More on Muddled Mulberries

Julian Campbell et al. (bluegrasswoodland.com)

More on Muddled Mulberries:

with a review of the current status, propagation and consumption of *Morus rubra*, based in Kentucky

By Julian Campbell (Lexington KY; julian.campbell@twc.com; 859 229 7711); with help from Paul Adanick (Nicholasville KY); Dan Boone (Milford OH); and Jim Keesling (Natural Heritage AR). 22 Sep 2023; with minor edits, 31 Dec 2023.
[Image at front (above): from true *Morus rubra* of Fayette Co. KY, 6 June 2023.]

==========

Contents [relevant images, figures and tables are grouped between sections]

Introduction

Although the three widespread temperate species of *Morus*—East Asian *alba*, West Asian *nigra* and East North American *rubra*— were described by Linnaeus 270 years ago, there has a stubborn failure by some plants-people to identify and propagate them with accuracy. Fruit color has dominated common naming, but it is not a good diagnostic character. There has been much recent research into *Morus* taxonomy, especially by M.P. Nepal and associates, from Nepal (2008) to Nepal & Purintun (2021); see also Yang et al. (2023). Nepal has focussed partly on the hybridization and confusion of "red mulberry" (*rubra*) with "white mulberry" (*alba*), as also studied by Burgess & Husband (2004, 2008, etc.). After an initial summary of differences between *alba* and *rubra*, based in Kentucky (Campbell 2019, revised from 2013), it is useful to review current understanding of the status of these species across eastern states, together with hybrids. There is increasing interest in distinction of these taxa, and in propagation of *rubra* for its conservation. This interest is prompted by the frequent misidentification of *alba* as *rubra* in public education and in the nursery trade. The Kentucky Division of Forestry's nursery has corrected their labeling, but problems remain elsewhere and we still do not have a secure stable substantial flow of *rubra* seedlings for interested people to plant.

It is hoped that these notes can be developed into a proposal for more intensive propagation of *rubra* and for related research and recovery of native populations. We discuss identification problems, seed germination and establishment of nurseries and orchards. And there are some associated topics of fundamental scientific interest that should be addressed. Questions for research include: how frequent are hybrids formed in varied contexts, and how does their growth and survival compare to the parents? Also, how do pathogens and herbivores influence the growth and spread of diverse plants (*rubra*, *alba* and hybrids)? We could learn much from observing the fate of seedlings planted experimentally into varied types of site.

Continued misidentification and resulting issues

The general public remains exposed to much inaccurate information, despite the existence of characters to distinguish *alba* and *rubra* (Whittemore 2006, Nepal 2008, Campbell 2019); see Appendix Three for updated key. D. Boone and J. Decker (pers. comm.) have added a character that has not been mentioned in any published treatment: petioles of *alba* have a distinct groove about 0.3-0.5 mm deep along the upper (adaxial) side (Klimko 2016), but petioles of *rubra* are terete with no groove. Hybrids can present problems for identification, but intermediate sets of morphological characters can be used to indicate hybridity (Burgess et al. 2005, Nepal 2008). Leaf pubescence and texture alone can indicate hybrid status,

Appendix One lists some current websites with erroneous image labels, including universities and nurseries. S. Knott (pers. comm.) recently bought claimed "*rubra*" from several nurseries; only one supplied true *rubra*: Overhill Gardens in Tennessee. A *rubra* cultivar "Travis" in North Carolina also may have accurate identification to species (NC Extension 2023). Appendix Two compares some mappings for eastern North America, from BONAP (Kartesz 2023), iNaturalist (2023) and Forest Inventory Analysis [FIA] data of U.S. Forest Service (Peters et al. 2019). Misidentification is problematic in FIA data, where most records of *rubra* from northwestern margins of its range appear to be based on *alba* or perhaps hybrids. Frequent misidentification extends around the world, including many records in iNaturalist.org, even those with "research grade". As well as many North American errors, no Eurasian records of *rubra* in iNaturalist appear to be true *rubra*. Errors even appear to have occurred at the Royal Botanic Gardens of Kew (England) and Edinburgh (Scotland). A tree at Kew is labeled "*Morus rubra*" but available images suggest it is *alba* with introgression from *rubra* (Coles 2018, Christian & Coles 2022). At RBG Edinburgh (2023), there is a tree labeled "*M. rubra* L. Nana Issai" but that cultivar is known to be *alba* (Nurseries Caroliniana 2023).

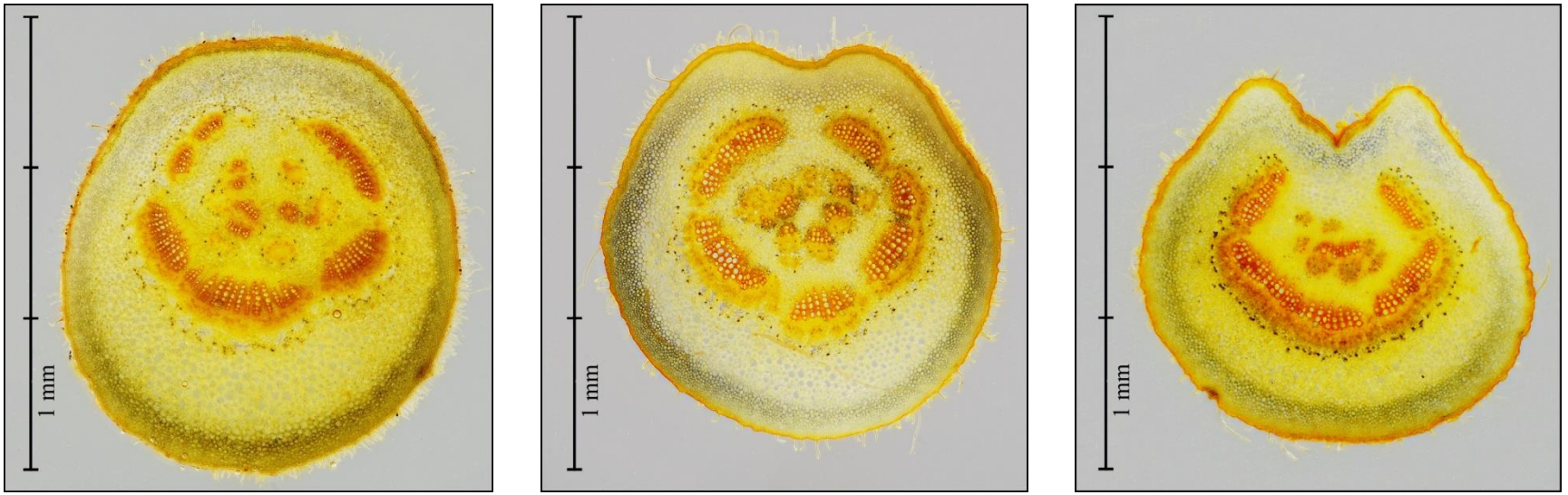
RBG Kew (2023) has stated that *rubra* is "Introduced into: Bermuda, New Mexico, Turkey, Turkey-in-Europe"; but there may be no verified records from those places. Their Bermuda record may come from a "research grade" record in iNaturalist, based on an image of *alba* foliage in poor condition [posted by "miguel-mejias1987" on 30 Nov 2021]. Records from New Mexico refer to collections of *M. microphylla* Buckley that had been labeled "*Morus parvifolia* Raf." (SERNEC 2023); *parvifolia* has no type or clear reference to an accepted taxon. Records from Turkey appear to be based only on erroneous iNaturalist records or similar observations, but without any herbarium collections. These records include some with "research grade" but associated images appear to show *nigra* [posted by "rey_bi_ey_ morgenstund" on 14 Jul 2021]. Horticultural research in Turkey and Iran has claimed to involve *rubra*, but associated images appear to be *alba* (e.g., Can et al. 2021, Ebrahimi et al. 2021, Al-Salihi et al. 2022; and in many previous papers); see also Appendix Five. Publications on the Flora of Turkey need to be checked in more detail (Güner et al. 2000).

Erroneous identifications in the U.S.A. include several records of state champion trees for *Morus rubra*. These include the supposed national (and thus global) champion in Hamburg, Arkansas (American Forests 2021), which is a hybrid with *alba*; see details in Appendix Four, which lists champions reported in each state. Most of these reports do not provide sufficient images for identification, and there are no references to herbarium collections. Several reports are dubious simply because verified *rubra* on favorable sites generally reaches only 45-100 cm dbh (18-40 in), based on authoritative sources (Sargent 1905, Lamson 1990, Sullivan 1993, Nepal & Wichern 2013) and personal observations. These same sources indicate that *alba* generally reaches 100-200 cm dbh (40-80 in) and occasionally 200-250 cm dbh (80-100 in). There are, however, a few verified records of *rubra* with 100-180 cm dbh from the mountains of North Carolina and Tennessee. The national (and global) champion may be an open-grown tree in Clay Co. NC on land of Don Schneider (as observed by D. Boone in 2016).

Despite the generally larger maximum trunk diameters of *alba* in eastern North America, that species does not appear to generally exceed *rubra* in height, and it may even be generally shorter in champion trees (Appendix Two). Authoritative sources (as cited above) report that *rubra* generally reaches a maximum height of 20-25 m (60-75 ft), and that *alba* reaches 15-20 m (50-60 ft). *M. alba* may generally develop a broader crown since it appears to be less shade tolerant and unusually large trees are generally restricted to open areas. As noted by Nepal & Wichern (2013): "The branching of a mature *M. rubra* is widely spaced, and the branches often grow horizontally giving the plant a planar appearance, while in *M. alba* the branching is more diffused giving the plant a bushy appearance." The shade tolerance of *alba* in east-central states can probably be described as "intermediate" (3 on five-point scale), while *rubra* appears "tolerant" (4). These rankings are based on personal observations plus detailed review of the literature (e.g. Valladares & Niinemets 2008, Dibala et al. 2022). They are also supported by understory densities in forest plots, such as FIA data of US Forest Service (Lienard et al. 2015), but these data are often unreliable for identification to species.

The status of the Eurasian species, *Morus nigra* L., in North America also deserves comment here, and it has been addressed by Whittemore (2006). There have been scattered reports of naturalized trees, especially in southern states. However, these reports have been based almost entirely on misidentified *alba* or occasionally *rubra* (Appendix Three). The current SERNEC (2023) database lists dozens of records, but only one herbarium collection can be verified with images: by H.M. Pollard during in 1968 from "Waste ground covered by thicket of *Rubus procerus*", Ventura Co., California.(GH, NA, USF). A verified collection from adjacent Los Angeles Co. is labeled "cultivated... at Scripps College" (CHSC); and the species also appears to be cultivated at the Los Angeles County Arboretum (2023). A verified collection from Nye Co., Nevada, also indicates naturalization: J. Beatley in 1976, "apparently escaped, in thicket with Screw-bean, Beatty townsite" (US, not yet in SERNEC).

Adaxial views of petioles, about 4 cm long: *rubra* (above), hybrid (central), *alba* (below).



Cross-sections of typical petiole summit for *rubra* (left), hybrid (center) and *alba* (right).
Petioles are 1.5-2 mm wide. Lower right corner is upper (adaxial) side of petiole.
A distinct adaxial groove is evident in *alba*, but no clear difference in vascular bundles.

Close-ups of typical petiole summits, upper (adaxial) view.
Upper: *rubra*. Central: hybrid. Lower: *alba*.
All petiole lengths are 2 cm from leaf base at left to cut at right.
These images and cross-sections on previous page were made by P. Adanick.
All material comes from Fayette County in central Kentucky.

Images from a tree labeled "*Morus rubra*" in the Royal Botanic Gardens, Kew, England (Coles 2018, Christian & Coles 2022). These suggest a hybrid with *alba*.

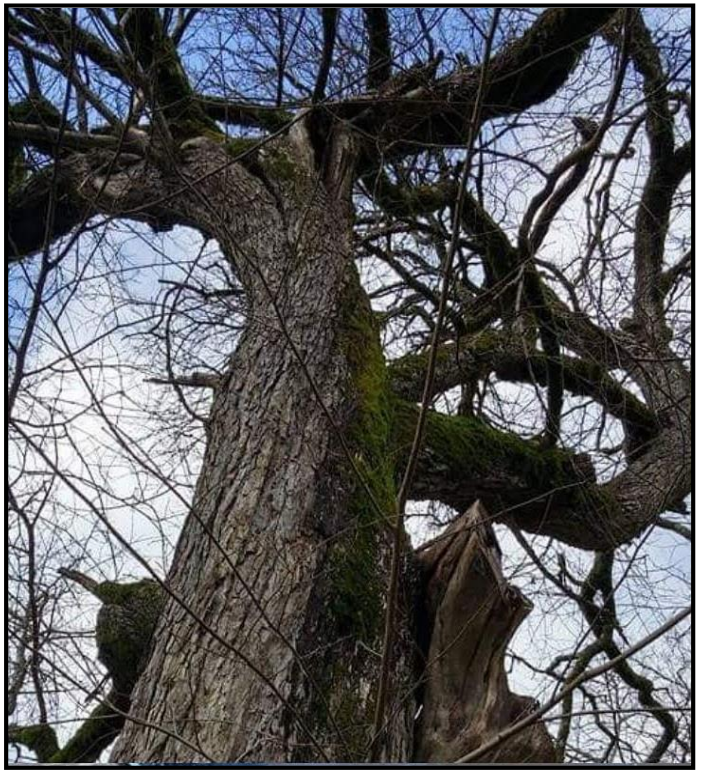
The “Chisholm Trail Mulberry” in Wichita, Kansas: 242 in around; 40 ft tall; 46 ft wide. The trail “was used in the post-Civil War era to drive cattle overland from ranches in Texas to Kansas railheads. It was one of the few trees in the plains and was used as a marker for natives and later cowboys” (Kelley 2021). Although locally called “red mulberry” it is *M. alba*!

The supposed national champion of “red mulberry” (*Morus rubra*), in Hamburg, Ashley Co. AR; 535 County Rd 81 E; 33.33730, -91.80194 (Magnolia Reporter 2018; American Forests 2021).

Dimensions are: circum. = 305 in; height = 75 ft; spread = 71 ft

The identification has now been checked by Jim Keesling in 2023. It appears to be *M. alba* × *rubra*; see details in Appendix Four.

Dan Boone with large *Morus rubra* on land of Don Schneider in Clay Co. North Carolina; posted on Facebook in Jan 2016. The tree had dbh of about 180 cm. This tree, if still living, may be the national champion and thus the global champion, since *rubra* is virtually unknown outside the U.S.A.



Hybridization

It seems likely that introgression has been occurring since the first introduction of *alba* into North America, when cultivated females would have been exposed to much pollen from *rubra* in the woodland around settlements. Presumably some of the hybrids were vigorous and backcrossed with *alba*. Later, in more developed urban and agricultural areas, *rubra* females may have become locally swamped with pollen from *alba* or introgressants.

As briefly reviewed before (Campbell 2019), several studies have indicated that introgression of *alba* into *rubra* is contributing to decline of pure *rubra* along its northern range margin, especially in the upper Midwest. Essential results from this research are as follows. Burgess & Husband (2004) compared seedling establishment and growth of *rubra*, *alba* and varied crosses. They germinated freshly cleaned seeds for two weeks with no treatment for dormancy; they grew seedlings in sun for 12 weeks. They found that *alba*, compared to *rubra*, had a five-fold greater indicated "fitness" (= seed set % x germination % x survival % x seedling weight). Moreover, crossed seedlings with *alba* mothers had consistently more "fitness" than those with *rubra* mothers. And seedlings from crosses with *rubra* mothers had less "fitness" than pure *rubra*, although the difference was only marginally significant. From four populations in Ontario, Burgess et al. (2005) found that 54% of trees were nuclear hybrids but 68% had the chloroplast DNA of *alba*; and the *alba* bias in hybrids was correlated with the frequency of pure *alba*. Burgess & Husband (2006) found that even in forest sites (with 7% versus 85% of full sun but richer soil), *rubra* had much lower survival and growth than *alba*. However, shade appears to have caused more proportionate reduction in *alba*. Burgess et al. (2008) confirmed that: "Results indicate that seeds of red mulberry, ordinarily sired by conspecific pollen, are being discounted through fertilization of ovules by heterospecific pollen, which may contribute to local decline of red mulberry."

Nepal (2008) initiated a modern taxonomic revision of *Morus*; see also Nepal & Ferguson (2012) and Nepal & Purintun (2021). He went on to study sexuality in *alba* and *rubra* of Kansas; see also Nepal et al. (2015). He found that about 50-60% of trees are male, 35-40% are female, and 10-12% are hermaphrodites. Slightly higher male ratios occurred in *rubra*. Also, about 10% switched sex from year to year between purely unisexual to hermaphrodites. Curiously, hermaphrodites tend to occur in more isolated positions relative to other trees of *Morus,* with mean nearest neighbor at about 130 m versus about 50 m for males and females. There was no clear difference between males and females in size-class distribution or spatial patterns.

Nepal (2008, his Chapter 5) also studied introgressive hybridization among 45 trees of *Morus* at Konza Prairie, which has largely natural woodland along stream corridors. There were 18 trees with indications of introgression based on DNA markers: 73% indicating introgression with *rubra*, 27% with *alba*. But only half of these potential hybrids showed clear morphological signs of hybridity. He concluded: "*Morus* hybridization at [Konza] is asymmetrical as in Ontario (Burgess et al., 2005), but differing in that introgression toward *M. rubra* is more frequent, in correspondence with the greater abundance of *M. rubra*..." Subsequently, Nepal & Wichern (2013) surveyed material from across several midwestern states, documenting much hybridization and misidentification. The earliest hybrid collection they found was made in 1957 (Dunn #12465 at MINN).

An ecological factor not considered by Burgess et al. or by Nepal et al. is consumers: herbivores and pathogens, which are discussed further below. Although *alba* is generally more vigorous in seed production, germination and growth, it is possible that herbivores, especially deer and rabbits, limit its spread into deeper woodland.

The extent of hybridization across eastern North America remains poorly documented. Simple F1 hybrids can generally be identified by intermediate morphology, but introgression presents difficulties and DNA is then needed for definitive assessment. In Ontario, genetic markers show asymmetric introgression into *alba*, which can be indicated by intermediate leaf size (greater on average in *rubra*) and lobing (less on average in *rubra*), but pubescence had little or no indicator value. Pubescence (with denser longer hairs in *rubra*) may be useful further south where there is less asymmetric introgression into *alba* (M. Nepal, pers. comm.). The lack of reported hybrids across the southern range of *rubra* is intriguing. It may just result from lack of attention by botanists. However, there may be a greater difference in flowering times across the south—such difference is indicated in Kentucky, but we need a definitive phenological comparison. Alternatively, there may be other physiological or ecological factors inhibiting establishment of hybrids, perhaps involving low fitness of hybrids (especially from *rubra* mothers), effects of competition or consumers (Burgess & Husband 2004 etc.).

Variation within *alba* deserves deeper research, and this would aid in identification of hybrids with *rubra*. Many segregates have been named, but in China Wu et al. (2014) only recognzed var. *multicaulis* (Perr.) Loudon, noted as "cultivated" in eastern provinces; but that taxon may be transferred to the more southern *M. australis* Poir. (Nepal 2008). Wu et al. distinguished it as follows: leaf blade thick, wrinkled, to 30 cm long (versus thin, flat, 5-15 cm); fruits greenish white to purple when mature, cylindric (versus blackish purple, ovoid to ellipsoid). Larger rugulose leaves and more cylindric fruits suggest some similarity to *rubra*, but leaves are not densely pubescent nor fruits deeply colored as in *rubra*. Plants known as *multicaulis* were introduced to North America in 1826, especially for silk production (Rafinesque 1839, Monson 1996), but they reportedly lacked cold-hardiness. There is support for recognition based on leaf anatomy (Klimko 2016) and chloroplast DNA (Zheng et al. 2022); but see Appendix Five for issues with morphological identifications in the latter study.

From Burgess et al. (2005): their Figures 3, 5 and 6.

