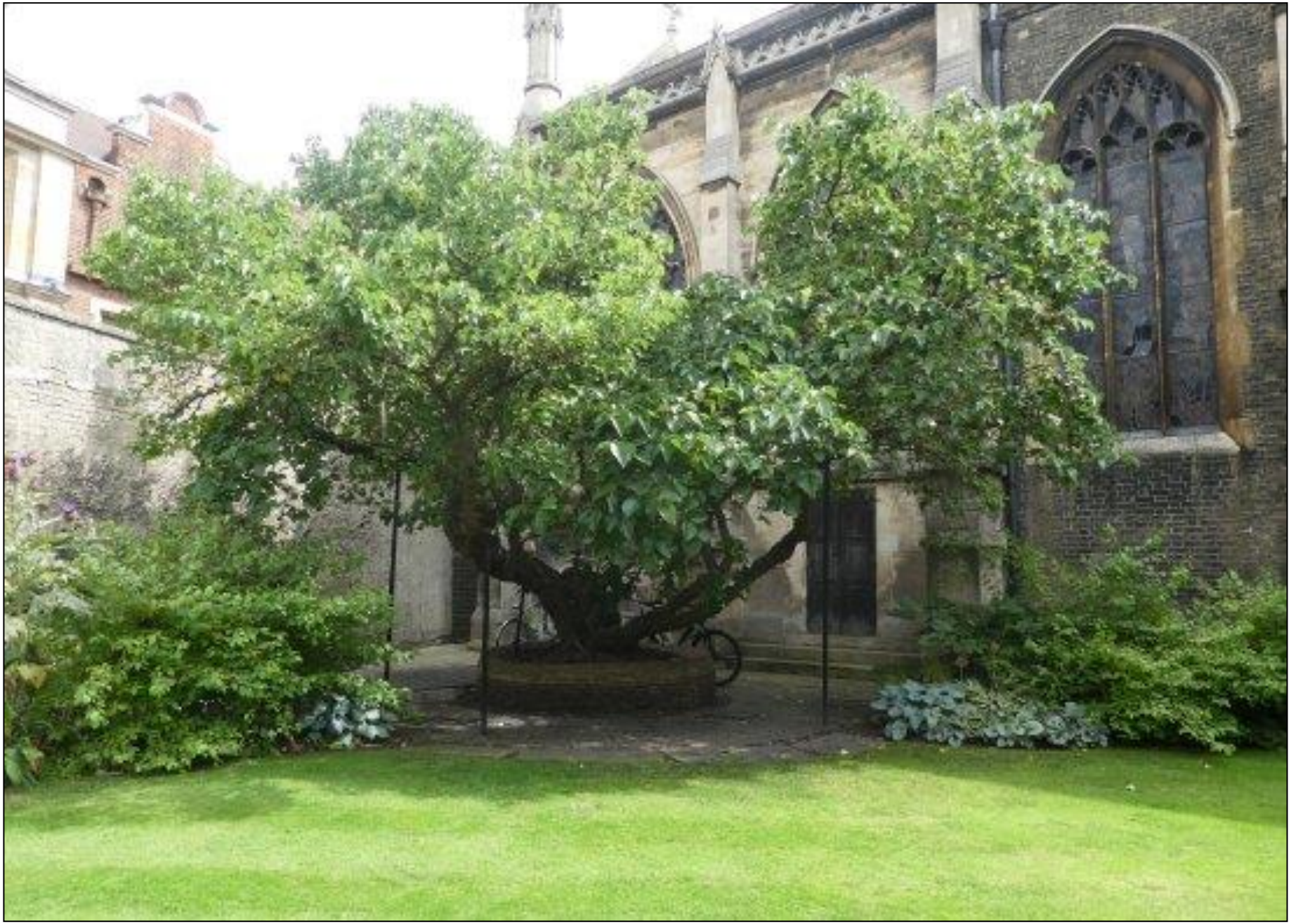
Slichter 2012

Supplementary notes and photographs: Persian or "black" mulberry (*Morus nigra*). This Southwest Asian tree reaches only 5–10 m, but trunks are up to 10 dm dbh or more. It has been cultivated for fruit since antiquity, but it has not become naturalized in eastern North America (Whittemore 2006). There are several polyploid or aneuploid races (see citations of Whittemore), with reported 2n ranging from 89 to 308, in contrast to 28 in *rubra* and 28, 42 or 84 in *alba*. Some *alba* in North America has been misidentified as *nigra*. However, there do appear to be some cultivated trees or perhaps escaped waifs of true *nigra* in North America, based on evidence from Nevada, California and Washington state (Whittemore 2006, Jacobson 2011). Although there has been little definitive research on apomixis or parthenogenesis in *Morus* (Griggs & Iwakiri 1972, Firetti 2018), it may be relatively frequent in *nigra* since isolated trees often produce many fruits.

Pages with photographs are as follows; for sources of photos, see list after Literature Cited.
56: flowering shoot, with male catkins.
57: flowering shoot, with female catkins.
58: ripening fruit and leaves.
59: fruiting branches.
60: ripe fruit.
61: leafy shoot.
62: close-up of leaves; 62R shows ozone damage.
63: leaves, above and below.
64: view of whole tree in garden.
65: old tree at Corpus Christi College, England
66: old tree at Lesnes Abbey, England.
67: longitudinal sections of tree trunks.


© W.P. Armstrong 2008





Footnotes on taxonomy of *Morus* in general

Recent analysis suggests that as few as eight species may be reasonable (Zeng et al. 2015), but deeper revision is needed (Vijayan et al. 2004, Nepal & Ferguson 2012, Yamanouchi et al. 2017). The eight are as follows; with reported chromosome numbers (2n) added after names.
mesozygia (28): dry transitions of tropical Africa; leaves eaten by primates; may be new genus
insignis (84): wet montane Central & South America; evergreen; may be new genus with *meso*.
notabilis (14, ?28, ?42): SW China; may include *yunnanensis*; see Yamanouchi et al. for ?2n.