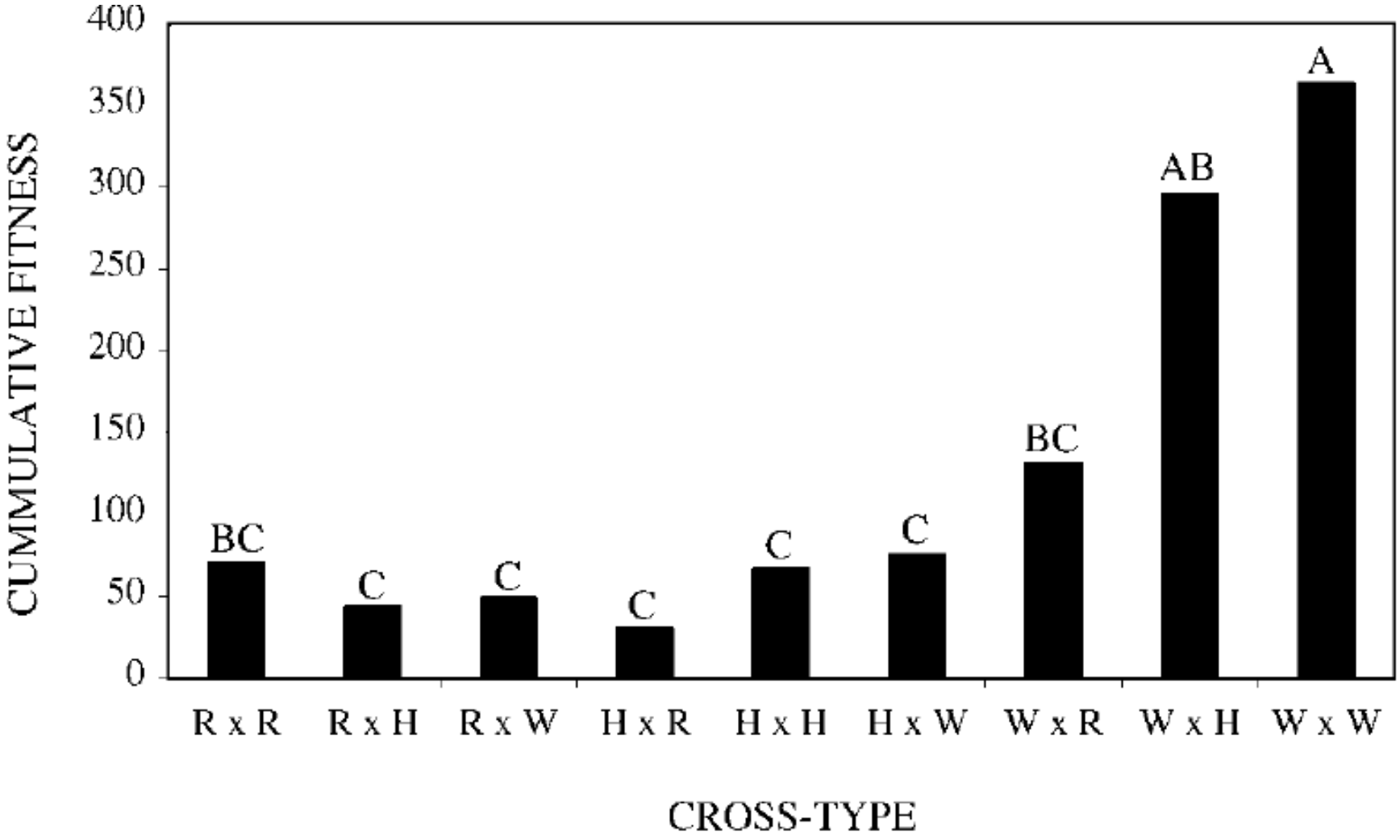
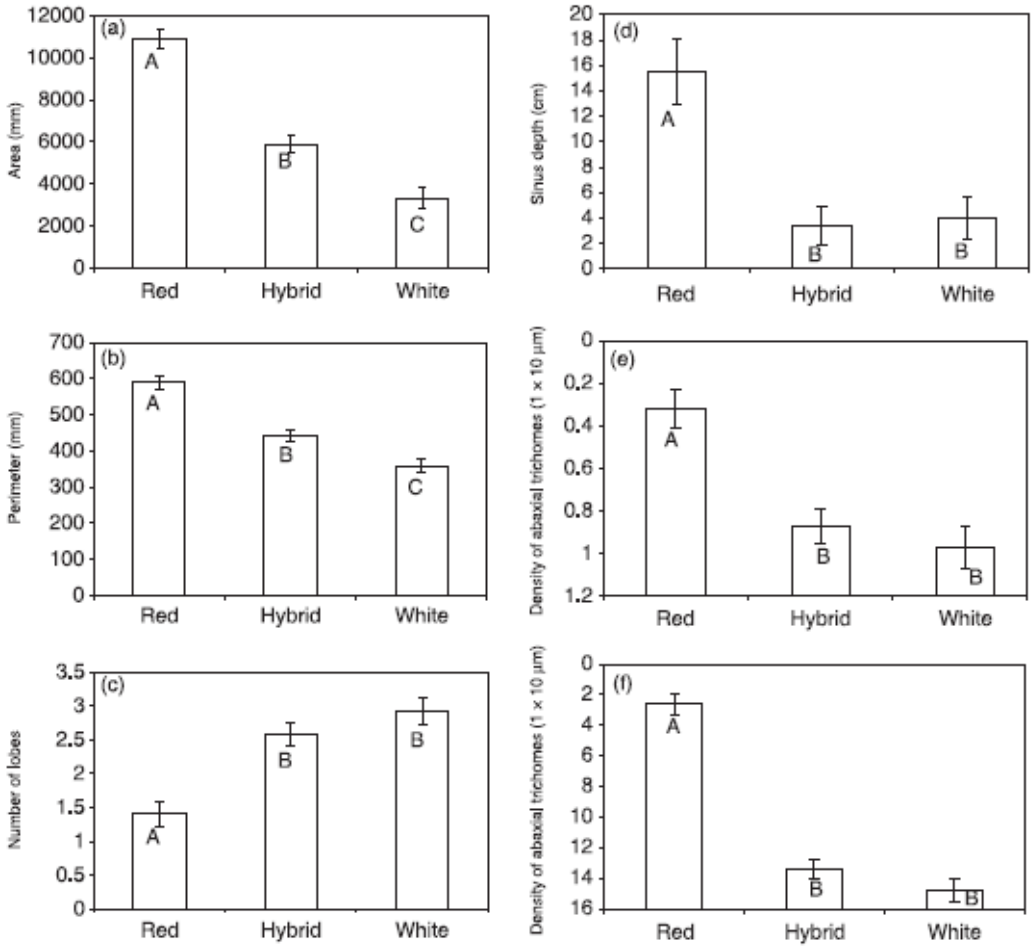
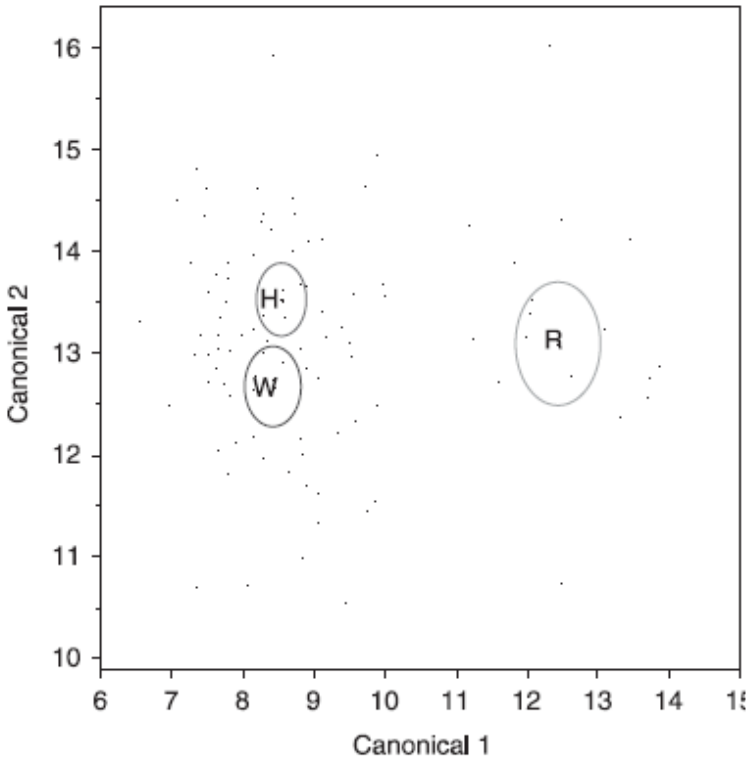


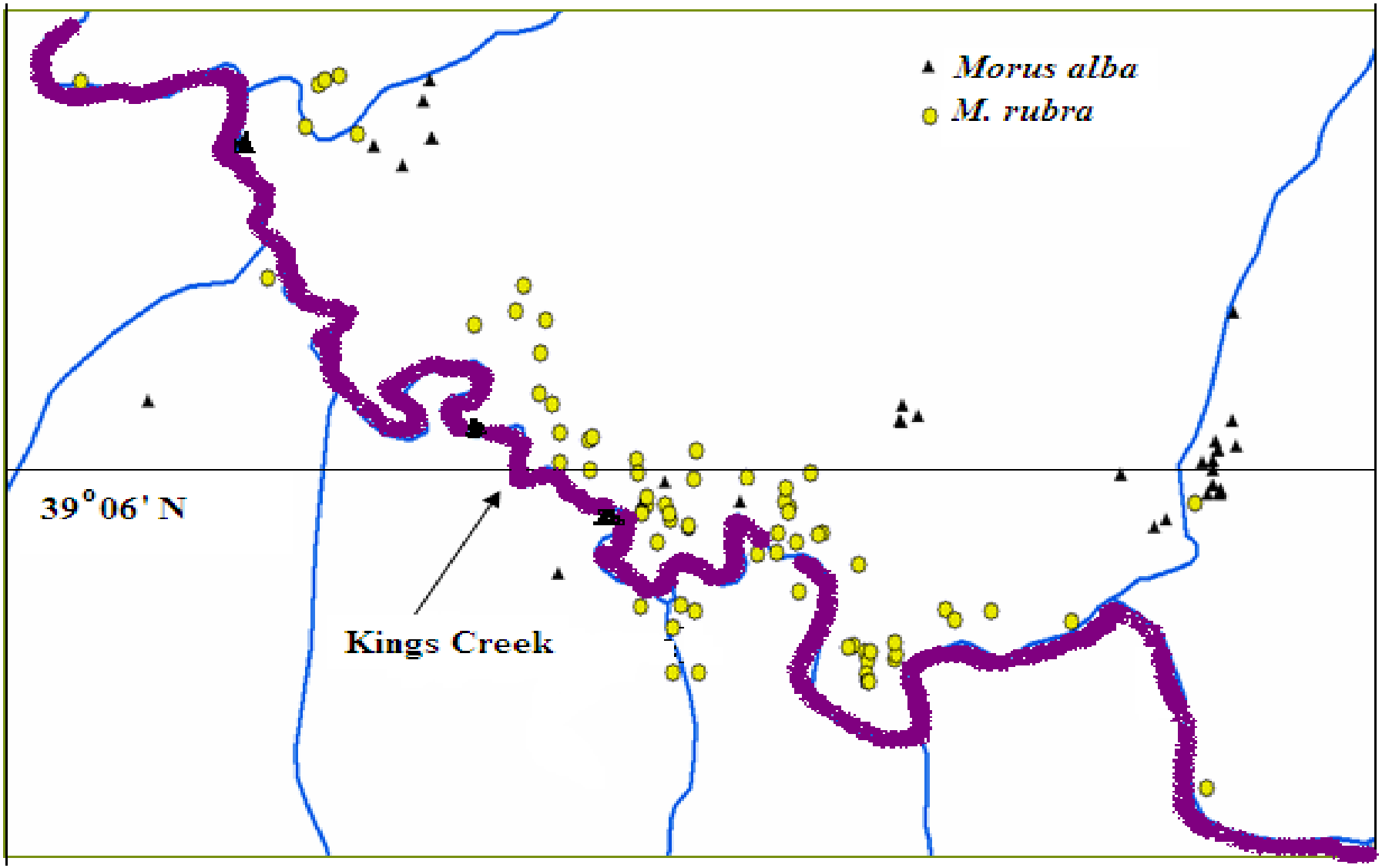
Fig. 3. Mean cumulative fitness of (A) offspring from red, white and hybrid mulberry mothers, and (B) all nine maternal × paternal cross-combinations between red (R), white (W), and hybrid (H). Means with different letters indicate significance based on a Tukey's post hoc comparison of means.





Left: Fig. 5 of Burgess et al. (2005): "Mean (± SE) values for red, hybrid, and white mulberry leaves with respect to six morphological characters: (a) area; (b) perimeter; (c) number of lobes; (d) length of sinus; (e) density of adaxial trichomes; and (f) density of abaxial trichomes. Differences were compared using a Tukey–Kramer post hoc comparison of means. Means with different letters are significantly different."

Right: Fig. 6: "Two-dimensional canonical plot displaying the points and multivariate means that best separate red (R), hybrid (H), and white (W) mulberry based on morphological analysis. Canonical variable 1 is correlated with the density of adaxial and abaxial trichomes. Leaf area, perimeter, number of lobes and sinus depth are correlated with canonical variable 2. Circles depict 95% confidence limits of the multivariate means for each taxonomic class. A MANOVA confirmed significant differences among red, hybrid, and white mulberry (Wilks lambda/10,180 = 0.33, $P < 0.0001$)."



From Nepal (2008): "Figure 5.1 Distribution of *Morus* trees along Kings Creek area at KPBS."
KPBS = Konza Prairie Biological Station, about 6 miles south of Manhattan, Kansas.
Frame is approximately 1600 m wide, 900m high.
Western edge is 96 degrees, 36 minutes; eastern edge is 96 degrees, 35 minutes.

From Google Earth, 2022 Aug 9: aerial image to match Figure 5.1 of Nepal (2008).
Yellow circles indicate approximate locations with clusters of *Morus alba*; see preceding page.
These clusters are located in more open edges of the riparian corridor.
Frame is approximately 1600 m wide, 900m high.

Examples of apparent hybrids: left = M.M. Garabrandt #678 from Washington Co. NE (ISC); right = M. Brock #1352 with J. Campbell from Montgomery Co. TN (APSC).

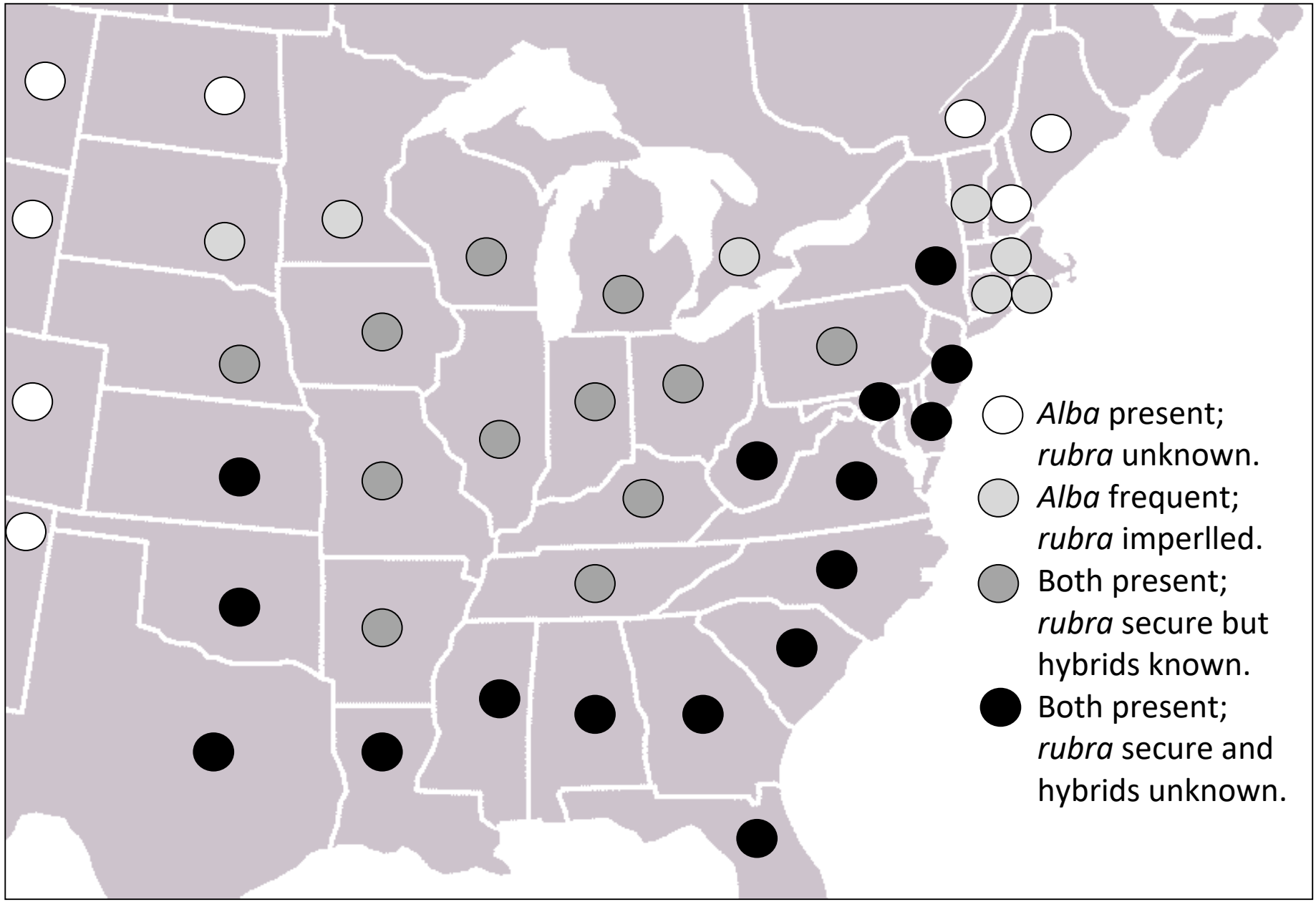
Historic spread of *alba* and geographic differences from *rubra*

For silk production, *Morus alba* was first introduced to Mexico in 1531 (Wyckoff 1881), and then during 1609-42 to Virginia (Hatch 1957, Ewan 1969, Coles 2022). As noted above, the superior cultivar "*multicaulis*" was introduced in 1826 (Rafinesque 1839, Monson 1996). The Shakers of Kentucky produced silk from 1812 to the 1880s (Jeffrey & Parker 1996). 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." The Mormans introduced *alba* to Utah in the 1860s for silk production (Monson 1996). Barbour et al. (1990) stated: "White, sometimes called "Russian", mulberry [var. *tatarica* (L.) Ser.] was introduced to the United States by Mennonites from Russia in 1875."

Morus alba probably naturalized soon across the Midwest due to dispersal by birds from initial plantings. There is a remarkable statement from the journal of Croghan (1831, p. 137) on 6 June 1765 at the Wabash River at its confluence with the Ohio River: "The mouth of this river is about two hundred yards wide, and in its course runs through one of the finest countries in the world, the lands being exceedingly rich, and well watered; here hemp might be raised in immense quantities. All the bottoms, and almost the whole country abounds with great plenty of the white and red mulberry tree. These trees are to be found in great plenty in all places between the mouth of the Scioto and the Ouabache [Wabash]; the soil of the latter affords this tree in plenty as far as Ouicatoon [meaning?], and some few on the Miame River." Herbarium data generally suggest that *alba* was present across much of eastern North America by the early 1800s (SERNEC 2023). Further west, an early tree on the Great Plains in Kansas was the "Chisholm Trail Mulberry", dating perhaps from the 1820s (Kelly 2021). However, the earliest collections from Texas may have been as late as 1894 (W.N. Speckman at CHIC).

Hybrids of *alba* and *rubra* in the Midwest may have existed by the 1890s; see notes under map below. Some plants known as "Illinois Everbearing" may have been among the earliest recognized hybrids. This popular cultivar does not appear to be documented by herbarium specimens or DNA sequencing, and it has been referred to as "*alba*" (McDaniel 1980, Ourecky 1980), "*alba* × *rubra*" (McCormack 1985, Pietrella et al. 2019), or "*rubra*" (Marchetti et al. 2021, RHS 2023). Images indicate that this cultivar name has been applied to *alba* or perhaps *alba* × *rubra*, but not pure *rubra*. Christian & Coles (2022) described "Illinois Everbearing" as follows: "A culinary mulberry selected for its hardiness, vigour, a long cropping season lasting several weeks, and for its nearly seedless, very sweet, black fruits... This chance hybrid was discovered by Peter Glaser of Evansville, Indiana, in White County, Illinois, in 1947 and commercialised in 1958, but it is now more commonly cultivated in Europe than in the US. It bears a far greater resemblance to *M. alba* than *M. rubra*." It may be the basis for records of *rubra* in Europe and Asia (Appendix Five).

Despite the early spread of *alba* across North America, that species remains relatively uncommon to rare in many less agricultural landscapes of southeastern states. The website iNaturalist.org provides some insight when *alba* and *rubra* are compared (Appendix Two). However, initial checks indicate that about 10% of North American "*rubra*" records in iNaturalist are erroneous identifications of *alba*. There appear to be strong concentrations of *alba* records in urban areas, such as around Dallas TX, San Antonio TX, Houston TX, Nashville TN, Atlanta GA and Durham NC. In contrast, there is a remarkable paucity of records from the Appalachian Plateaus of WV, KY and TN. It is likely that *alba* is rare in these largely wooded hills due to lower shade tolerance plus browsing by deer or other herbivores. *M. rubra* remains much more widespread through Appalachian regions, but it also has moderate concentrations of records around urban areas; such concentration is expected due to observer biases in iNaturalist (Daru & Rodriquez 2023).



Map of status for *alba* and *rubra* in each state. Documentation is provided from initial papers of Burgess, Nepal and others, plus herbarium data (SERNEC 2023) and personal observations.

==========

Footnotes for map of preceding page. Occurrence of hybrids remains uncertain in some states. Following are some examples of potential hybrids in Illinois and Indiana, based on images posted at SERNEC (2023). These identifications need to be checked with collections.

Illinois

B.T. Gault s.n. 1898-08-03; DuPage Co. (F)
https://sernecportal.org/portal/collections/individual/index.php?occid=4409993&clid=0

H.C. Skeels 180 1904-05-27; Will Co. (F)
https://sernecportal.org/portal/collections/individual/index.php?occid=4409988&clid=0

W.H. Dunham s.n. 1921-09-00; Cook Co. (F)
https://sernecportal.org/portal/collections/individual/index.php?occid=4409989&clid=0

Indiana

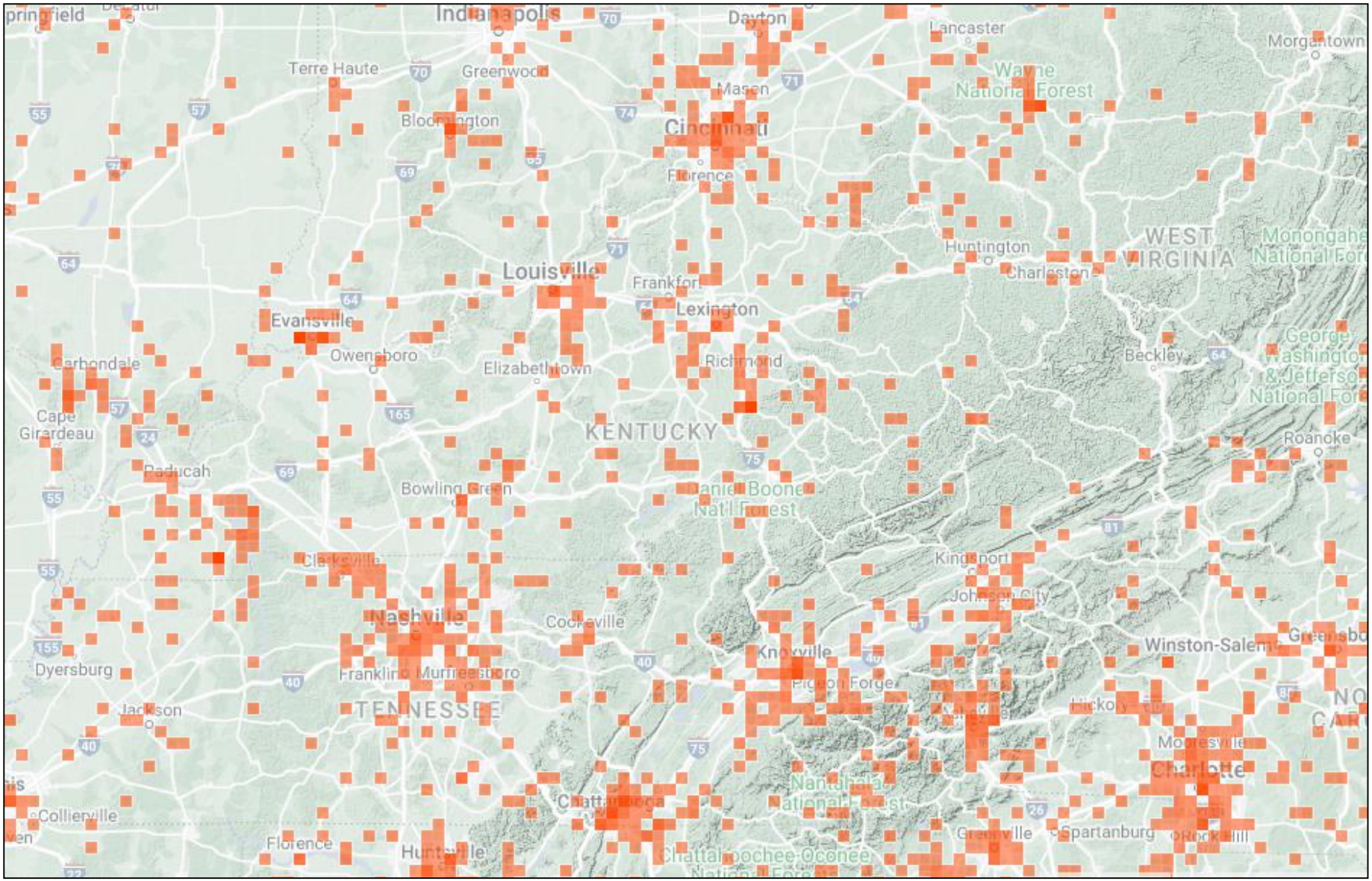
Charles C. Deam s.n.1897-06-07; Wells Co. (IND)
https://imago.indiana.edu/downloads/pk02ck34c

E. Rechenberg R511 1929-08-16; Porter Co (IND)
https://imago.indiana.edu/downloads/zw12zf204

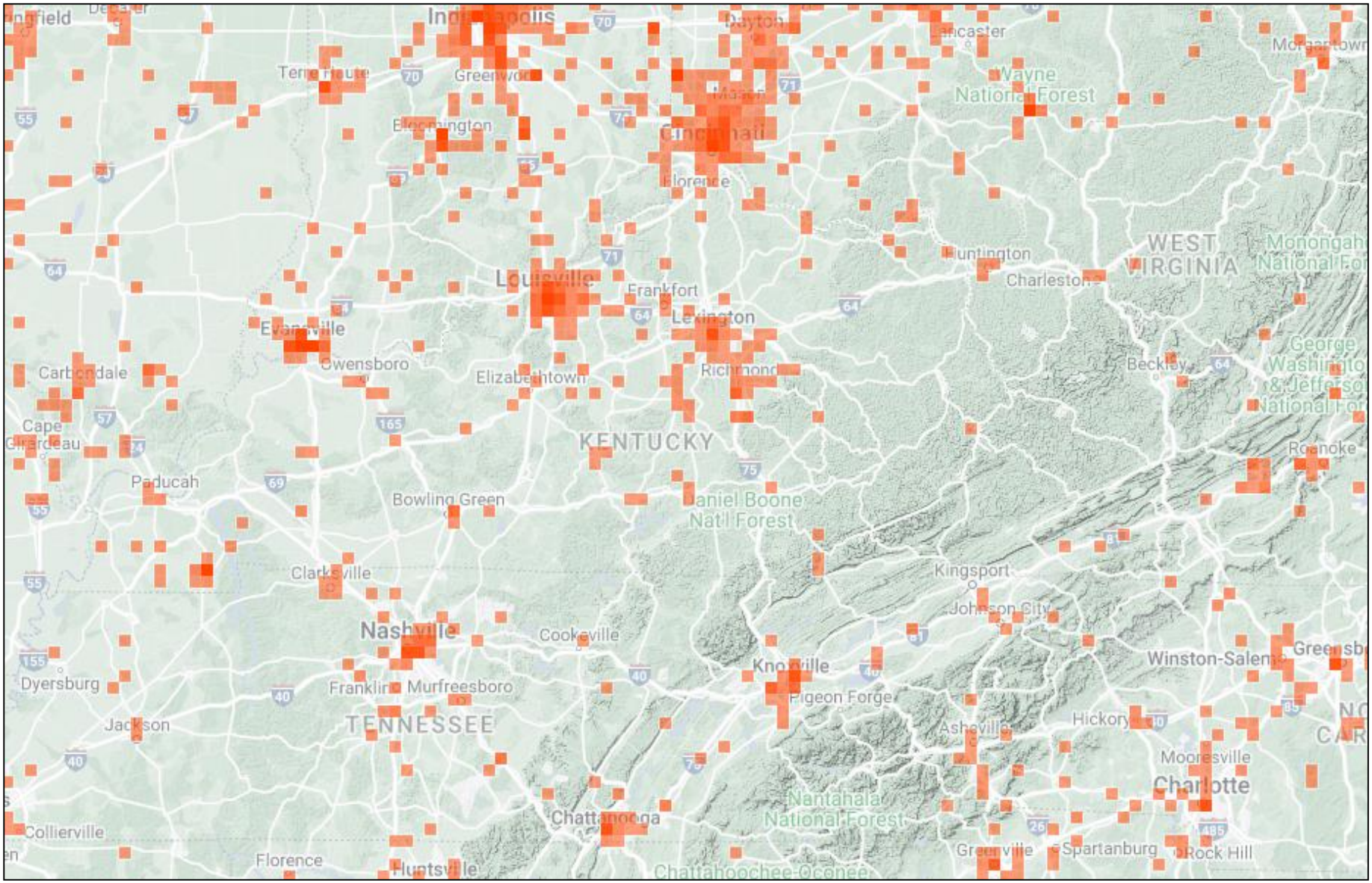
M. McKee 1067 1930-10-04; Newton Co. (NY)
https://sweetgum.nybg.org/images3/1681/802/02513751.jpg

S. Namestnik... 2023 pers comm.; recent coll. from Shades State Park, Montgomery Co. [?]

==========



Records of *Morus rubra* in iNaturalist.org [1 July 2023] for east-central states, centered on Kentucky and Tennesee. Although distinction from *alba* is somewhat unreliable (with about 10% misidentification as *rubra*), the comparison with *alba* is interesting; see next page.



Records of *Morus alba* in iNaturalist.org [1 July 2023] for east-central states. Compared to records of *rubra* (previous page), there are concentrations in more urban or agricultural regions. Sparser records in wooded hills may be due to shady conditions and more browsing by deer.

Propagation

Given the continuing erroneous provision of *alba* by many nurseries under the name "*rubra*", it is important to develop efficient systems for propagation of true *rubra*. After initial trials in Kentucky, methods are being developed and will lead, hopefully, to serve conservation organizations and the general public. The small (1-3.5 mg) seeds of *Morus* are unusual for woody plants. We need more measurements to compare species, but it appears that *rubra* generally has smaller seeds than *alba*; and that *nigra* has larger seeds. Barbour et al. (2008) report ranges (among samples from different trees) of 0.9-2.3 mg for *rubra* and 1.3-3.5 mg for *alba*. Torok et al. (2013) reported averages of 1.6 mg for *alba* and 2.4 mg for *nigra*. Brindza et al. (2016) reported a range of 1.8-7.6 mg among 431 trees of *nigra* in Slovakia, with a mean of 5.8 mg. Descriptions in Floras and horticultural notes indicate that *rubra* seeds are generally about 2 mm wide, *alba* about 2-3 mm, and *nigra* about 3-4 mm (Wunderlin 1997, Travis 2023).

Several wind-dispersed woody genera in eastern North America have seeds as small or smaller (as little as 0.05 mg): *Salix, Populus, Betula, Alnus, Chamacyparis, Picea, Larix* (Bonner 2008). Extremely small seeds also occur in many Ericaceae with capsules. But *Morus* seeds are among the smallest for fleshy-fruited species generally dispersed by birds, or by bats in warmer zones (Tang et al. 2008). There are other bird-dispersed species with such small seeds among small trees or shrubs: in Rosaceae (*Amelanchier, Aronia, Rubus*), Ericaceae (*Gaylussacia, Vaccinium*), *Ribes* and *Sambucus*. But *Morus* are the only larger bird-dispersed trees with seeds mostly less than 2.5 mg; close rivals are *Sorbus* (ca. 2.8 mg; then *Ilex*, ca. 5-17 mg; *Juniperus*, ca. 10-12 mg). Moreover, *Morus* is the only woody genus with aggregate fruits that are largely dispersed by birds—containing seeds from multiple flowers. Confamilial *Maclura* has unusually large aggregate fruits (with ca. 30 mg seeds) that are largely dispersed by mammals.

There is much variation in patterns of germination by *Morus*, but little definitive published research covers verified *rubra*. Germination can occur during summer within a few weeks after sowing of fresh seed, at least in *alba* or its close relatives (Petkov 1995, Burgess & Husband 2004, Vijayan et al. 2004, Barbour et al. 2008, Sánchez-Rendón et al. 2017, Wani et al. 2018, Rafeeq et al. 2020a). Light may be generally required, and naturalistic diurnal variation in temperature is generally beneficial. Some of our initial trials in Kentucky have achieved good early germination in *rubra* after fresh ripe fruits are pulverized and seed are extracted with pulp washed off. Application of gibberellic acid can increase germination of *Morus* seeds, and can sometimes obviate the need for cold stratification; see results of Petkov (1995) with *alba*; Koyuncu (2005) with *nigra*; and Chettri & Singh (2022) with *laevigata*. Our initial trials with gibberellic acid on *rubra* seed increased germination speed but led to excessive etiolation.

There is a viscid covering around seeds that may play some role in germination patterns, as studied by Ramirez (1976). He reported that with so-called "*rubra*" (probably *alba*): "seeds planted experimentally in sterilized soil failed to germinate, but responded favorably when inoculated with untreated soil." Under natural conditions, birds may play a major role, and there is some evidence with *nigra* in Israel that longer periods of digestion can increase germination after subsequent winter months, and can spread seeds in space (Barnea et al. 1991, 1992). Prior fermentation of fruits may allow high subsequent germination in *Morus* (but perhaps just shown for *alba*), given a diurnal cycle of light and temperature (Barbour et al. 2008). However, we have found that fermentation of *rubra* even for a week or two can greatly reduce the germination rate, and presumably induces dormancy until the subsequent spring. Also, we have found that refrigeration of fresh or fermenting fruits appears to induce deep dormancy. It is reported that dormancy of *Morus* in general can be overcome after moist cold stratification for a month, but periods of two or three months may reduce germination compared to one month (Barbour et al. 2008).

Variation in dormancy may be partly due to natural selection for diverse responses to the environmental uncertainties faced by small seeds. As well as being deposited on soil surfaces, frugivorous mammals (or perhaps other animals) may bury some seeds in burrows. Moreover, small seeds in bird-dispersed fruits have potential for widespread long-distance dispersal into unpredictable conditions. Although small seeds may be more subject to competition from other plants, they probably suffer less destructive consumption by vertebrates than larger seeds (e.g. Burton & Bazzaz 1991). Burton & Bazzaz showed that, compared to several other tree species, "*Morus rubra*" (but perhaps *alba*) had highest germination percent in a relatively narrow range of temperature, peaking at 25-30 degrees C. But ground vegetation had relatively little effect.

Cuttings of *Morus*, at least *alba*, are generally able to root from material taken in June or July (McDaniel 1985, Dirr & Heuser 1987). D&H stated:"When mid-July cuttings were treated with 8000 pm IBA in talc and stuck into sand, 100% rooted in 3 weeks". Some success has also been reported with cuttings of *alba* and *nigra* taken in March or earlier (Ahlawal et al. 2016, Hawramee et al. 2019, Rafeeq et al. 2020b). Research on cutting methods in Turkey and Kurdistan has reported using "*rubra*" (Çekiç et al. 2013, Mohammed & Kako 2021), but as noted above plants were probably *alba*. Our initial trials with cuttings of *rubra* in Kentucky have failed. McDaniel (1985) indicated that an supposed *alba* × *rubra* cultivar ("Illinois Everbearing") was more difficult to root than typical *alba*.

Morus alba is locally common in urban areas and such trees can often supply an abundance of easily collected fruits. In contrast, *rubra* is generally much less common in urban areas or even near rural residences. Opportunities for easy collection of abundant *rubra* fruit are relatively infrequent; occasional trees along roads, driveways and trails need to be scouted in advance. The ripening season is relatively late and prolonged, compared to *alba*: from late May to early July (versus mostly in mid-May to early June).

Serious sustained propagation of *rubra* is best planned through establishment of orchards, where fruits can be collected for seed and for food. Also, orchards will allow selection of genotypes for various purposes in conservation or production. Such orchards do not appear to exist yet, although we have recently established 50 trees for this purpose at Hisle Farm Park in Fayette Co., Kentucky (Oliva 2023). Another project has recently begun to collect verified *rubra* for commercial production at Solid Ground Farm in Athens Co., Ohio (SARE 2023, Travis 2023). Suitable locations for at least small plantings should continue to be sought across Eastern North America.

But production of fruits may not guarantee diverse new genotypes. There is potential for apomictic seeds (from only maternal DNA without fertilization) or parthenocarpic fruits (with no seeds at all). Curiously, there has been little definitive published research on these matters in *Morus*. Liutenko et al. (2015) reported evidence of apomixis in *alba*, using screens to prevent pollination. From a broad review of Neotropical plants, Firetti (2017) stated: "In Moraceae, adventitious embryony predominate and was registered in *Ficus*, *Morus* and *Streblus*." Griggs & Iwakiri (1973) have reported evidence of parthenocarpy in cultivars of "*Morus rubra*" known as "Tufts" and "Hicks" [perhaps = "Hicks Everbearing" of Ourecky (1980)], but it is likely that they used *alba* or *alba* × *rubra*; there are no documented images or herbarium collections of these cultivars. [Ourecky (1980) listed "Hicks" under *alba* and *rubra*.] Gustafson (1942) reported that parthenocarpy can occur in*Morus nigra*, and it is generally known in Europe and California that isolated trees of this species can produce fruit without pollination (Orwa et al. 2009).

County of origin	GA_3 treated	Days stored	Stored wet /dry	Number of tested seeds	Germinated after 30 days	Percent germinated
Fayette-1	No	6-10	Wet ferm.	90	2	2%
Fayette-1	Yes	6-10	Wet ferm.	90	3	3%
Russell-1	No	11	Wet	90	2	2%
Russell-1	Yes	11	Wet	90	19	21%
Madison	No	17	Dry-wet	90	7	8%
Madison	Yes	17	Dry-wet	90	38	42%
Fayette-2	No	2-5	Dry	90	18	20%
Fayette-2	Yes	2-5	Dry	90	73	81%
Russell-2	No	11	Dry	90	24	27%
Russell-2	Yes	11	Dry	90	30	33%

Germination results from some initial tests by P. Adanick. Fruits were collected in late May to early June, 2023. Some of each collection (shaded rows) were treated with gibberellic acid (GA_3), which increased germination in all cases. Samples were stored for different periods and conditions before tests. Some stored for longer became wet and fermented. Higher germination rates occurred with dry unfermented storage.

Morus rubra seedlings after a month; leaves lack the dense long hairs of older plants.

Three year old seedlings grown in Fayette Co. from a local *rubra* mother (2023 July 1st). The four plants at left are typical; the four at right are stunted in overall growth and have small leaves. They may have hybrid origin, with pollen from *alba*. Next page: close ups of them.




See previous page for caption.

Planting of 50 local red mulberries established as orchard in Lexington/Fayette County park.

The mulberries are interplanted with pawpaws. Minor problems include some browsing by deer and perhaps fungal dieback, but the trees appear to recover so far [11 Aug 2023].

Consumption by vertebrates

The sparse amount of available information was initially summarized by Campbell (2019). Following is an updated review. The fruits of *Morus* species are extremely attractive to some birds. In Arkansas, Jackson & Kannan (2018) observed the following species most frequently on "*rubra*" in a suburban lawn, with numbers of observations in parentheses: Cedar Waxwing (1709), Robin (843), Mockingbird (177), Grosbeak (131), Swainson's Thrush (90), Catbird (73), House finch (57), etc. In Fayette Co., Kentucky, the following species are among the most frequent feeders on both *alba* and *rubra* in woodland (D. Svetich & L. Combs, pers. comm.): Cedar Waxwing, Robin, Flicker, Carolina Chickadee, Blue Jay, Woodpeckers, Scarlet Tanager, Baltimore Oriole. In Fayette Co., *alba* ripens mostly during mid April to early May but can continue into early July. In contrast, *rubra* ripens during mid May to early July.

Differences in herbivory on *alba* versus *rubra* are poorly documented but may be significant (Sullivan 1993, Stone 2009, Ambrose & Kirk 2011). Both species, but especially *alba* (with some misidentification), have been reported to be at least locally preferred browse by herbivorous mammals in North America: cattle or other livestock (Sargent 1919, Dibala 2022), elk (Schneider et al. 2006), deer (Atwood 1941, Shaffer 2023, but *alba* not "*rubra*"), rabbits (Khan et al. 2020, Shaffer 2023, but *alba* not "*rubra*"), beaver (Baccus et al. 2007, Shah 2015), woodchuck (Swihart & Picone 1991), gray squirrels on buds and bark (D. Taylor, pers. comm.). Swihart & Picone reported that woodchucks (groundhogs) found "red mulberry" leaves highly palatable:"Nearly all previous reports of woodchucks climbing trees were attributed to predator avoidance or to sunning / resting behavior. Our results suggest that tree climbing by woodchucks also occurs because of dietary considerations." (They will also climb for pawpaws; D. Taylor, pers. comm.)

There has been 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 by ungulates on verified *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 separate, 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..." For *rubra*, Sargent (1919) noted: "Occasionally planted, especially in the southern states, for its fruit valued for fattening hogs and as food for poultry. A few natural varieties, distinguished for the large size and good quality of their fruit, or for their productiveness, are occasionally propagated by pomologists." There has been some revival of interest in such use of "*rubra*". Dibala et al. (2022) grew seedlings of "*rubra*" under canopies of different density to show that maximum leaf production for forage occurs with partial shade; but they did not provide images or references to herbarium vouchers.

There has been a recent flurry of published papers and reviews concerning the overall nutritional and medicinal benefits of *Morus* fruits or leaves for herbivorous vertebrates, including humans (e.g. Ustundag et al. 2015, Dhiman et al. 2020, Hassan et L. 2020, Hou et al. 2020, Rohela et al. 2020, Chen et al. 2021, Jan et al. 2021, Mwai et al. 2021, Acharya et al. 2022, Memete et al. 2022, Wang et al. 2022, Dadwhal & Banerjee 2023).

The abstract of Memete et al. (2022) stated: “In recent years, mulberry has acquired a special importance due to its phytochemical composition and its beneficial effects on human health, including antioxidant, anticancer, antidiabetic and immunomodulatory effects. Botanical parts of *Morus* sp. (fruits, leaves, twigs, roots) are considered a rich source of secondary metabolites. The aim of our study was to highlight the phytochemical profile of each of the botanical parts of *Morus* tree, their health benefits and applications in food industry with an updated review of literature. Black and white mulberries are characterized in terms of predominant phenolic compounds in correlation with their medical applications. In addition to anthocyanins (mainly cyanidin-3-O-glucoside), black mulberry fruits also contain flavonols and phenolic acids. The leaves are a rich source of flavonols, including quercetin and kaempferol in the glycosylated forms and chlorogenic acid as predominant phenolic acids. Mulberry bark roots and twigs are a source of prenylated flavonoids, predominantly morusin. In this context, the exploitation of mulberry in food industry is reviewed in this paper, in terms of developing novel, functional food with multiple health-promoting effects.”

Although this phytochemical research is focussed on uses by domesticated animals and humans, it may be relevant to naturalistic ecological contexts. It would be interesting to explore in more depth whether *Morus* is generally preferred food by vertebrates for “nutraceutical” reasons. There are, however, a few reports of toxicity, notably from human consumption of leaf extracts (Young 2022) or unripe fruits (Brown 1986). It appears that the white sap (latex) of *Morus* can be toxic to vertebrates under some conditions, but its main role in the plant may be to repel invertebrate pests (e.g. Konno et al. 2006, Singh et al. 2008, Wasano et al. 2009, Patel et al. 2011, Datta et al. 2016, Gai et al. 2017, Marchetti et al. 2021). The latex contains varied lectins, protease inhibitors, other defensive proteins (some chitin-binding), and “sugar-mimic” piperidine alkaloids that can interfere with digestion or metabolism of insects. The silkworm moth (*Bombyx mori*) converts some of the proteins into silk.

Invertebrate pests and pathogens

Diverse insect or arachnid pests have been reported on *Morus* in North America or Eurasia, and in some cases there are associated pathogenic bacteria or viruses (Lawson 1990, Sharma et al. 2008, Sreenivasa et al. 2017, Dar 2020). Slugs can also become a locally serious problems for seedlings (Sakthivel et al. 2019;JC, pers. obs.).

A few invertebrates are strict or partial specialists on *Morus* in North America. These are mostly wood- or bark-boring beetles (Baker 1972, Van Dyk 2023): *Doraschema wildii* (Mulberry Borer, also on osage-orange); *D. alternatum* (Small Mulberry Borer); *D. cinereum* (?); *Parelaphidion incertum* (= *Elaphidion incertum*, Mulberry Bark Borer, also on oak & hickory); *Phloeotribus frontalis* (also on black locust, hackberry & elm); *Hylocurus langstoni* (also on honey locust, hackberry & elm). The "mulberry whitefly" (*Tetraleurodes mori*) was discovered on *Morus* but feeds on diverse trees. The "mulberry thrips" (*Psudodendrothrips mori*) is a Eurasian introduction that is only a pest for silkworm production. Severe epidemics of invertebrate pests are not documented in North America, except perhaps in orchards. It would interesting to consider in more depth whether the generally sparse populations of *Morus* in natural woodland tends to limit the development of epidemics.

Lepidopteran caterpillars are generally uncommon to rare on *Morus* in North America, presumably due to toxic chemistry (e.g. Konno et al. 2006). However the fall webworm (*Hyphantria cunea*), which lives on a wide range of trees and shrubs, has become an invasive problem on cultivated *alba* in China (Tang et al. 2016), and there are several reports from *alba* or *rubra* in North America. The silkworm itself (*Bombyx mori*) is a flightless domesticated introduction from East Asia that feeds usually on *alba*, but it has no close relatives that feed on *Morus* in North America. Silkworms do not prosper on leaves of *rubra* (Oliver 1907, Ewan 1969, Coles 2022), perhaps due to in part to the dense pubescence (Kumar 2012). Other trees in

Moraceae have been tried for silkworms. The glabrous leaves of *Maclura pomifera* (osage-orange) have been successfully used (Davidson 1885, Jeffrey & Parker 1996). But the leaves of *Broussonetia papyrifera* (paper mulberry), with dense rough hairs on both surfaces, were noted as "absolutely useless" by Oliver (1907).

Tyler (2023) provided the following curious anecdote from his efforts to grow seedlings of *nigra* in England: "After a year or two, they may be transplanted to their proposed location - unless this is frequented by deer, or other large herbivores. Various ants may attack and destroy mulberry seedlings. In particular, the yellow meadow ant - *Lasius flavus* - will happily move into the moist basement of a mulberry seedling, plant its sap-sucking aphids on the roots, and suck the plant dry until it is dead. This is a relatively common fate of mulberry seedlings, in some areas. I recommend the use of ant powder. Also - if possible - avoid planting out near existing *Lasius flavus* nests."