nigra (89-308): from SW Asia; some with remarkably high 2n; may be close to *celtidifolia*.
celtidifolia (28, 84): riparian, dry SW US to Argentina; may include *microphylla*, other names.
serrata (84): E Himalaya; *rubra* may be closest relative.
rubra (28): E North America; includes *tomentosa*, *murrayana*.
alba (28, 42, 84): from NE Asia; variable complex; perhaps sister to *nigra-celt.-serrata-rubra*.

Potential segregates within the *alba* complex do need further study. The following taxa have been included in this complex (2n = 28 unless noted): *atropurpurea* (28, 42), *acidosa*, *australis*, *bombycis* (28, 42, 56), *boninensis* (56), *cathayana*, *indica*, *kagayamae*, *laevigata* (42, 56), *latifolia* (28, 42), *macroura* (with long fleshy fruit), *mongolica* (84), *rotundiloba* (28, 42), *tiliaefolia* (84), *wittiorum* (with long less fleshy fruit), and many other names. Polyploids may lack clear morphological distinction but tend to breed independently of ancestors with 2n = 28. A group of East Asian species has relatively long styles, but this may not be a natural group: *mongolica*, *australis*, *notabilis*, *trilobata* (Wu et al. 2003). A trilobate cultivar of *australis* is reportedly planted in Mediterranean Europe, and also called *bombycis*, *kagayamae* or "*platanifolia*", a nomen nudum (J. Rabensteiner, Univ. Gratz, pers. comm.); it has been combined with *alba* in the "Flora Italiana" website (luirig.altervista.org). The *australis* variant may be closely related to *indica* (Gafour 1995).

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Note also: D. Boone and J. White (pers. comm.) found in 2014-2015 that the supposed state champions for *rubra* in Kentucky, Ohio, Illinois and Iowa are actually *alba*; and photos from supposed champions in Indiana, Missouri and Tennessee looked suspicious.

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Sources of Images

Front Cover (*rubra*): http://kentuckyforager.com/wp-content/uploads/2013/06/IMG_3598.jpg
Thanks to Britt Corley for permission.

Pages

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Back Cover (*alba*): http://www.daleysfruit.com.au/UserFiles/Image/fruit-tree-2013/Mulberry%20-%20Dwarf%20Black%20(Medium).JPG