Declines of *rubra* populations have been attributed to pathogens in some cases, but definitive research is lacking (Lamson 1990, Sullivan 1993). In the central Bluegrass region of Kentucky, Van Shipp (a deceased long-time resident of Versailles) recounted 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 & 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. Shoemaker at al. (2003) noted in particular: “*Asteromasssaria olivaceohirta* appeared to be a weak, opportunistic pathogen and saprophyte. It was commonly observed on dead twigs and small branches in the underside of the canopy of suppressed trees. In one case, it had clearly invaded living tissue of a branch 1 cm in diameter.”

On *alba* or *nigra* in western North America and Eurasia, diverse other fungi and bacteria have been found to cause cankers and diebacks (e.g. Dill 1953, Vajna 2000, Arzanlou & Dokhanchi 2013, Allahverdi et al. 2016, Ahmadpour et al. 2017, 2023, Huang et al. 2019, Bassavand et al. 2020, Travis 2023). The “popcorn disease” on fruits is an ascomycete fungus (*Cibora carunculoides*) that is common on *alba* but may be unknown on *nigra* or *rubra* (Gray & Gray 1987, Hong et al. 2007, Lv et al. 2021); it does not reduce vegetative growth. A definitive comparison of pathogens and pests in *alba* versus *rubra* would be useful. It is likely that *alba* is generally more tolerant of disturbances and stresses, perhaps leading to less pests and pathogens. Moreover, it is possible that some natural enemies are lacking in North America. However, mammalian herbivores in general appear to favor *alba* for browse.

Cankers on a small tree of *Morus rubra* in Fayette Co., Kentucky; 3525 Willowood Road; 28 Jun 2023. More images on next pages. A large adjacent tree is canker-free; see below.

Branch dying back with yellowing leaves. Such dieback with cankers is common in Kentucky on branches with up to 5-7.5 cm diameter, but plants usually survive.

Male tree about 25 years old and 30 cm dbh; 3525 Willowood Road, 15 Aug 2023..
This tree has provided most pollen for the seedlings now being grown here.

Base of the large male tree shown above. There is little to no sign of cankers

Summary

Across eastern North America, there continues to be much confusion between the native *Morus rubra* (“red mulberry”) and the alien *M. alba* (“white mulberry”). Almost all plants sold from nurseries as “*rubra*” are in fact *alba*. Even some websites of universities and other professional organizations include images of *alba* labeled as “*rubra*”. Several state champion trees claimed to be “*rubra*” appear to be *alba* or hybrids; these include the supposed national (thus global) champion in Arkansas. Mapping of distributions is erroneous in some cases, as in the Forest Inventory data of U.S. Forest Service, which shows “*rubra*” extending too far into the Great Plains. Moreover, records of “*rubra*” from Europe appear to be generally erroneous, even in cultivation, although some plants may be introgressants. Also, the central Eurasian species, *M. nigra*, has often been listed as an escape in scattered locations across North America, but this can only be verified in California and Nevada; the species has low hardiness.

Hybridization of *rubra* with *alba* has become common across the northern side of its range, especially in the mid-west, where at least 40-50% of *Morus* trees show evidence of nuclear hybridity along range margins. There is evidence of asymmetric introgression into *alba* in Ontario (Burgess et al. 2005 etc.), but locally into *rubra* in woodland of eastern Kansas (Nepal 2008 etc.). Burgess et al. found that the product of seed germination and seedling growth in sun was five times greater in *alba* and in hybrids, and that some reduced advantage was retained in forest (which also had richer soil). However, despite being widespread across eastern North America for at least 200 years, *alba* remains concentrated in more developed agricultural and urban areas. *M. rubra* does often appear more tolerant of shade than *alba*, and it may tend to have more seed dormancy, allowing establishment of a seed bank in woodland. Also, the potential selective effects of mammalian herbivory in woodland may be significant, given that *alba* appears to be especially palatable.

Morus seeds are unusually small for trees. Initial efforts to propagate *rubra* from seed in Kentucky have been successful, but germination patterns are variable. Good germination can be achieved with cleaned seed from fresh ripe or partially green fruit. However, if fruit are aged, fermented or chilled then much more dormancy seems to result. Gibberellic acid can increase germination in some cases. Propagation from cuttings has largely failed so far. Seed of *rubra* are generally difficult to collect from wild trees unless they are close to trails or roads; thus planted orchards will eventually allow much easier collection of fruit for food and seed. However, there will be a need to cull any apparent hybrids from seedlings, since *alba* pollen is probably widespread in many suitable localities for orchards. An initial cohort of 122 seedlings grown from a *rubra* female in a suburban location produced eight distinctly stunted plants, only 10-20% as large as the remaining plants after three years. Leaves of these stunted plants suggested a hybrid origin. The potential for apomixis and parthenocarpy could also be studied in orchards; there is evidence for these processes in some species of *Morus*.

In Kentucky and elsewhere, fruits of *alba* and *rubra* (with later average phenology) are avidly sought by birds, especially cedar waxwings and robins, and by squirrels, potentially limiting collection by humans. Leaves of both species, but especially *alba*, are often preferred forage by some native mammalian herbivores—elk, deer, rabbits, groundhogs, beaver—and by most livestock. There is potential to develop woodland pastures (or other agroforestry) with both species. *Morus* has complex chemistry with various potential medicinal benefits, but its white sap contains diverse N-rich compounds that can repel invertebrate pests and can be toxic to mammals in some cases. In North America, there are few invertebrates known to specialize on *Morus*, except for some wood- or bark-boring beetles. These beetles may be associated with fungal cankers that often weaken trees, but there has been little research on such problems. The dense hairs on foliage of *rubra* may reduce herbivory by mammals and lepidoptera.

Acknowledgements

We thank the following people for specific assistance: John Kartesz for permission to use maps from the Floristic Synthesis of BONAP; Steve Knott for observations on propagation; David Taylor for editing and observations.

Literature Cited [highlighted items have not been located or fully reviewed.]

Acharya, R., T. Bagchi & D. Gangopadhyay. 2022. Mulberry as a valuable resource for food and pharmaceutical industries: a review. Chapter 19 in: Kumar, S (ed.). Medicinal Plants. Ambika Prasad Research Foundation, India.

Ahlawat, T., N.L. Patel, R. Agnihotri, C.R. Patel & Y. Tandel. 2016. Black mulberry (*Morus nigra*). Pages 195-212 (Chapter 9) in: Ghosh, S.N., A. Singh & A. Thakur (eds). Underutilized Fruit Crops: Importance and Cultivation. Java Publishing House, Delhi, India.

Ahmadpour, S.A., R. Farokhinejad & M. Mehrabi-Koushki. 2017. Further characterization and pathogenicity of *Didymella microchlamydospora* causing stem necrosis of *Morus nigra* in Iran. Mycosphere 8: 835-852.

Ahmadpour, S.A., M. Mehrabi-Koushki, R. Farokhinejad & Z. Mirsoleymani.2023. Characterization and pathogenicity of *Neoscytalidium novaehollandiae* causing dieback and sooty canker in Iran. Tropical Plant Pathology . 15 pages. <https://doi.org/10.1007/s40858-023-00591-8>

Allahverdi, T., H. Rahimian & A. Ravanlou. 2016. First report of bacterial canker in mulberry caused by *Citrobacter freundii* in Iran. Plant Disease 100: 1774. ?? pages.

Al-Salihi, A.A.M., M. Olgaç, E. Dinçer, H. Polatcı & O. Saraçoğlu. 2022. Comparison of some quality parameters in fresh and dry samples of *Morus rubra* fruits. Turkish Journal of Agriculture - Food Science and Technology 10: 3008-3013.

American Forests. 2021. Official Register of Champion Trees. <https://www.americanforests.org/champion-trees/champion-trees-registry/>

Arzanlou, M., & H. Dokhanchi. 2013. Morphological and molecular characterization of *Diplodia seriata*, the causal agent of canker and twig dieback disease on mulberry in Iran. Archives of Phytopathology and Plant Protection 46: 682-694.

Baccus, J.T., M.A. Kainer & M.F. Small. 2007. Foraging preferences by American beavers, *Castor canadensis* (Rodentia: Castoridae) on central Texas rivers. Texas Journal of Science 59: 243-261.

Baker, W,L, 1972. Eastern Forest Insects. Miscellanous Publication 1166. US Forest Service, Washington, D.C. 642 pages.

Barbour, J.R., R.A. Read & R.L. Barnes. 2008. *Morus* L., mulberry. Pages 728-732 in Bonner, Franklin T. The Woody Plant Seed Manual. Agriculture Handbook 727. Forest Service.

Barnea, A., Y. Yom-Tov & J. Friedman. 1991. Does ingestion by birds affect seed germination Functional Ecology 5: 394-402. [The species may have been *alba* not *nigra*.]

Barnea, A., Y. Yom-Tov & J. Friedman. 1992. Effect of frugivorous birds on seed dispersal and germination. Acta Ecologica 13: 209-219. [The species may have been *alba* not *nigra*.]

Basavand, E., P. Khodaygan, H. Rahimian, A. Ganjeh, S. Molaei & S. Firouzianbandpey. 2021. Identification and characterization of *Klebsiella oxytoca* strains associated with wetwood disease of *Morus* trees. Indian Phytopathology 74: 1-5.

Brindza, J., D. Toth, P. Brindza, O. Grygorieva, J. Sajbidor & L. Kucelova. 2016. Forgotten and less utilised plant species as functional food resources. Pages 209-232 (Chapter 15) in: K. Kristbergsson & S. Ötles (eds). Functional Properties of Traditional Foods. Springer, New York.

Brown, T. 1985. Tom Brown's Guide to Wild Edible and Medicinal Plants. Berkley Trade, New York City. 256 pages.

Burgess, K.S., & B.C. Husband. 2004. Maternal and paternal contributions to the fitness of hybrids between red and white mulberry (*Morus*, Moraceae). American Journal of Botany 91: 1802-1808.

Burgess, K.S., M. Morgan, L. Deverno & B.C. Husband. 2005. Asymmetrical introgression between two *Morus* species (*M. alba*, *M. rubra*) that differ in abundance. Molecular Ecology 14: 3471-3483.

Burgess, K.S., & B.C. Husband. 2006. Habitat differentiation and the ecological costs of hybridization: the effects of introduced mulberry (*Morus alba*) on a native congener (*M. rubra*). Journal of Ecology 94: 1061-1069.

Burgess, K.S., M. Morgan & B.C. Husband. 2008. Interspecific seed discounting and the fertility cost of hybridization in an endangered species. New Phytologist 177: 276–284.

Burton, P. J., & F.A. Bazzaz. 1991. Tree seedling emergence on interactive temperature and moisture gradients and in patches of old-field vegetation. American Journal of Botany 78: 131-149.

Campbell, J.J.N. 2019. A Mess of Muddle d Mulberries (especially in Kentucky). Posted at: https://bluegrasswoodland.com/uploads/Muddled_Mulberries_in_Kentucky.pdf [corrected and revised from earlier versions of 2013 and 2014].

Can, A., A. Kazankaya, E. Orman, M. Gundogdu, S. Ercisli, R. Choudhary & R. Karunakaran. 2021. Sustainable mulberry (*Morus nigra* L., *Morus alba* L. and *Morus rubra* L.) production in Eastern Turkey. Sustainability 13: 13507. 13 pages.

Çekiç, Ç., S. Ö. Erdem & M. Aydemir. 2013. The effects of pacrobutrazol and IBA treatments on the rooting of wood-cuttings of black mulberry (*Morus nigra* L.) and red mulberry (*Morus rubra* L.). TABAD, Tarım Bilimleri Araştırma Dergisi 6: 174-177.

Chen, C., U.H.M. Razali, F.H.Saikim, A. Mahyudin & N.Q.I.M. Noor. 2021. *Morus alba* L. plant: bioactive compounds and potential as a functional food ingredient. Foods 10: 689. 28 pages.

Chettri, S., & B. Singh. 2022. Germination of pre-treated *Morus laevigata* Wall. seed under laboratory conditions at Pasighat in Arunachal Pradesh, India. Pharma Innovation Journal 11: 136-141.

Christian, T. & Coles, P. 2022, '*Morus* ' from the website Trees and Shrubs Online.<treesandshrubsonline.org/articles/morus/>

Coles, P. 2018. Hunting for mulberries at Kew Gardens. <https://www.moruslondinium.org/research/kew-mulberries>

Coles, P. 2022. The wrong mulberries? Moriculture before the white mulberry. Chapter 7 (pages 117-132) in: Baker, E. (ed). Textiles and Clothing Along the Silk Roads. UNESCO, (Paris, France) and China National Silk Museum (Zhejiang, China).

Croghan, G. 1831. Journal of Colonel George Croghan, 1765. First printed in G.W. Featherstonhaugh (ed). Monthly American Journal of Geology and Natural Science, December 1831., Philadelphia. [Also included in M. Butler. 1834. A History of the Commonwealth of Kentucky. J.A. James, Cincinnati. Also included in R.G. Thwaites (ed). 1904. Early Western Travels 1748-1846. Vol. 1. Arthur C. Clark Co., Cleveland, Ohio.]

Dadhwal, R., & R. Banerjee. 2023. Ethnopharmacology, pharmacotherapeutics, biomedicinal and toxicological profile of *Morus alba* L.: a comprehensive review. South African Journal of Botany 158: 98-117.

Dar, M.Y. 2020. European Red Spider Mite; an alarming threat pest to mulberry." Environmental Ecology 16: 101-104.

Datta, D., G. Pohlentz, M. Schulte, M. Kaiser, F.M. Goycoolea, J. Müthing, M. Mormann & M.J. Swamy. 2016. Physico-chemical characteristics and primary structure of an affinity-purified α-D-galactose-specific, jacalin-related lectin from the latex of mulberry (*Morus indica*). Archives of Biochemistry and Biophysics 609 : 59-68.

Davidson, M.M. 1885. Silk: Its History and Manufacture, from the Earliest Ages to the Present Time. Including Instructions for Silk Culture on Osage Orange Or Mulberry. J.B Wadleigh, Junction City, Kansas.

Dawes, H. 1979. Reevaluating cold hardiness of certain tropical fruit trees. California Rare Fruit Growers Yearbook 11: 46-49.

Demirel, M.A., & K. Yildiz. 2021. Flower structures of black mulberry (*Morus nigra*) trees. Turkish Journal of Food and Agriculture Sciences 3: 60-65.

Dibala, R., S. Jose, M.Gold, R. Kallenbach & B. Knapp. 2022. Initial performance of red mulberry (*Morus rubra* L.) under a light gradient: an overlooked alternative livestock forage? Agroforestry Systems 96: 565-576.

Dill, H.A. 1953. Sooty canker of mulberry (*Morus alba* L.) in Arizona. M.Sc. thesis, University of Arizona. 42 pages.

Dhiman, S., V. Kumar, C.M. Mehta, Y. Gat & S. Kaur. 2020. Bioactive compounds, health benefits and utilisation of *Morus* spp.–a comprehensive review. Journal of Horticultural Science and Biotechnology 95: 8-18.

Ebrahimi, A., A. Poursalavati, M.M. Esboei, S.R. Monfared, M. Sahebi, M.R. Amerian & H.H. Khoshro. 2021. Population and individual multivariate analysis of white (*Morus alba*), red (*Morus rubra*) and black (*Morus nigra*) mulberry genotypes: applications for breeding, conservation and development. Euphytica 217: 152. 27 pages.

Ewan, J. 1969. Silk culture in the colonies. Agricultural History 43: 129-142.

Firetti, F. 2018. Apomixis in neotropical vegetation. Chapter 7 (p. 129-148) in Sebata, A. (ed). Vegetation. IntechOpen, National University of Science and Technology, Zimbabwe. <http://dx.doi.org/10.5772/intechopen.71856>

GBIF [Global Biodiversity Information Facility]. 2023. [Mapped records of *Morus nigra*; accessed on July 1st.] <https://www.gbif.org/species/5361888>

Gai, Y-P., Y-N. Zhao, H-N. Zhao, C-Z. Yuan, S-S.Yuan, S. Li, B-S. Zhu & X-L. Ji. 2017. The latex protein MLX56 from mulberry (*Morus multicaulis*) protects plants against insect pests and pathogens. Frontiers in Plant Science 8: 1475. 11 pages.

Gray, E., & R.E. Gray. 1987. Observations on popcorn disease of mulberry in south central Kentucky. Castanea 52: 47-51.

Griggs, W.H., & B.T. Iwakiri 1973. Development of seeded and parthenocarpic fruits in mulberry (*Morus rubra* L.). Journal of Horticultural Science 48 : 83-97.
[The study probably used *alba* not *rubra*.]

Godfrey, R.K. 1988. Trees, Shrubs, and Woody Vines of Northern Florida and adjacent Georgia and Alabama. University of Georgia Press, Athens. 734 p.

Güner, A., N. Özhatay, T. Ekim, K.H.C. Başer & I.C. Hedge (eds). 2000. Flora of Turkey and the east Aegean Islands. Edinburgh University Press. 600 pages.

Gustafson, F.G. 1942. Parthenocarpy: natural and artificial. Botanical Review 8: 599-654.

Hassan, F., M.A. Arshad, M-W. Li, M.S. Rehman, J.J. Loor & J-X. Huang. 2020. Potential of mulberry leaf biomass and its flavonoids to improve production and health in ruminants: mechanistic insights and prospects. Animals 10: 2076. 24 pages.

Hatch, C.E. 1957. Mulberry trees and silkworms. Sericulture in early Virginia. Virginia Magazine of History and Biography 65: 3-61.

Hawramee, O., K. Aref, R.R. Aziz & D.A. Hassan. 2019. Propagation of white mulberry *Morus alba* L. fruitless cultivar using different cutting times and IBA. In IOP Conference Series: Earth and Environmental Science, vol. 388, no. 1, p. 012069. IOP Publishing.

Hong, S.K, W.G. Kim, GB. Sung & S.H. Nam. 2007. Identification and distribution of two fungal species causing sclerotial disease on mulberry fruits in Korea. Mycobiology 35: 87-90.

Hou, Q.R., J. Zhang, T. Chen, W.G. Zhao & L. Li. 2020. Effects of dietary supplement of mulberry leaf (*Morus alba*) on growth and meat quality in rabbits. Indian Journal of Animal Research 54: 317-321.

Huang, Y., L. Meng, J. Liu & C. Wang. 2019. First report of *Botryosphaeria dothidea* causing shoot canker on mulberry in China. Plant Disease 103: 1788. ?? pages.

Jackson, J.L., & R. Kannan. 2018. Avian frugivory in a fruiting mulberry tree (Morus rubra) in Arkansas. Journal of the Arkansas Academy of Science 72: 38-46.

Jan, B., R. Parveen, S. Zahiruddin, M. U. Khan, S.Mohapatra & S. Ahmad. 2021. Nutritional constituents of mulberry and their potential applications in food and pharmaceuticals: a review. Saudi Journal of Biological Sciences 28: 3909-3921.

Jeffrey, J., & D. Parker. 1996.A thread of evidence: Shaker textiles at South Union, Kentucky. Register of the Kentucky Historical Society 94: 33-58.

Kartesz, J.T. 2022. Floristic Synthesis [maps of vascular plants]. Biota of North America Program (BONAP), Taxonomic Data Center. Chapel Hill, North Carolina. <http://www.bonap.org/> [and subsequent distributions]

Kellet, B. 2021. Chisholm Trail Mulberry. <https://www.gatheringgrowth.org/trees-of-significance/chisholm-trail-mulberry>

Khan, K., I. Ullah, N.A. Khan & S. Khan. 2020. Evaluation of mulberry (*Morus alba*) leaves as a concentrate substitute in rabbit diet: effect on growth performance and meat quality. Turkish Journal of Veterinary & Animal Sciences 44: 1136-1141.

Klimko, M. 2016. Micromorphology and anatomy of leaves of *Morus alba* L. (Moraceae) cultivars from Poland. Steciana 20: 73-83.

Konno, K., H. Ono, M. Nakamura, K. Tateishi, C. Hirayama, Y. Tamura, M. Hattori, A. Koyama & K. Kohno. 2016. Mulberry latex rich in antidiabetic sugar-mimic alkaloids forces dieting on caterpillars. Proceedings of the National Academy of Sciences [U.S.A.] 103: 1337-1341.

Koyuncu, F. 2005. Breaking seed dormancy in black mulberry (*Morus nigra* L.) by cold stratification and exogenous application of gibberellic acid. Acta Biologica Cracoviensia Series Botanica 47: 23-26.

Kumar, V. 2012. Ultrastructural study on the leaf surface of four mulberry (*Morus* sp.) genotypes and the influence of foliar trichomes on egg layings by *Spilosoma obliqua* (Wlk.) (Lepidoptera Arctiidae). Redia 94: 3-11.

Lamson, N. 1990. *Morus rubra* L. Red Mulberry. Pages 470-473 in: Burns, R.M., & B.H. Honkala. 1990. Silvics of North America. U.S.D.A. Agriculture Handbook 654. Washington, D.C.

Liutenko, V. S., G.I. Babaieva, V.M. Lytvyn, V.I. Vojtenko &T.S. Hmel'ova. 2015. Autonomous apomixis at plants of stem *Morus*. Bulletin of Agricultural Science [Russia] [ISSN: 2308-9377 E-Mail: agrovisnyk@ukr.net]

Los Angeles County Arboretum. 2023. [Website].

<https://www.arboretum.org/crescentfarm/grow/arid-orchard-plant-list>

Lv, Z-Y., L-J. Hao, B. Ma, Z-W. He, Y-W. Luo, Y-C. Xin & N-J. He. 2021. *Ciboria carunculoides* suppresses mulberry immune responses through regulation of salicylic acid signaling. Frontiers in Plant Science 12: 658590. 13 pages.

Magarey, R.D., D.M. Borchert & J.W. Schlegel. 2008. Global plant hardiness zones for phytosanitary risk analysis. Scientia Agricola 65: 54-59. [Map adapted for download in 2012.] < https://upload.wikimedia.org/wikipedia/commons/a/a7/World_Hardiness_Zones.png>

Marchetti, L., A. Saviane, A. dalla Montà, G.Paglia, F. Pellati, S. Benvenuti, D. Bertelli & S. Cappellozza. 2021. Determination of 1-deoxynojirimycin (1-dnj) in leaves of italian or Italy-adapted cultivars of mulberry (*Morus* sp. pl.) by hplc-ms. Plants 10: 1553. 13 pages.

Magnolia Reporter. 2018 [Oct 26]. Red mulberry in Hamburg new addition to "biggest tree" list. Magnolia, Arkansas <http://www.magnoliareporter.com/sports/outdoors/article_f3dab3a4-d8fc-11e8-834b-eb6467d5f4d4.html>

McDaniel, J.C. 1980. A plant breeder looks at some American tree crops: *Morus*, *Gleditsia*, and *Diospyros*. Pages 113-118 in: Milne, T.A. (ed). Tree Crops for Energy Co-production on Farms. U.S. Department of Energy, Estes Park, Colorado.

McCormack, J. 1985. Rooting of Illinois Everbearing mulberry cuttings. Pomona 18: 30-31. [Reprinted 2018.] <https://www.savingourseeds.org/pdf/mulberry_propagation.pdf>

McLaughlin, J.A., & S. Greifenhagen. 2002. A pathological survey and disease management analysis for red mulberry in southern Ontario. Report of the findings of a study conducted for the Parks Canada's Species at Risk Program, project No. 2001:SARRFII-10.

Memete, A.R., A.V. Timar, A.N. Vuscan, F. Miere, A.C. Venter & S.I. Vicas. 2022. Phytochemical composition of different botanical parts of *Morus* species, health benefits and application in Food Industry. Plants 11: 152. 29 pages.

Marek, A., M. Bailey & G. Hansen. 2022. Edible Ornamental Landscaping Guide for North-Central Florida: ENH1354/EP618, 2/2022. Institute of Food and Agricultural Sciences Extension, University of Florida..

Mohammed, N.W., & S.M. Kako. 2021. Effect of planting dates and different concentrations of IBA on rooting and vegetative growth of hardwood stem cuttings of three species of mulberry (*Morus* spp.). Journal of Duhok University, 24(1), 32-40.

Monson, C.S. 1996. Mulberry trees: the basis and remnant of the Utah silk industry. Economic Botany 50: 130-138.

Mwai, L.M., A.M. Kingori & M.K. Ambula. 2021. Mulberry leaves as a feed source for livestock in Kenya: a Review. International Journal of Agricultural Research, Innovation and Technology 11, no. 2355-2022-148: 1-9.

Nepal, M.P. 2008. Systematics and Reproductive Biology of the Genus Morus L. (Moraceae). Ph D dissertation, Kansas State University. 171 pages.

Nepal, M.P., & C.J. Ferguson. 2012. Phylogenetics of *Morus* (Moraceae) inferred from ITS and trnL-trnF sequence data. Systematic Botany 37: 442-450.

Nepal, M.P., & D.J. Wichern. 2013. Taxonomic status of red mulberry (*Morus rubra*, Moraceae) at its northwestern boundary. Proceedings of the South Dakota Academy of Science 92: 19-29.

Nepal, M.P., & J.M. Purintun. 2021. Systematics of the genus *Morus* L. (Moraceae). Chapter 1 in: Razdan, M.K., & D.T. Thomas (eds). Mulberry: Genetic Improvement in Context of Climate Change. CRC Press. 262 pages.

Neuner, G., B-C. Xu & J. Hacker. 2010. Velocity and pattern of ice propagation and deep supercooling in woody stems of *Castanea sativa*, *Morus nigra* and *Quercus robur* measured by IDTA. Tree Physiology 30: 1037-1045.

NRCS [Natural Resource Conservation Service]. 2002. Red mulberry, *Morus rubra* L. USDA NRCS Natonal Plant Data Center. <https://plants.usda.gov › doc › cs_moru2>

North Carolina Extension. 2023. North Carolina Extension Gardner Plant Toolbox: *Morus rubra* 'Illinois Everbearing'; *Morus rubra* 'Travis'. <https://plants.ces.ncsu.edu/plants/morus-rubra-illinois-everbearing/>

Nurseries Caroliniana. 2023. *Morus alba* 'Issai'. <https://nurcar.com/products/copy-of-morus-alba-issai>

Oliva, P. 2023. Donation of 48 red mulberry trees. The Lexington Times, 17 April 2023. <https://lexingtonky.news/2023/04/17/>

Oliver, G.W. 1907. The Mulberry and Other Silkworm Food Plants. Bureau of Plant Industry Bulletin No. 119. US Government Printing Office, Washington, D.C. 23 pages.

Orwa C, A. Mutua, R. Kindt, R. Jamnadass, S. Anthony. 2009. *Morus nigra*. In: Agroforestree Database: a tree reference and selection guide version 4.0 <http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp>

Ourecky, D.K. 1980. Minor fruits in New York State. Information Bulletin 11, New York State College of Agriculture and Life Sciences, Plant Sciences, Pomology 2. 12 pages.

Patel, A.K., V.K. Singh, U. Bergmann, M.V. Jagannadham & P. Kursula. 2011. Purification, crystallization and preliminary X-ray crystallographic analysis of MIL, a glycosylated jacalin-related lectin from mulberry (*Morus indica*) latex. Acta Crystallographica Section F: Structural Biology and Crystallization Communications 67: 608-612.

Peters, M.P., L.R. Iverson, A.M. Prasad & S.N. Matthews. 2019. DISTRIB-II: habitat suitability of eastern United States trees. U.S. Forest Service Research Data Archive, Fort Collins, Colorado. <https://www.fs.usda.gov/nrs/atlas/tree/682>

Petkov, Z. 1995. Effect of some growth regulators on the germination of white mulberry (*Morus alba* L.) seeds. Rasteniev' dni Nauki [Bulgaria, Plant Science] 32: 149-152.

Pietrella, M., D. Giovannini & S. Cappellozza. 2019. Simple sequence repeat markers enabled genetic characterization of mulberry germplasm preserved in the CREA's collection of Padua, Italy. Pages 299-306 in: XV EUCARPIA Symposium on Fruit Breeding and Genetics 1307.

Rafeeq, J., A.H. Mughal, S.N. Zaffar, V. Dutt, K. Ahmad & T. Raja. 2020a. Effect of polyhouse conditions on germination and seedling growth of *Morus alba* var. *Kokuso*. Pharma Innovation 9: 417-419.

Rafeeq, J., A.H. Mughal, S.N. Zaffar, V. Dutt, K. Ahmad & T. Raja. 2020b. Effect of IBA on rooting and growth of *Morus alba* shoot cuttings under temperate conditions of Kashmir. International Journal of Chemical Studies 8: 3800-3802.

Rafinesque, C. S. 1839. American Manual of the Mulberry Trees. Publications of the Eleutherium of Knowledge, Number 5. Published by the author, Philadelphia. 96 pages.

Ramírez, W. 1976. Germination of seeds of New World *Urostigma* (*Ficus*) and of *Morus rubra* L. (Moraceae). Revista de Biologia Tropical 24: 1-6.

Rohela, G.K., P. Shukla, R. Kumar & S.R. Chowdhury. 2020. Mulberry (*Morus* spp.): an ideal plant for sustainable development. Trees, Forests and People 2: 100011. 17 pages.

Royal Botanic Garden, Edinburgh. 2023. Catalogue of the Living Collections: *Morus rubra*. <https://data.rbge.org.uk/search/livingcollection/?eti=morus+rubra&cfg=livcol.cfg>

Royal Botanic Garden, Kew. 2023. Plants of the World Online: *Morus rubra*. <https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:854710-1>

Royal Horticultural Society. 2023. Find a Plant: *Morus rubra* 'Illinois Everbearing'. <https://www.rhs.org.uk/plants/385735/morus-rubra-illinois-everbearing/details>

Sakthivel, N., J.B.N. Kumar, N.D. Beevi, M.M. Devamani & R.S. Teotia. 2019. Mulberry pests: current status and management practices. Central Sericultural Research and Training Institute, Mysuru, India. 48 pages.

Salah, S.M. 2006. Genetic and morphological characterization of red mulberry (*Morus rubra* L.), white mulberry (*Morus alba* L.) and their hybrids. M.Sc. thesis, Central Missouri State University, Warrensburg. [Not yet seen.]

Sánchez-Rendón, J.A., J.J. Reino-Molina, M. Pernús-Alvarez, D. Morales-Querol & G.J. Martín-Martín. 2017. Effect of controlled conditions on the germination of five *Morus alba* L. varieties. Pastos y Forrajes 40: 264-271.

SARE [Sustainable Agriculture Research and Education]. 2023. Red Mulberry Search and Rescue: Preserving Genetic Diversity for the Future of Sustainable Agroforestry.

<https://projects.sare.org/sare_project/fnc22-1338/>

Shaffer, J.D. 2023. Competition and herbivory influence the survival, growth, and physiology of native tree seedlings in the Kentucky Inner Bluegrass savanna-woodland. Ph.D. dissertation, University of Kentucky, Lexington. 283 pages. [*Morus alba* was grown not "*rubra*".]

Shah, P. 2015. Characteristics of beaver herbivory in an early to mid-successional floodplain forest of the Upper Mississippi River. M.Sc. thesis, Western Illinois University, Macomb. ?? pages.

Sharma, D., N.B. Chowdary, V. Nishithanaik & V.R. Mala. 2008. Systemic diseases of mulberry—a review. Sericologia 48: 327-339.

Shoemaker, R.A., J. McLaughlin, S. Greifenhagen & S. Hambleton.2003. Fungi Canadenses No. 435. *Asteromassaria olivaceohirta*. Canadian Journal of Plant Pathology 25: 384–386.

Singh, V.K., A.K. Patel, A.J. Moir & M.V. Jagannadham. 2008. Indicain, a dimeric serine protease from *Morus indica* cv. K2. Phytochemistry 69: 2110-2119.

Small, R.K. 1933. Manual of the Southeastern Flora. University of North Carolina Press, Chapel Hill, North Carolina. 1554 pages.

Spisani, S.R., J.L. Sylvester & C.J. Rothfels, 2004. Inventory and health assessment of the nationally endangered *Morus rubra* (red mulberry) on Royal Botanical Gardens' properties and adjacent areas. Unpublished report for the Ontario Ministry of Natural Resources, Guelph District. Guelph, Ontario. 62 pp.

Sreenivasa, B., M.N. Morrison & D. Manjunath. 2017. Incidence of leaf eating insect pests of mulberry in Kolar region (Karnataka, India) as impacted by agronomic practices. Research

Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences: DOI - 10.26479/2017.0301.10. 13 pages,

Sullivan, J. 1993. *Morus rubra*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. <https://www.fs.usda.gov/database/feis/plants/tree/morrub/all.html> [2023, June 29].

Swihart, R.K., & P.M. Picone. 1991. Arboreal foraging and palatability of tree leaves to woodchucks. American Midland Naturalist 125: 372-374.

Tang, Z-H., M. Cao, L-X. Sheng, X-F. Ma, A. Walsh & S-Y. Zhang. 2008. Seed dispersal of *Morus macroura* (Moraceae) by two frugivorous bats in Xishuangbanna, SW China. Biotropica 40: 127-131.

Tang, R., F. Zhang & Z-N. Zhang. 2016. Electrophysiological responses and reproductive behavior of fall webworm moths (*Hyphantria cunea* Drury) are influenced by volatile compounds from its mulberry host (*Morus alba* L.). Insects 7: 19. 12 pages.

Török, P., T. Miglécz, O. Valkó, K. Tóth, A. Kelemen, Á-J. Albert, G. Matus, A. Molnár, E. Ruprecht, L. Papp,, B. Deák, O. Horváth,A. Takács, B. Hüse & B. Tóthmérész .2013. New thousand-seed weight records of the Pannonian flora and their application in analysing social behaviour types. Acta Botanica Hungarica 55: 429-472.

Travis, M. 2023 [?]. Growing Mulberry [website]. <https://www.growingmulberry.org/contact> [Mark Travis growingmulberry@gmail.com]

Tyler, T. 2023 [?]. Mulberry Tree – Propagation [website]. <https://mulberrytrees.co.uk/propagation/> [Tim Tyler at http://timtyler.org/]

Ustundag, A.O., & M. Ozdogan. 2015. Usage possibilities of mulberry leaves in poultry nutrition. Scientific Papers, Series D, Animal Science [Turkey] 58: 170-178.

Utah State Parks. 2009. Antelope Island State Park Resource Management Plan. Utah State Parks and Recreation, Salt Lake City, Utah. 122 pages.

Vajna, L. 2000. First report of trunk blight and canker of *Morus alba* var. *pendula* caused by *Fusarium lateritium* f. sp. *mori* in Hungary. Plant Disease 84: 372-372.

Valladares, F., & U. Niinemets. 2008. Shade tolerance, a key plant feature of complex nature and consequences. Annual Review of Ecology, Evolution, and Systematics 39: 237-257.

VanDyk, J. [editor]. 2023. Bug Guide: Identification, Images, & Information For Insects, Spiders & Their Kin For the United States & Canada. Department of Plant Pathology, Entomology, and Microbiology. < https://bugguide.net/node/view/15740>

Vijayan, K., S.P. Chakraborti & P.D. Ghosh. 2004. Screening of mulberry (*Morus* spp.) for salinity tolerance through in vitro seed germination. Indian Journal of Biotechnology 3: 47-51

Wang, L-X, H-Q. Gao, C. Sun & L.X. Huang. 2022. Protective application of *Morus* and its extracts in animal production. Animals 12: 3541. 26 pages.

Wani, M.Y., M.R. Mir, S. Mehraj, R.A. Rather, N.A. Ganie, M.F. Baqual, K.A. Sahaf & A. Hussain. 2018. Effect of different types of mulches on the germination and seedling growth of mulberry (*Morus* SP.). International Journal of Chemical Studies [India] 6: 1364-1367.

Wasano, N., K. Konno, M. Nakamura, C. Hirayama, M. Hattori & K. Tateishi. 2009. A unique latex protein, MLX56, defends mulberry trees from insects. Phytochemistry 70: 880-888.

Whittemore, A.T. 2006. Notes on southwestern Moraceae. SIDA, Contributions to Botany 22: 769-775.

Wu Z-Y., Z-K. Zhou & M.G. Gilbert. 2003. Moraceae. Flora of China 5: 21-75.

Wunderlin, R.P. 1997. Moraceae. Flora of Nort h America 3: 388-399 . Oxford University Press, New York.

Wyckoff, W. 1881. Report on the Silk Manufacturing Industry of the United States. U.S. Department of Interior. Government Printing Office, Washington, D.C. 32 pages.

Zhengyi W., Z-K. Zhou & M.G. Gilbert. 2014. Moraceae. Flora of China 5: 21-73 [2003; revised for online edition 2014].

Yang, C-X., S-Y. Liu, N.J.C Zerega, G.W. Stull, E.M. Gardner, Q. Tian, W. Gu, R.A. Folk, H.R. Kates, R.P. Guralnick, D.E. Soltis, P.S. Soltis , Y-H. Wang & T-S.Yiet. 2023. Phylogeny and biogeography of *Morus* (Moraceae). Agronomy 13: 2021. 24 pages.

Young, S. 2022. Congressman's wife died after taking herbal remedy marketed for weight loss and diabetes. Kaiser Health News, for NBC [National Broadcasting Company]. <https://www.nbcnews.com/health/health-news/congressmans-wife-died-herbal-remedy-white-mulberry-leaf-rcna44721>

Zeng, Q-W., M. Chen, S-C. Wang, X-X. Xu, T. Li, Z-H. Xiang & N-J. He. 2022. Comparative and phylogenetic analyses of the chloroplast genome reveal the taxonomy of the *Morus* genus.

Appendices

Appendix One. Some current websites based in eastern USA that have erroneously labelled images or other misinformation for distinguishing *Morus rubra* from *M. alba*.

Universities, Arboreta and Gardens

https://www.youtube.com/watch?v=x2FZMeexN74
In this video produced by the Department of Forestry and Natural Resources at the University of Kentucky, some images of "*rubra*" are errors, including that on first slide.

https://www.clemson.edu/cafls/demo/plant_profiles/morus-rubra-red-mulberry.html
Clemson University, South Carolina; image is *alba*.

https://gardeningsolutions.ifas.ufl.edu/plants/trees-and-shrubs/trees/mulberry.html
University of Florida (ifas); first and probably second image are *alba*.

https://naturalresources.extension.iastate.edu/forestry/iowa_trees/trees/red_mulberry.html
Iowa State University; first two images of "*rubra*" are closer to *alba*.

https://plants.ces.ncsu.edu/plants/morus-rubra/
North Carolina State; images 1, 3, 4 and 5 are *alba* or close.

https://wp.towson.edu/glenarboretum/home/red-mulberry/
Towson University, Maryland; second image is *alba*.

https://www.thespruce.com/growing-red-mulberry-trees-5101681
The Spruce (newsletter of Dotdash Meredith Inc.); image with leaves is closer to *alba*.

https://www.nwmissouri.edu/arboretum/tree/morusrubra.htm
North West Missouri State University Arboretum; leaf image, at least, is *alba*.

Nurseries

https://sciotogardens.com/product/morus-rubra-3-red-mulberry/
Scioto Gardens, Delaware, Ohio; images of "Morus rubra #3" are *alba*.

https://whitetailhillchestnuts.com/products/red-mulberry?_pos=1&_sid=4549bc850&_ss=r
Whitetail Hill Chestnuts, Alabama; image of "red mulberry" is *alba*.

https://www.coldstreamfarm.net/product/red-mulberry-morus-rubra/
Cold Stream Farm, Michigan; leaf image is *alba*.

https://littleredwagonnativenursery.com/products/red-mulberry-morus-rubra-3-gal
Little Red Wagon Native Nursery, Florida; all images are *alba*.

https://www.nativnurseries.com/products/red-mulberry-seedlings-for-sale-morus-rubra
Nativ Nurseries, Mississippi; image is *alba*.

https://www.wilsonbrosgardens.com/red-mulberry-tree-3-gallon.html
Wilson Bros Gardens, Georgia; images are probably all *alba*. The website also has this erroneous statement: "Red Mulberry is also the larval host of Mourning Cloak butterflies". Google Scholar shows no record of feeding by this butterfly (*Nymphalis antiopa*) on *Morus*.

http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp
Agroforestree Database (Orwa et al. 2009); images appear to be *alba*.

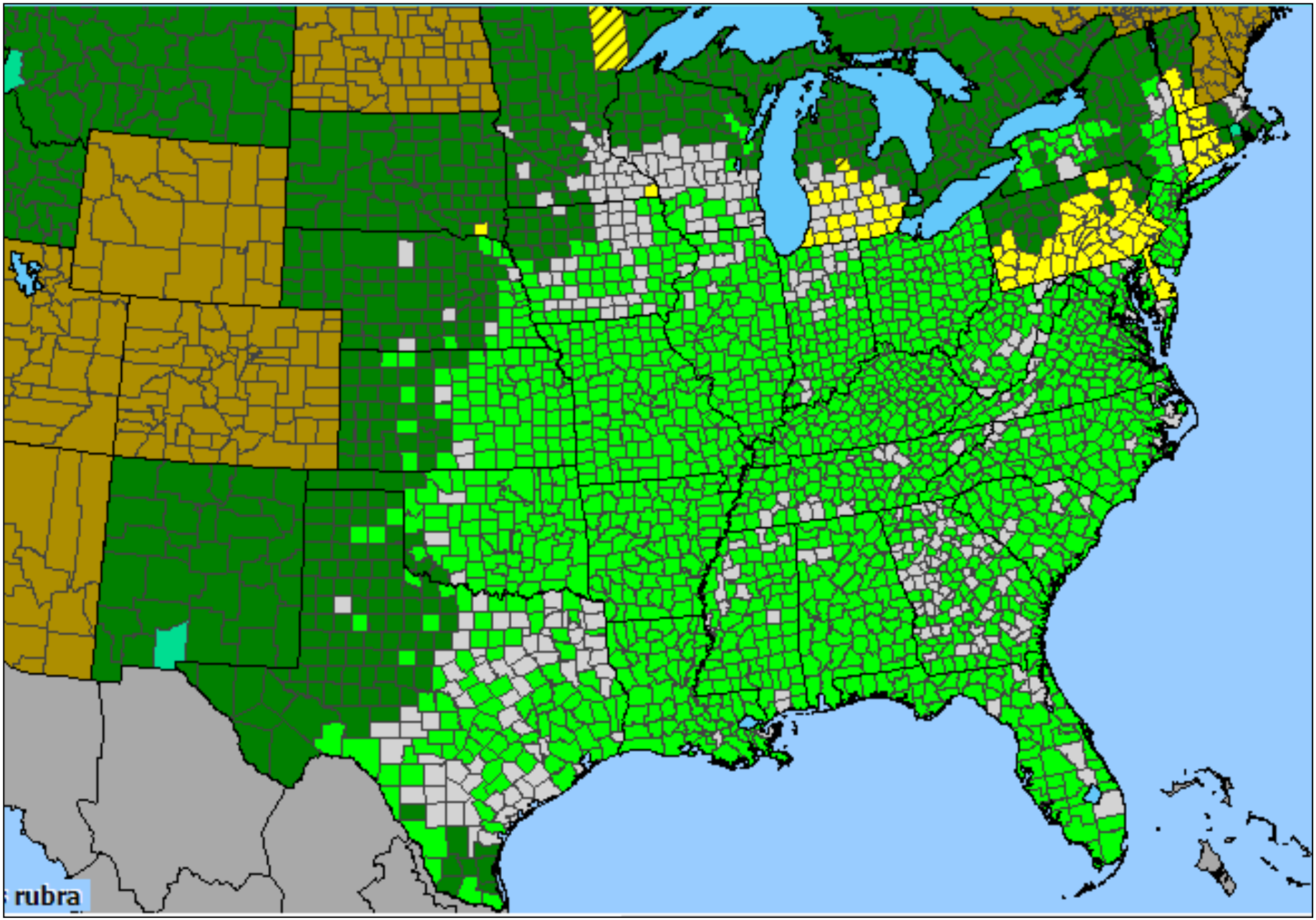
==========

Websites previously listed by Campbell (2013, revised 2019, p. 5): University of Texas (errors remain). Virginia Tech University (error is removed); University of Florida (website changed but second image is still error); University of North Carolina at Chapel Hill (errors remain); Daves Garden (errors remain); Amazon advertisement for *M. nigra* (error remains).

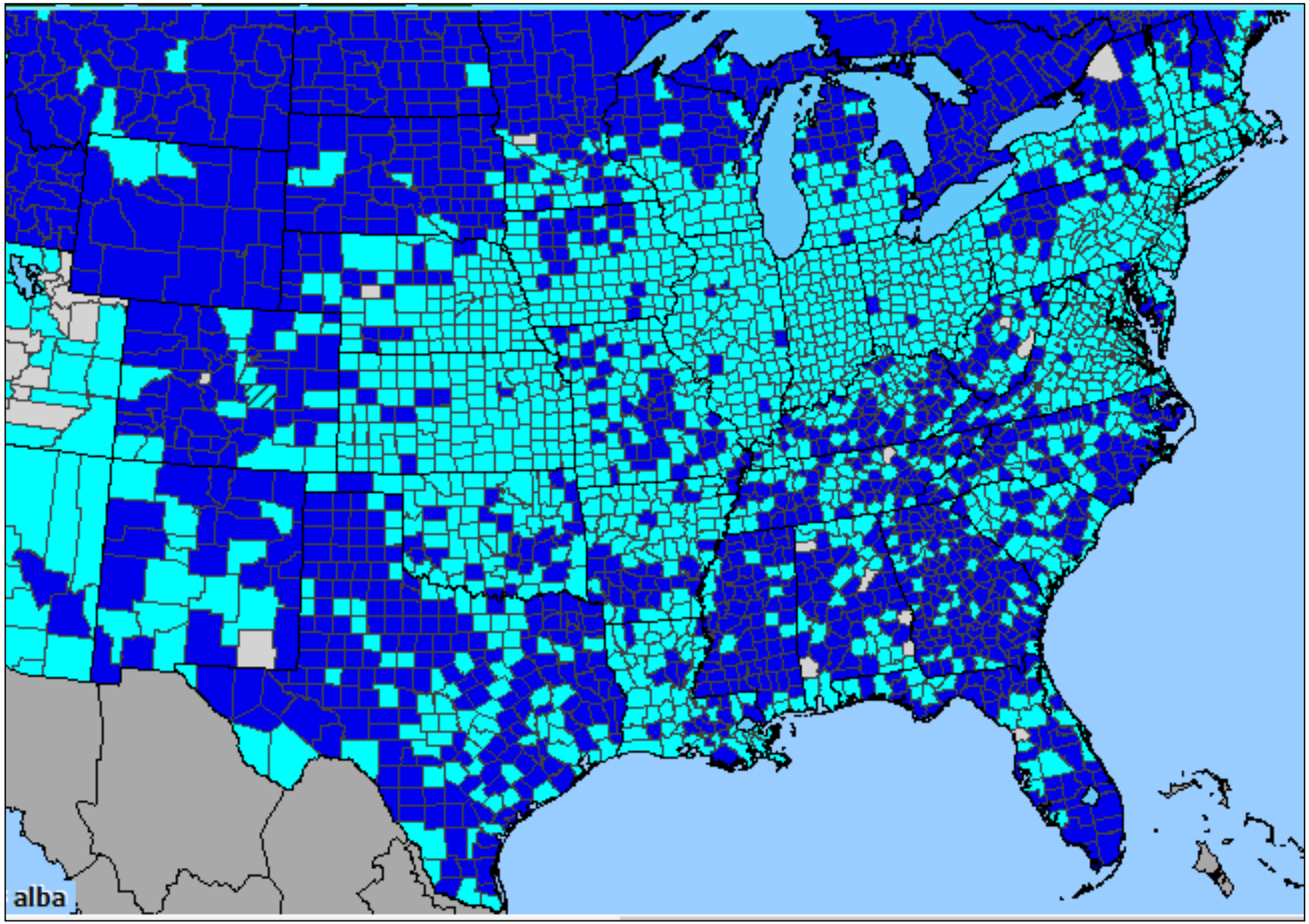
Appendix Two. Some comparisons of mappings for eastern North America.

The following two pages show distributions of *Morus rubra* and *M. alba* in counties of eastern U.S.A., from Kartesz (2022). The grayed counties for rubra are records that have been reassessed, from original identifications as "*rubra*" to *alba*. These changes reflects work by Nepal & Wichern (2013) and others, especially in the upper Midwest. The yellow counties are in states where *rubra* is considered imperiled (MN, MI, PA, VT, CT); further assessment of rare status is needed in NY and MA. The outlying record from Dona Ana Co. NM is dubious; there has been confusion with *M. microphylla*. The outlying record from Ravalli Co. MT is erroneous; the only known herbarium collections of *Morus* from MT are *alba* (including "*rubra*" of D. Schaff 1968 Aug 27 at LEA). The outlying record from St. Louis Co. MN is erroneous (based on "*rubra*" of D.L. Pomroy-Petry at UMD); the only known collections of *rubra* from MN are at from along its southern edge,

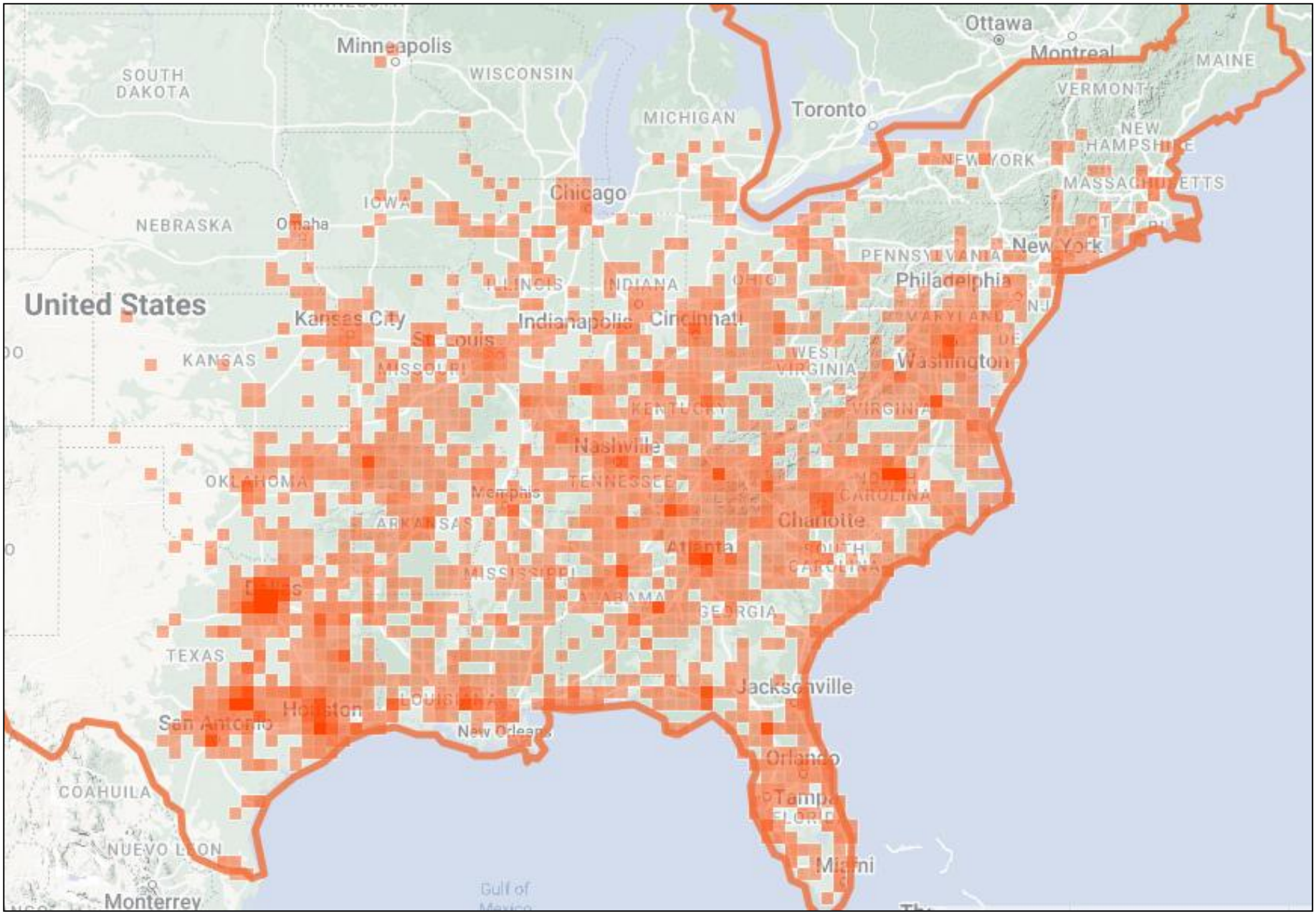
The subsequent two pages show records in iNaturalist.org; there is an erroneous extension of *rubra* into western regions. Although both species show concentrations of records around urban areas, this concentration is stronger for *alba*, which appears to be relatively infrequent in more wooded regions due to competition and perhaps herbivory; see discussion above. The final two pages show distributions based of Forest Inventory Analysis [FIA] data of US Forest Service, which Peters et al. (2019) used to model climatic effects. They stated: "White mulberry is a non-native, narrowly distributed (1.4% of area) species, sparse, and with low IV across part of the Corn Belt in the Midwest. We were not able to model it... Red mulberry is fairly common (9.1% of area), but sparse and with low IV, across the eastern part of the region. The low reliable model suggests no change in habitat, but that there is good habitat in the western portion of the region. SHIFT classes it as a decent infill species for those areas. It is also moderately adaptable, yielding a fair capacity to cope with the changing climate."



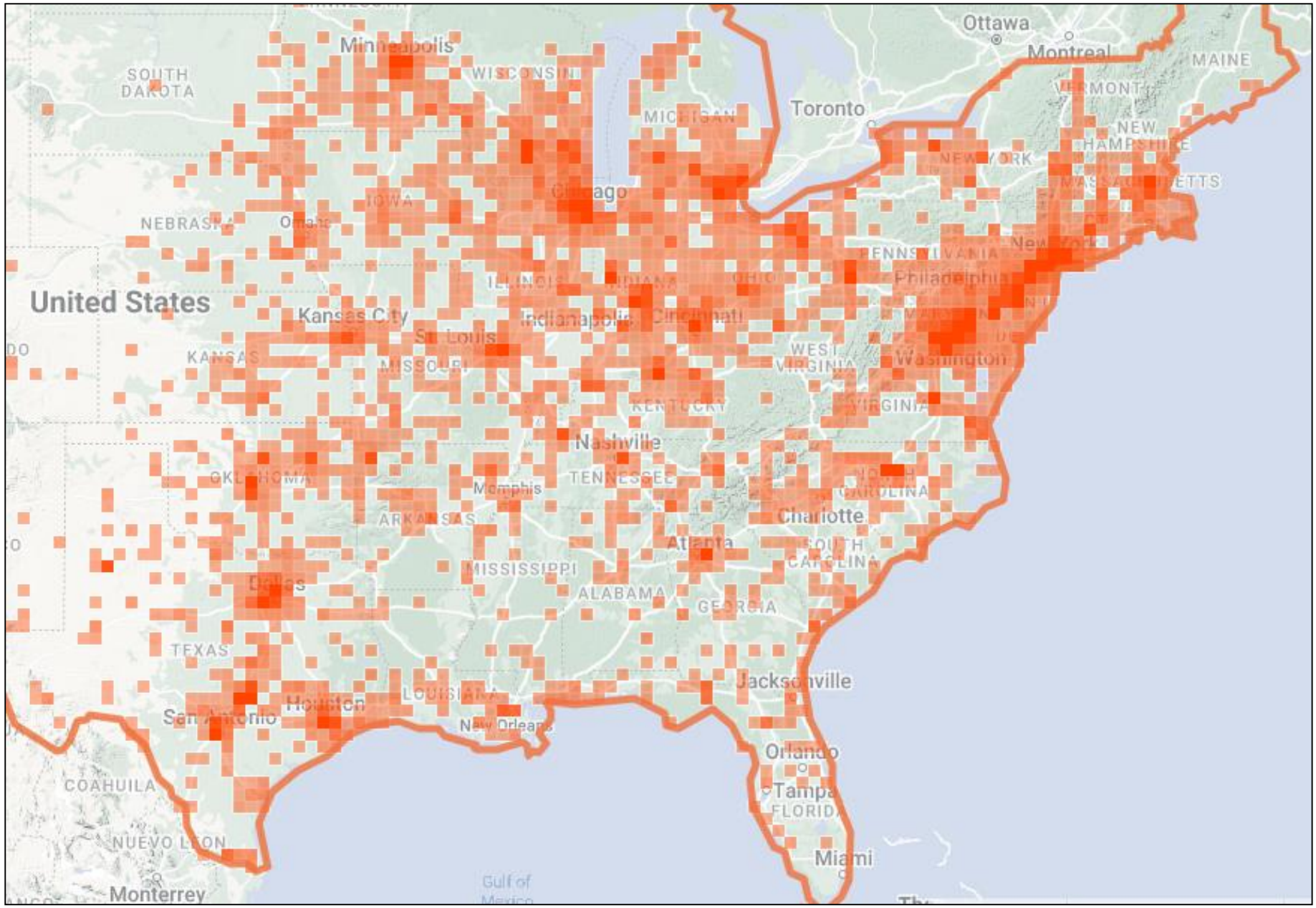
Morus rubra as mapped in the current "Floristic Synthesis" of BONAP (Kartesz 2022). Gray indicates "false" reports in past editions; yellow indicates "rare" in state.



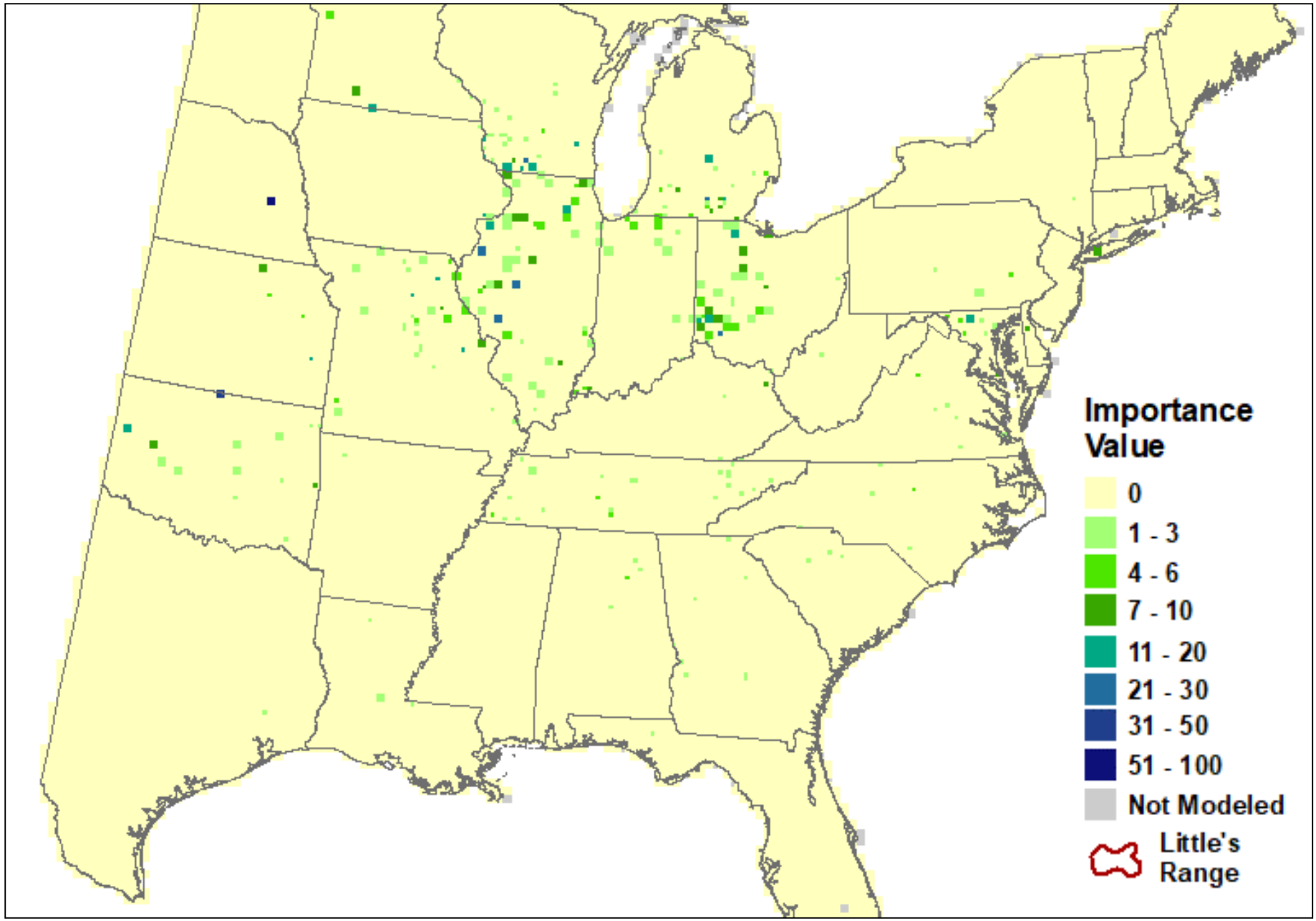
Morus alba as mapped in the current "Floristic Synthesis" of BONAP (Kartesz 2022). Blues (pale for counties, dark for states) indicate alien status.



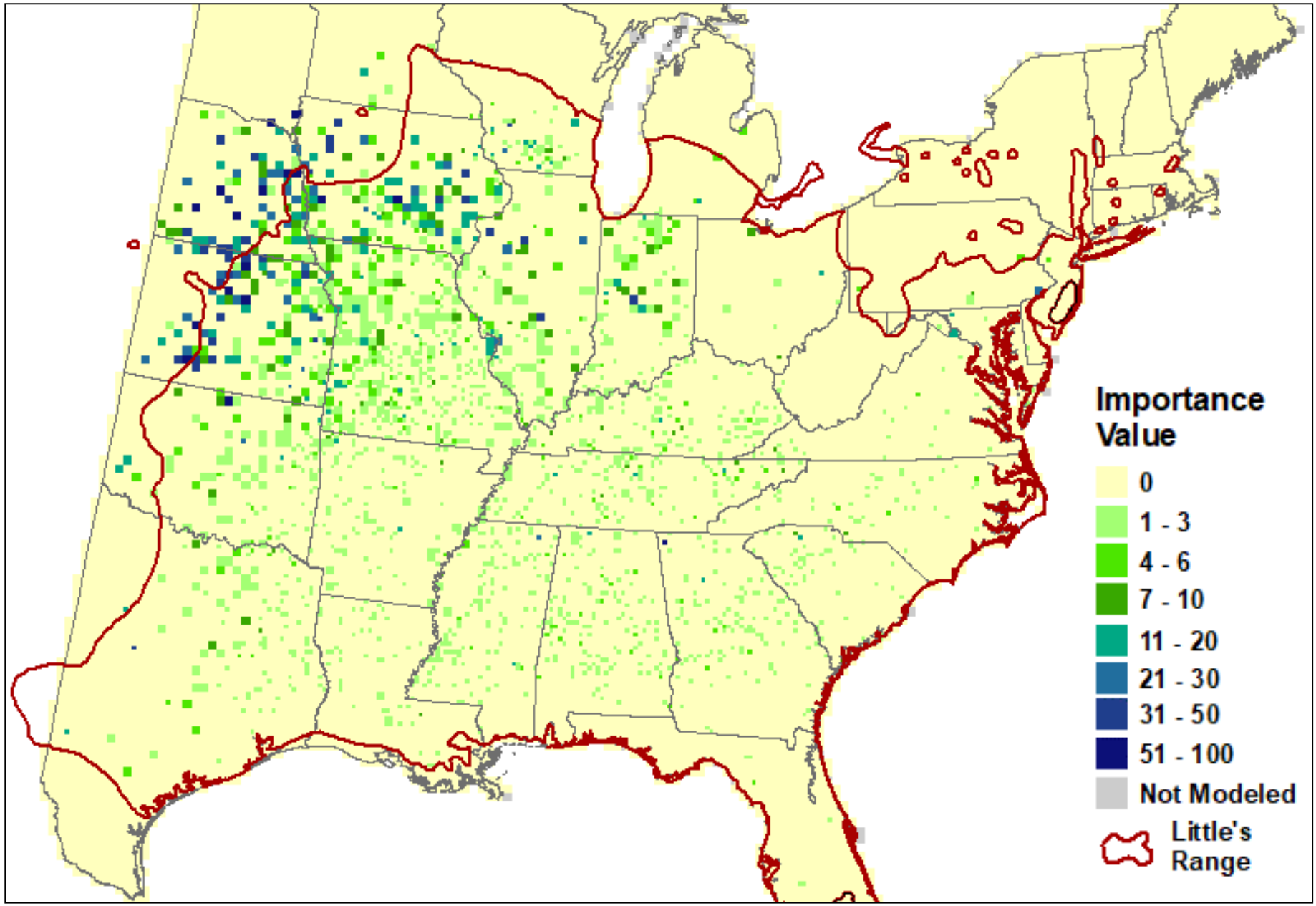
Records of "*Morus rubra*" from the USA in iNaturalist.org; although most records are accurate, there are many errors in some western regions. Darker red indicates denser records.



Records of "*Morus alba*" from the USA in iNaturalist.org; misidentification of *rubra* as *alba* is uncommon, but much *alba* has been misidentified as *rubra* in western regions.



Mapped distribution of "*Morus alba*" in FIA data of USFS (Peters et al. 2019)



Mapped distribution of "*Morus rubra*" in FIA data of USFS (Peters et al. 2019). There is a highly erroneous concentration in northwestern regions, due to inclusion of misidentified *alba*.

Appendix Three. Records of "*Morus nigra*" from North America.

It is likely that *Morus nigra* was introducted soon after settlement in Mexico and in what became the southern states (from California to Texas to Florida), but there is no evidence that this species became widespread further north (Rafinesque 1839, Wyckoff 1881). Nevertheless, there has been considerable confusion with *alba*, leading to many spurious records. Small (1933) was usually a reliable taxonomist, but he did not publish research on Eurasian plants. He did not understand the differences between *nigra* and *alba*, distinguishing *nigra* simply as follows: "syncarps black at maturity" (versus "white or pinkish"). He summarized its range as "fencerows, roadsides and waste grounds, Florida to Texas to NewYork". He distinguished *rubra* from *nigra* and *alba* as follows: "leaf-blades softly pubescent beneath" (versus "glabrous or sparingly pubescent on the nerves"). He noted: "In Florida the [red] mulberry is largely confined to the sites of aboriginal activity."

In a historical account of the early silk industry in Utah, Munson (1996) stated: "The varieties of mulberry trees established upon the Great Basin landscape included at least one North American species, the red mulberry (*Morus rubra* L.), and two varieties traditionally propagated in Europe, the black mulberry (*Morus nigra* L.), and white mulberry (*Morus alba*)... [but] ... only the white mulberry (and several of its cultivars) became widespread in Utah." However, there are no known illustrations or herbarium specimens or old living trees to prove that *rubra* and *nigra* were established. Munson also stated: "Perhaps the most intriguing location of mulberry trees in Utah is a hardy orchard of 71 red mulberry trees on remote Antelope Island in the middle of the Great Salt Lake. This grove of trees was planted neatly in rows and stands near a former pioneer homestead. Interestingly, however, core samples extracted from several of the largest trees showed that none was more than 70 years old." This mulberry grove now appears to contain just *alba* (Utah State Parks 2009).

Whittemore (2006) confirmed collections of potentially naturalized *nigra* in the U.S.A. only from a few sites in California and Nevada. Nepal (2008; Nepal & Purintun 2021) verified collections of cultivated or perhaps naturalized plants from further in the Caribbean region and Central America: BERMUDA. Manuel 652 (GH), January 2, 1964. COSTA RICA. Condeez 17451 (GH), 1909. CUBA. Shafer 8816 (GH), Ferbruary 16, 1911; Harvard Tropical Garden Soledad, Jack 5004 (GH), March 26, 1927. EL SALVADOR. Cardenson 288 (GH), November 1921. WEST INDIES. Procter 18232 (GH), April 4-June12, 1958.

The cold-hardiness of *nigra* is poorly documented, but its native range is centered in Iran and perhaps Turkey. It appears to be concentrated in Zone 8 of USDA, with mean annual minimum temperature of 10-20 degrees F or about 7-12 degrees C below zero (Margarey et al. 2008). There are local extensions into Zones 9 and 7 or even 6, but perhaps only in cultivation; see mapped records below from GBIF (2023). In North America cultivation appears generally possible only in Zones 9 or 8 (Dawes 1979). That limit would be similar to the species' limit in Eurasia (Neuner et al. 2010, Christian & Coles 2022). Even if plants grow far outside Zone 8, there may be less production of fruit and little viable seed. The potential role of patterns in precipitation and humidity should also be considered. In Eurasia, *nigra* is concentrated in regions with relatively dry summers, unlike the monsoonal summers of East Asia.

The closest relatives of *Morus nigra* may include *M. serrata* Roxb., which occurs in the Western Himalayas, and perhaps *M. cathayana* Hemsley of southern China and Japan (Wu et al. 2003). However, considerable uncertainty remains in phylogenetic relationships (Nepal 2008, Nepal & Ferguson 2012, Nepal & Wichern 2013, Zeng et al. 2022). Moreover, diagnostic morphological characters remain poorly defined in many cases. For example, style length and pubescence may have some diagnostic value, but we need more definitive observations, such as provided by the recent work of Demirel et al. (2021).

The following key is adapted from information in Wunderlin (1997), Whittemore (2006), Campbell (2019) , Nepal & Purintun (2021) and Yang et al. (2023).

1. Leaves with deeply cordate base, the sinus ca. 1.5-2 cm deep, the overall shape reniform-triangular to suborbicular, unlobed or rarely 3-lobed, usually with ca. 2-3 mm deep serrations; lower surfaces of mature sun-leaves softly pubescent; ripe fruits elliptic to short cylindric (Length / Width mostly 1-1. 5), with peduncle ca. 0.5 cm long, often persisting on tree in overripe condition, usually with 20-40 drupelets; seeds usually 2.5-4 mm long ..... *nigra*

1. Leaves with cuneate to truncate to shallowly cordate base, the sinus usually < 1.5 cm deep, the overall shape usually ovate, unlobed or often with 3-7 lobes, crenate or with ca. 1-2 mm deep serrations; lower surfaces of mature sun-leaves tomentose, pubescent, or glabrous except on veins; ripe fruits short- or long-cylindric (L / W mostly 1.5-4), with peduncles ca. 1-2 cm long, often falling in firm condition, usually with 30-70 drupelets; seeds usually 1.5-3 mm long

2. Lower surface of mature sun-leaves largely glabrous except for scattered short hairs (mostly 0.2-0.5 mm) on the major veins, usually crenate to bluntly serrate; upper surface glabrous or with a few hairs on the main veins, often glossy, usually bright or yellowish green; blades (2)5-10(18) cm wide, usually truncate, acute or with up to 0.5-1 cm acuminate tips; petioles with shallow groove on upper side; fruits short cylindric to elliptic (L / W mostly 1.5-3) ..... typical *alba* [excluding var. *multicaulis*]

2. Lower surface of mature sun-leaves with dense long hairs (mostly 0.4-0.7 mm), not restricted to the major veins, usually with regular serrations; upper surface scabrid or with scattered appressed hairs, wrinkled with impressed veins, usually dull deep bluish green; blades (5)8-16(22) cm wide, usually shallowly cordate, with 0.5-2 cm acuminate tips; petioles terete; fruits cylindric (L / W mostly 2.5-4) ..... *rubra*

Some USA nurseries selling "*Morus nigra*" associated with images of *alba* (1 Aug 2023). However, real *nigra* appears to be represented by the "dwarf" or "everbearing" black mulberry that is offered by some nurseries, especially in Florida (Miarek et al. 2022).

https://urbantropicals.com/product/cold-hardy-sweet-black-mulberry-tree-morus-nigra/
Urban Tropicals, Florida

https://sweetcanes.com/product/giant-cold-hardy-mulberry-black/
Sweetcanes, Florida?

https://chestnuthilloutdoors.com/shop/black-mulberry-2/#:~:text=Mulberries%20are%20an%20important%20early,depending%20on%20care%20and%20climate.
Chestnut Hill Outdoors, Florida

https://www.logees.com/mulberry-trader-morus-nigra.html
Logee's, Connecticut; clearly = alba. "Mulberry 'Trader' has a unique history. The original tree was brought to the U.S. from Germany in 1892 by the Trader family and planted on their farm in North Dakota. The original mulberry tree is still producing fruit more than 100 years later... [It is] one of the hardiest fruiting plants easily surviving in zone 4 and zone 3 with protection."

https://wellspringgardens.com/products/dwarf-everbearing-mulberry-morus-nigra
Wellspring Gardens, Florida.

https://southernseedexchange.com/products/mulberry-black-morus-nigra-50-seeds
Southern Seed Exchange, Virginia?

https://eureka-farms.com/products/mulberry-tree-morus?variant=45715995656473
Eureka Farms, Florida.

Table listing all 93records of "*Morus nigra*" in SERNEC (2023), downloaded on July 1st. The inserted field with yellow highlight show identifications suggested by available images: "likely" indicates probable ID but not certain; "maybe" indicates uncertain or possible hybrid. Only three of the 50 collections with images appear to be *nigra*; four appear to be *rubra*; and the rest appear to be *alba*.

id	institution Code	scientific Name	JC IDs	recorded By	record Number	year	country	state Province	county
4113798	UNM	Morus nigra	Morus alba	G.R. Rink	4935	2006	USA	New Mexico	San Juan
11557060	MTSU	Morus nigra	Morus alba	William A. Zaharias		1979	USA	Tennessee	Rutherford
11557065	MTSU	Morus nigra	Morus alba	Ira Scott	39	1980	USA	Tennessee	Rutherford
12618889	TENN	Morus nigra	Morus alba				USA	Louisiana	Lafayette
16539661	USAM	Morus nigra	Morus alba	Michel G. Lelong	6069.2	1971	USA	North Carolina	Orange
16544510	USAM	Morus nigra	Morus alba	Michel G. Lelong	6069.1	1971	USA	North Carolina	Orange
18896386	BEREA	Morus nigra	Morus alba				USA	Kentucky	Laurel
19980559	GA	Morus nigra	Morus alba				USA	Kentucky	Laurel
1964676	ASU	Morus nigra	Morus alba likely	A. Roman	387	1980	Mexico	Nuevo Leon	
6579125	NY	Morus nigra	Morus alba likely	S. Brown	480	1905	Bermuda		
6579126	NY	Morus nigra	Morus alba likely	S. Brown	997	1912	Bermuda		
7258266	FTU	Morus nigra	Morus alba likely				USA	Florida	

7258267	FTU	Morus nigra	Morus alba likely				USA	Florida	
7258271	FTU	Morus nigra	Morus alba likely				USA	Florida	
9096539	LSU	Morus nigra	Morus alba likely	Cecil Slaughter	867	1989	USA	Louisiana	Vermilion
9096541	LSU	Morus nigra	Morus alba likely	R. Dale Thomas	100999	1987	USA	Louisiana	Ouachita
9096543	LSU	Morus nigra	Morus alba likely	R. Dale Thomas	123507	1991	USA	Louisiana	Orleans
9096548	LSU	Morus nigra	Morus alba maybe	R. Dale Thomas	134642	1993	USA	Louisiana	Lafayette
9096549	LSU	Morus nigra	Morus alba maybe	R. Dale Thomas	126934	1991	USA	Louisiana	Jefferson
9096551	LSU	Morus nigra	Morus alba likely	R. Dale Thomas	117278	1990	USA	Louisiana	Saint James
9096559	LSU	Morus nigra	Morus alba likely	R. Dale Thomas	90007	1984	USA	Louisiana	Cameron
9096563	LSU	Morus nigra	Morus alba likely	R. Dale Thomas	117456	1990	USA	Louisiana	Assumption
9096848	BRIT	Morus nigra	Morus alba likely	R. Dale Thomas	104576	1988	USA	Texas	Harris
12618880	TENN	Morus nigra	Morus alba likely				USA	Arkansas	Jefferson
12618882	TENN	Morus nigra	Morus alba likely				USA	Arkansas	Ouachita
12618883	TENN	Morus nigra	Morus alba likely				USA	Arkansas	Union
14667752	NY	Morus nigra	Morus alba likely	W. C. Brumbach	7881	1972	USA	Florida	Lee
14687982	NY	Morus nigra	Morus alba likely	M. White	s.n.	1899	USA	Kansas	Cowley
14703290	NY	Morus nigra	Morus alba likely	Collector unknown	s.n.	1889	USA	New Jersey	Bergen

14703959	NY	Morus nigra	Morus alba likely	N. L. Britton	152	1903	USA	Florida	Hillsborough
14825184	NY	Morus nigra	Morus alba likely	W. C. Brumbach	7878	1972	USA	Florida	Lee
14886471	NY	Morus nigra	Morus alba likely	R. D. Thomas	147422	1995	USA	Arkansas	Jefferson
15049908	NY	Morus nigra	Morus alba likely	J. K. Small	9861	1921	USA	Florida	
15064142	NY	Morus nigra	Morus alba likely	A. A. Heller	1448	1894	USA	Texas	Nueces Co.
15274063	NY	Morus nigra	Morus alba likely	C. L. Hitchcock	21806	1959	USA	Washington	Asotin Co.
15696302	FSU	Morus nigra	Morus alba likely				USA	Texas	Zapata
19595586	FSU	Morus nigra	Morus alba likely	Elmer C. Prichard	530	1953	USA	Florida	Volusia
24035200	LSU	Morus nigra	Morus alba likely	Claude E. Valentine	s.n.	1936	USA	Louisiana	Orleans
26807484	BRIT	Morus nigra	Morus alba likely	Antonia Araiza	98	1964	USA	Texas	Zapata
28256649	BAYLU	Morus nigra	Morus alba likely	Artie Browning		1947	USA	Texas	McLennan
28859550	OKLA	Morus nigra	Morus alba likely	V. L. Cory	54355	1948	USA	Texas	Tarrant
16535506	USAM	Morus nigra	Morus alba maybe	R. Dale Thomas, et al	91698 & 4215	1985	USA	Louisiana	Cameron
19595587	FSU	Morus nigra	Morus alba maybe	Bunny Bergin	147	1962	USA	Florida	Volusia
21660366	USF	Morus nigra	Morus nigra	H. M. Pollard	s.n.	1968	USA	California	Ventura Co.
23072372	Harvard	Morus nigra	Morus nigra	H. M. Pollard		1968	USA	California	Ventura
30241663	MICH	Morus nigra	Morus nigra	Walter N. Koelz	18643	1942	Iran	Lorestan	Borujerd

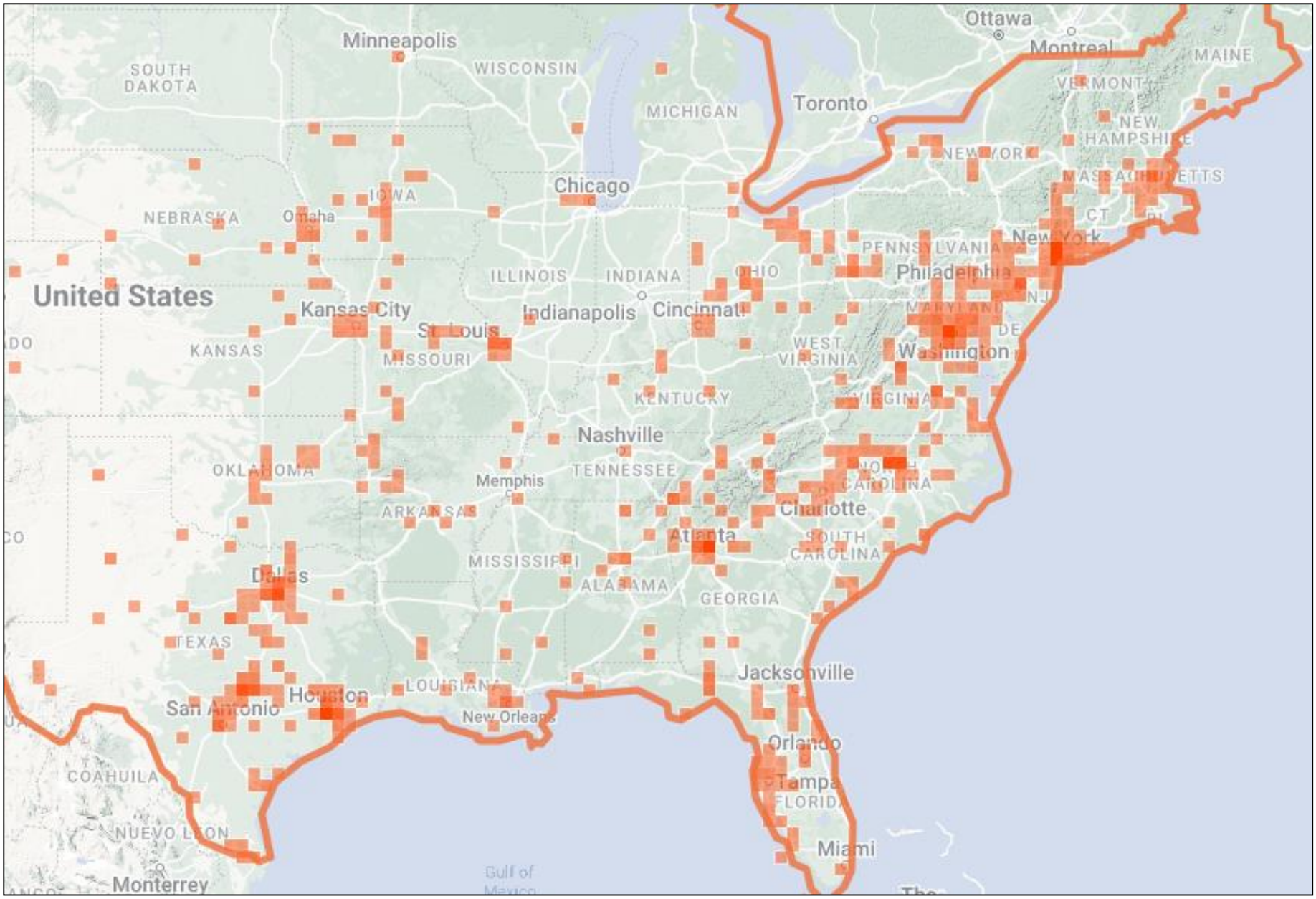
13300002	NCU	Morus nigra	Morus rubra	Cusick, Allison	25627	1986	USA	Kentucky	Lewis
15214225	NY	Morus nigra	Morus rubra likely	G. W. Stevens	1896	1913	USA	Oklahoma	Kay Co.
21130574	GEO	Morus nigra	Morus rubra likely	Don E. Eyles	4240	1938	USA	Georgia	Chatham
21131174	GEO	Morus nigra	Morus rubra likely	Don E. Eyles	4239	1938	USA	Georgia	Chatham
103664	ENMU	Morus nigra	no image	Ali Jafary Jahaghy	21	1976	USA	New Mexico	Roosevelt
3474079	MWI	Morus nigra	no image	Thomas, Robert Dale	91698&4125	1985	USA	Louisiana	Cameron
4395646	CHIC	Morus nigra	no image	E. Gardner	29	2013	USA	Florida	Miami-Dade
7066625	ILLS	Morus nigra	no image	Ishenbay Sodombekov+	KPL_00576	2006	Kyrgyzstan	Chuy Province	
7718749	BDI	Morus nigra	no image	Melville, Naomi		1891	USA	Iowa	Scott
7893738	WJC	Morus nigra	no image	Audrey B. King	4611	1947	USA	Missouri	Clay
7893743	WJC	Morus nigra	no image	Wanda Ponder	7667	1953	Paraguay	Asuncion	
10476542	MO	Morus nigra	no image	R.L. Walker	392	1983	USA	Florida	Charlotte
11465677	NO	Morus nigra	no image	Henry M. Pollard	s.n.	1965	USA	California	Ventura
11465695	NO	Morus nigra	no image	Joseph A. Ewan	22196	1973	USA	Mississippi	Jackson
11465699	NO	Morus nigra	no image	Harold St. John	13504	1933	USA	Hawaii	Kauai
12027156	CM	Morus nigra	no image		2742		Israel	Jerusalem	
12035887	CM	Morus nigra	no image	Britton, N.L.	152	1903	USA	Florida	Hillsborough

13299965	NCU	Morus nigra	no image	Koch, Rudy	3432	1967	USA	Kansas	Cowley
13299967	NCU	Morus nigra	no image	Jones, D.	192	1967	USA	Oklahoma	Payne
16042001	FLAS	Morus nigra	no image	R.A. & E.S. Howard	21135	1995	USA	Florida	Miami-Dade
16072443	FLAS	Morus nigra	no image	Ronald Lange	857	2011	USA	Florida	Alachua
16076405	FLAS	Morus nigra	no image	Walter S. Judd	8415	2013	USA	Florida	Miami-Dade
17257035	BRIT	Morus nigra	no image				USA	Tennessee	Davidson
18820086	CalBG	Morus nigra	no image	Laney Widener	17	2011	USA	California	San Bernardino
20304425	KE	Morus nigra	no image	Dumke, J.	1655	1984	USA	Ohio	LAWRENCE
20308622	KE	Morus nigra	no image	Dumke, J.	1662	1984	USA	Ohio	LAWRENCE
24272224	UAC	Morus nigra	no image	R. Dale Thomas et al	98410	1986	USA	Louisiana	
26229769	TAES	Morus nigra	no image	Leticia A. Alamia	151	1967	USA	Texas	Hidalgo
26229770	TAES	Morus nigra	no image	Tom Sanaherr	23620	1937	USA	Texas	Sutton
26229771	TAES	Morus nigra	no image	Maria Eva Uribe	112	1962	USA	Texas	Zapata
26229772	TAES	Morus nigra	no image	Ivan Shiller	741	1905			
26229773	TAES	Morus nigra	no image	Tom Sandherr	23619	1937			
27589726	NTSC	Morus nigra	no image	F. Shafer	s.n.	1992	USA	Texas	Bell
27875313	NTSC	Morus nigra	no image	Greg Boggs	s.n.	2001			

27949570	FTG	Morus nigra	no image	P. K. Fawcett		1969	USA		
27985766	FTG	Morus nigra	no image	A. Will	1994-27		USA	Florida	Broward
29004588	BEREA	Morus nigra	no image				USA	Kentucky	Laurel
29350136	uruza	Morus nigra	no image	Narciso Martinez Rivera	sn	1999	Mexico	Durango	
29385888	uruza	Morus nigra	no image	C.A. Yescas Albaran	sn	2003	Mexico	Durango	
29385937	uruza	Morus nigra	no image	Norma Yoana Perez Villalva	sn	2005	Mexico	San Luis Potosí	
29432667	uruza	Morus nigra	no image	Omar Correa Diaz	sn	2003	Mexico	México	
29619901	MICH	Morus nigra	no image	T. G. Yuncker	18642	1958	Jamaica	Saint Andrew	
30478084	TREC	Morus nigra	no image	Robert L. Harris	2007-37	2007	USA	Pennsylvania	Erie
30478086	TREC	Morus nigra	no image	Robert L. Harris	2007-39	2007	USA	Pennsylvania	Erie
30539766	ILLS	Morus nigra	no image	Igor Belolipov +	UPL_00389	2005	Uzbekistan	Dijzak	
30623227	uruza	Morus nigra	no image	Adrián Reyes Cruz	sn	2008	Mexico	Durango	
31083421	uruza	Morus nigra	no image	F.Y.P. Herrera	sn	2011	Mexico	Durango	Mapimí

==========

Next page: mapped records of "*Morus nigra*" from the U.S.A. in iNaturalist.org (1 July 2023). Almost all of these are erroneous. The are 66 "research grade" records from the USA but even most of these are erroneous. The few that appear correct are probably from cultivated trees: in California (degelduo 7Aug2022), in Florida (merishka 1May2018) and in Texas (janea 30Mar2018). There are also good records from Mexico.

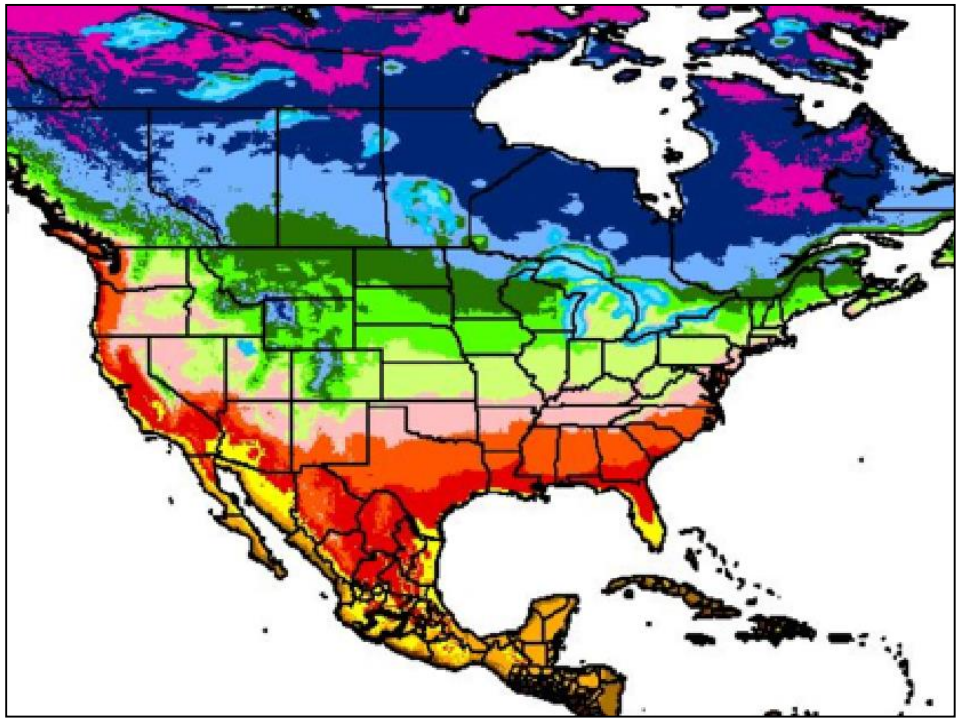


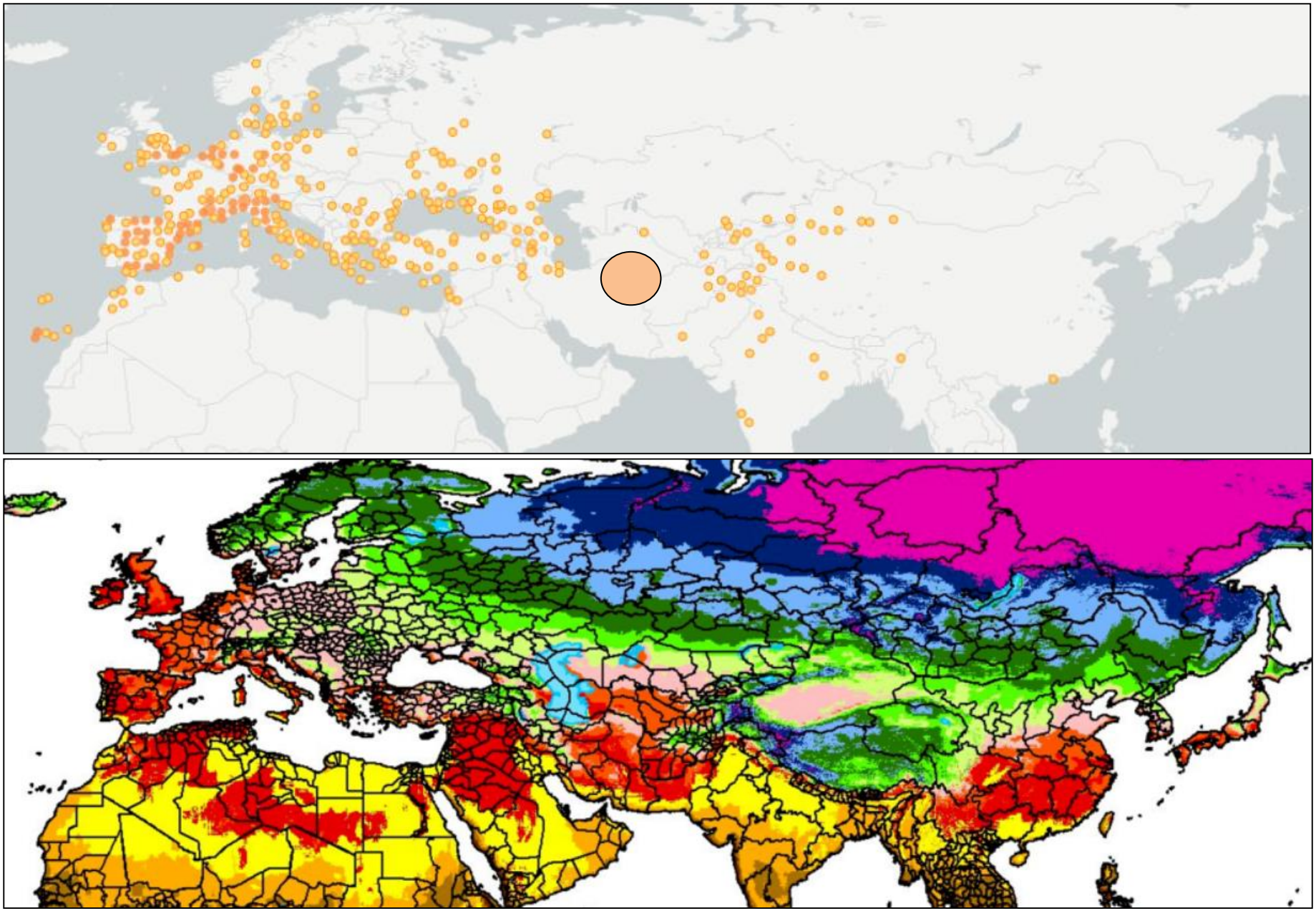
Records of "*Morus nigra*" from the USA in iNaturalist.org ; see notes on previous page.

Zone	Mean annual minimum
1	= -60 to -50 ° F
2	= -50 to -40 ° F
3	= -40 to -30 ° F
4	= -30 to -20 ° F
5	= -20 to -10 ° F
6	= -10 to 0 ° F
7	= 0 to 10 ° F
8	= 10 to 20 ° F
9	= 20 to 30 ° F
10	= 30 to 40 ° F
11	= 40 to 50 ° F
12	= 50 to 60 ° F
13	= 60 to 70 ° F

From: Global Plant Hardiness Zones of USDA (Magarey et al. 2008)); posted at Wikipedia: https://en.wikipedia.org/wiki/Hardiness_zone

Morus nigra is concentrated in zone 8. There are extensions into zone 9 and 7-6, but probably just as cultivated trees. There is little information on truly wild or naturalized populations, with reproduction from seed. In North America (see below), it is cultivated in zones 9 and 8, with almost none elsewhere.





Above: *nigra* as mapped in Eurasia by GBIF (2023); large dot indicates missing data from Iran.
Below: Hardiness Zones of USDA (Margarey et al. 2008); see legend on preceding page.

Appendix Four. State champion trees reported as "*Morus rubra* ".

"Circum" = circumference. "Spread" = average crown width.
Several of these appear to be *alba* or hybrids.
At left margin: "×" = *alba* or hybrid; "?" = doubted as *rubra*; "!" = confirmed as *rubra*.
Most identifictions remain unverified; those with circumference over 120 inches could be added to the suspect class. D. Boone and J. White (pers. comm.) found in 2014-2015 that the supposed state champions for *rubra* in Kentucky, Ohio, Illinois and Iowa were actually *alba*; and photos from supposed champions in Indiana, Missouri and Tennessee looked suspicious.
==========

Alabama: circum 256 in; height 55 ft; spread 51ft. No image available.
https://forestry.alabama.gov/Pages/Management/Forms/Champion_Trees.pdf

× Arkansas: circum 305 in; height 75 ft; spread 71 ft. ID is wrong, an apparent hybrid.
This is also considered the national champion for *rubra*. See photos and notes below.
Location: in Hamburg, Ashley Co.; 535 Ashley County Rd 81 E; 33.33730, -91.80194
https://www.agriculture.arkansas.gov/forestry/champion-trees/red-mulberry-morus-rubra/
https://d3f9k0n15ckvhe.cloudfront.net/wp-content/uploads/2021/11/2021-National-Register-of-Champion-Trees.pdf

? Connecticut: circum 163 in; height 46 ft; spread 53 ft. Image suggests *alba*.
http://oak.conncoll.edu:8080/notabletrees/ChampsByCommonName.jsp

Delaware: no *Morus* is listed.
https://delawaretrees.com/bigtrees_delaware_4th_edition.pdf

? Florida: circum 116 in; height 74 ft; spread 60.5 ft. Images inadequate; unusual stem cluster.
https://ffs.fdacs.gov/ChampionTrees/home.mvc/Detail/1230 [Suggests *Tilia*?]

? Georgia: circum 275 in; height 54 ft; spread 75 ft. ID is suspect; possible hybrid.
https://gatrees.org/champion_tree/1796/

× Kentucky: circum 144 in; height 64 ft; spread 62.1 in. Image not adequate; Carter Co.
JC visited on 10 Sep 2023 and found that the tree is an apparent hybrid; see photos below.
A previous claimed champion in Grayson Co. was *alba* (D. Boone, pers. comm. in 2015).
https://eec.ky.gov/Natural-Resources/Forestry/ky-champion-trees/Pages/default.aspx

! Illinois: circum 71 in; height 87 ft; spread 46 ft. Image convincing; bark is typical.
A previous claimed champion was *alba* (D. Boone, pers. comm. in 2015).
https://univofillinois.maps.arcgis.com/apps/Shortlist/index.html?appid=090997c75b2e4ca39dd7d35db4328962

Indiana: circum 46.8 in; height 30 ft; spread 41 ft. No image available.
https://www.in.gov/dnr/forestry/forestry-publications-and-presentations/indiana-big-tree-register/

Iowa: circum 153 in; height 60 ft; spread 45ft. No image available.
This is number 2 tree, since number 1 had circum 247 ft measured at only 1 ft above ground,
https://www.iowadnr.gov/Portals/idnr/uploads/forestry/Big%20Trees%20of%20Iowa%20Web-ready.pdf

Kansas: circum 244 in; height 48 ft; spread 64ft. No image available.
https://www.kansasforests.org/about/kfs_docs/Champion%20Tree%20Report.pdf
Note also the “Chisholm Trail Mulberry” that is identified as *rubra* but appears to be *alba*.
Its dimensions are: circum 242 in; height 40 ft; spread 46 ft.
https://www.gatheringgrowth.org/trees-of-significance/chisholm-trail-mulberry

Louisiana: circum 176 in; height 46 ft; spread 65 ft. Insufficient image for identification.
https://www.laforestry.com/champion-trees-in-louisiana
https://www.laforestry.com/single-post/2019/07/08/red-mulberry-in-lafayette-new-state-champ

? Maryland: circum 140 in; height 40; spread 64. Images suggest *rubra*.
https://www.mdbigtrees.org/websitedata
Note also, Maryland has claimed the national champion of Morus nigra (293+49+72), located in Westminter, Carroll County. However, the images suggest *alba*; and this tree is not listed by American Forests (2021) in the current register national champions.
https://www.baltimoresun.com/news/bs-xpm-1992-02-16-9213001546-story.html

Massachusetts: no *Morus* are isted except supposed "*nigra*" (141+42.5+54), which is dubious.
https://storymaps.arcgis.com/stories/01b1f730be644630b44bd3655d1a9201

Michigan: only *alba* is listed (149+57.6+67).
https://docs.google.com/spreadsheets/d/1uH6l1s3Sn6lEUeZMJGkrN0I4PtzTVoqf0xt3vX2pJXM/edit#gid=537799349
However, there is a previous dubious report of the national champion for *rubra* from Michigan in 1981 (225+72+98); see Godfrey (1988) and Sullivan (1993)..

Minnesota: circum 71 in; height 44 ft; spread 27 ft. No image available.
https://www.dnr.state.mn.us/trees_shrubs/bigtree/big-tree-champions.html

Mississippi: no website can be located despite mention.
https://www.mfc.ms.gov/2016/02/new-champion-trees-discovered/

Missouri: circum 204 in; height 64 ft; spread 63 ft. No images available.
https://mdc.mo.gov/trees-plants/champion-trees/current-champion-trees

Nebraska: only "*alba* or *rubra*" is listed (263+49+76).
https://nfs.unl.edu/registry

New York: circum 132 in; height 32 ft; spread 32 ft. No images available.
https://www.dec.ny.gov/docs/lands_forests_pdf/champcom.pdf

North Carolina: circum 217 in; height 52 ft; spread 69 ft. No images available.
A large verified *rubra* in the state has been verified on land of Don Schneider in Clay Co. by D. Boone (Jan 2016): 72 in dbh [182 cm]; this may be the global champion!
https://www.ncforestservice.gov/urban/big_species_results.asp

× Ohio: circum 169 in; height 54 ft; spread 78 ft No image but in 2015 D.Boone found that the tree is *alba* or hybrid. The largest *rubra* he knows in Ohio is at Mt Airy (Hamilton Co.), with has circum of ca. 63 in (20 in dbh).
https://ohiodnr.gov/discover-and-learn/safety-conservation/about-ODNR/forestry/champion-trees/native-champion-trees

Oklahoma: circum 234 in; height 58 ft; spread 71 ft..No image available.
https://ag.ok.gov/wp-content/uploads/2022/08/2014_list.pdf

! Ontario: circum 38.4 in; height 52.5 ft; spread ?? Reliable identification after much research.
http://www.oldgrowth.ca/honour-roll-of-ontario-trees/

Pennsylvania: circum 206 in; height 47 ft; spread 79 ft. No image available.
https://www.pabigtrees.com/tree-listings

Rhode Island: only *Morus alba* is listed.
https://ritree.org/rhode-island-champion-tree-list/

South Carolina: circum 247 in; height 32 ft; spread 44 ft. No image available.
https://clemson.maps.arcgis.com/apps/dashboards/59cf965ed80348889f531527cb99d292

South Dakota: no *Morus* are listed.
https://danr.sd.gov/Conservation/Forestry/TreesofSouthDakota/BigTreeRegister/CurrentList.aspx

? Tennessee: circum 333.6 in; height 43.5 ft; spread 68 ft. Image is probably *alba*.
https://naturalresources.tennessee.edu/trees/

Texas: only *Morus microphylla* is listed.
https://texasforestinfo.tamu.edu/BigTreeRegistry/Lists

Virginia: circum 223 in; height 61 ft; spread 79 ft. No image available.
https://bigtree.cnre.vt.edu/results.cfm?BrowseType=StateChamp&Term=_

Vermont: no *Morus* are listed.
https://experience.arcgis.com/experience/7637f5256b65454aa123e0c631f1f46a/page/Map/

West Virginia: circum 92 in; height 40 ft; spread 40 ft. No image available.
https://wvforestry.com/big-tree-program/

Wisconsin: no *Morus* are listed.
https://experience.arcgis.com/experience/3baffe32b8c246dc8848bde36e583d73

Circumference (inches)	DBH mid-point (cm)	Reported as "*rubra*"	Reported as "*alba*"
30-39.9	28	!ON	
40-49.9	36		
50-59.9	44	IN	
60-69.9	53		
70-79.9	61	!IL MN	<SC
80-89.9	69		
90-99.9	77	WV	
100-109.9	85		
110-119.9	93	?FL	
120-129.9	101		
130-139.9	109	NY	WV
140-149.9	117	×KY ?MD	
150-159.9	125	IO	
160-169.9	133	?CT ×OH	
170-179.9	141	LA	RI TN
180-189.9	150		
190-199.9	158		
200-209.9	166	MO PA	PA
210-219.9	174	NC	
220-229.9	182	VA MI	
230-239.9	190	OK ?TN	CT IO MD
240-249.9	198	KA SC>	
250-259.9	206	AL	KA
260-269.9	214		NE
270-279.9	222	?GA	MO SC
280-289.9	230		
290-299.9	238		
300-309.9	246	×AR	
310-319.9	255		

Table to left shows distribution of state champion trees by circumference size class in inches.

States are indicated by postal acronyms.

! indicates ID as *rubra* is confirmed.

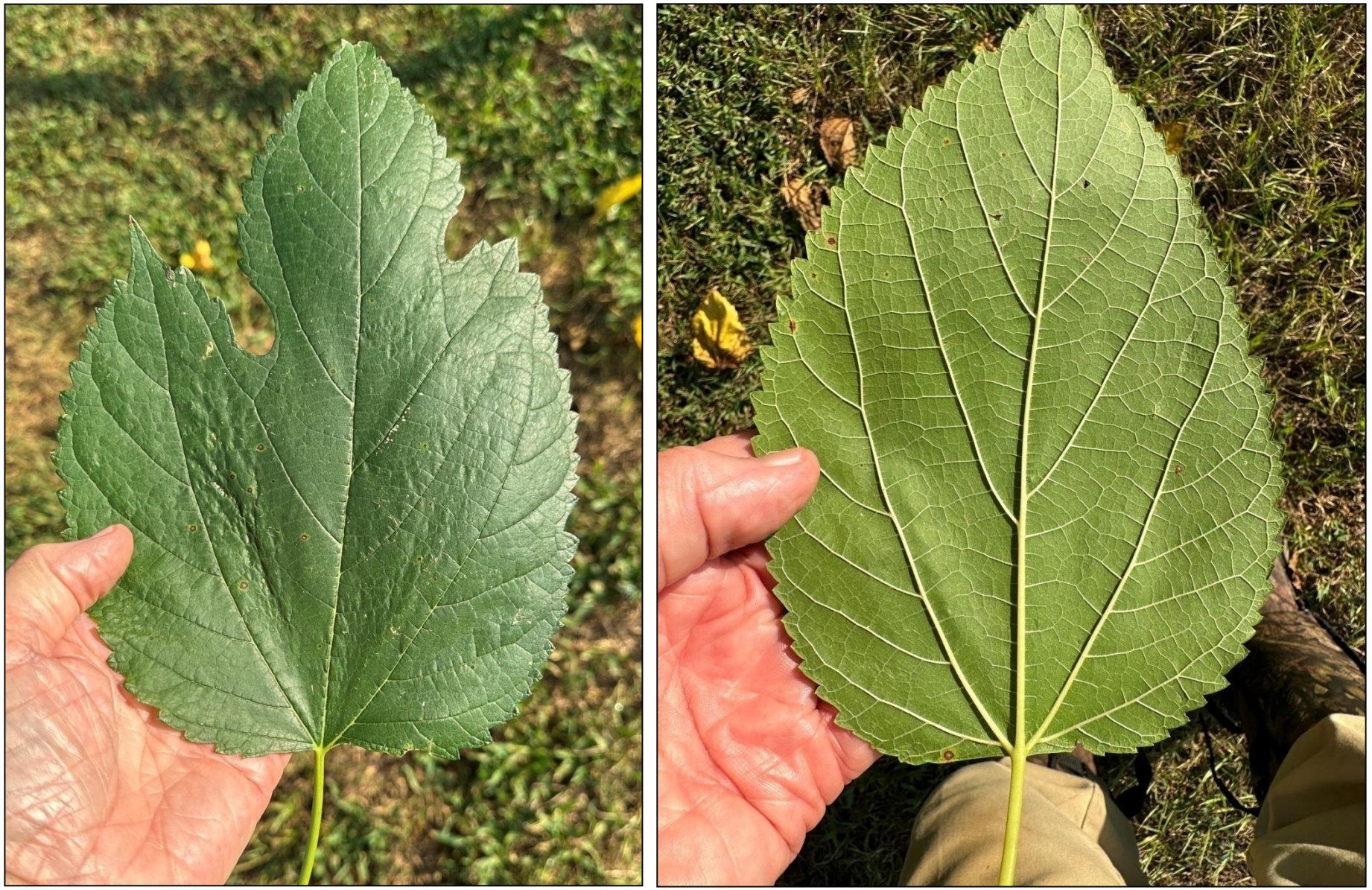
? indicates ID as *rubra* is doubted.

× indicates ID as *rubra* is erroneous.

>< in SC species may have been switched.

There may be two clusters in circumferences, about 70-180 inches and 200-280 inches. The former may be mostly *rubra*; the latter may be mostly *alba*.

Photos by Jim Keesling on 7 Sep 2023: reported national (global) champion of *Morus rubra* in Ashley Co., Arkansas; see details of location above. The tree appears to be a hybrid with *alba*.



Photos by Jim Keesling of supposed *rubra* champion; continued. “Adaxial surfaces were sparsely to moderately scabrous, with strongly impressed veins. Some leaves were adaxially glossy, while other examples were dull.” Collections will be accessed at ANHC.

Photos by Jim Keesling of supposed *rubra* champion; continued. “Abaxial surfaces had scattered hairs about 0.5 mm long on primary and secondary veins, with those hairs denser in vein axils. The primary veins were also often densely covered with hairs about 0.1 mm long. Petioles were also variable, with some round and ungrooved in cross-section and others flattened or modestly grooved on the top side ”

Supposed state champion *rubra* in Kentucky: Carter Co., Olive Hill, 361 Water Avenue.
This is a large tree in front yard, probably planted about 1910; it has produced much good fruit.
Left: Google Street View, Dec 2016. Right: JC 10 Sep 2023. Collections will go to APSC.

Leaves from left to right: 1 = *rubra* (Rowan Co.); 2 = supposed state champion *rubra* but apparent hybrid (Carter Co.); 3,4 = other hybrids nearby; 5 = *alba* nearby (across creek).

Appendix Five. Mysterious references to "*Morus rubra*" in Africa and Asia.

As already noted under "Continued misidentification...", there is virtually no evidence that true *rubra* occurs in Europe, even as a cultivated species, there are several horticultural publications from Turkey that refer to *rubra*. There are also papers from north Africa, Iran, India and China that refer to *rubra*, generally in a cultivated context. Following are some examples; these are supplementary to the Literature Cited above. A few of these papers mention voucher collections for herbaria; those papers are marked with asterisks at left margin. However, such collections are not yet imaged for viewing online. There is zero evidence that pure *rubra* occurs in Africa or Asia, but it is possible that some North American *alba* × *rubra* hybrids have been distributed there for horticultural interest (Christian & Coles 2022). The explanation for most of these references to "*rubra*" may be that they represent variants of *nigra*, or perhaps purple- or red-fruited *alba* as opposed to pink- or white-fruited *alba* (which has been called *M. alba* var. *multicaulis* as noted above).

Tunisia

Thabti et al. (2011); Aljane et al. (2016).

Egypt

Rouz (2009); see notes on his Figure 1 below.

Turkey

Ercisli & Orhan (2006): "The Anatolia region of Turkey has growing conditions suitable for cultivating high quality mulberry fruits, mainly *Morus alba*, *Morus nigra* and *Morus rubra* (Yaltirik, 1982). The production of mulberry in Turkey in 2005 was 78,000 tonnes (Anonymous, 2005) and its cultivation in Turkey has been known for more than 400 years. 95% of the mulberry trees grown in Turkey are *M. alba*, 3% are *M. rubra* and 2% are *M. nigra*

(Ercisli, 2004)... “Mulberry fruits were harvested from selected *M. rubra* clone kirmizi, *M. nigra* clone siyah and *M. alba* clone pirinc from our town, Erzurum, Turkey, in 2005.”

Koca et al. (2008).

Al-Salihi et al. (2011).

Erarslan et al. (2021): their “*rubra*” appears to be a variant of *nigra*, based on the image of large suborbicular leaf blades with more or less cordate bases. Moreover, they noted: “Despite certain morphological differences, sometimes fruits of *M. nigra* and *M. rubra* may not be identified by local people, and sellers replace *M. nigra* with an another less expensive black fruit.”

Iran

Ebrahimi et al. (2021).

Pakistan

Iqbal et al. (2012).

India

Awasthi et al. (2004): “The wild and cultivated mulberry species were obtained from the Central Sericultural Germplasm Research Center, Hosur, India”. They described *rubra* as follows: “Style absent or indistinct, stigma papillose, leaf ovate, margin crenate, apex acuminate, base cordate. Branches slightly drooping”; these characters do not clearly identify typical *rubra*. Their analysis of DNA markers indicates a close relationship with *M. bombycis* Koidz., which is generally considered to be a segregate of *M. australis* Poir. (first recognized in Japan).

*Singh et al. (2021): "Plant leaves were collected from Institute of Engineering & Technology, Lucknow. The sample was authentified by CSIR-National Botanical Research Institute Lucknow (U.P) as *M. rubra* (accession No. LWG -100981)."

John et al. (2023).

Phillippines

*Jose et al. (2021): "*M. rubra* bark was collected from Abucay, Bataan, Philippines (14.7128° N, 120.4934° E) on well cultivated arable land. The plant identity was substantiated and authenticated by the Bureau of Plant Industry (BPI) in Malate, Manila, National Capitol Region, Philippines."

China

Wang et al. (2016): "Mulberry (*Morus rubra*) is a plant native to Asia and widely cultivated in Southern Europe for centuries because of its wide usage for many purposes. In traditional Chinese medicine, dried mulberry fruits have been used for their tonic and sedative effects, like the leaves and root bark of mulberry ." [*M. rubra* is not native to Asia!]

Wang et al. (2017).

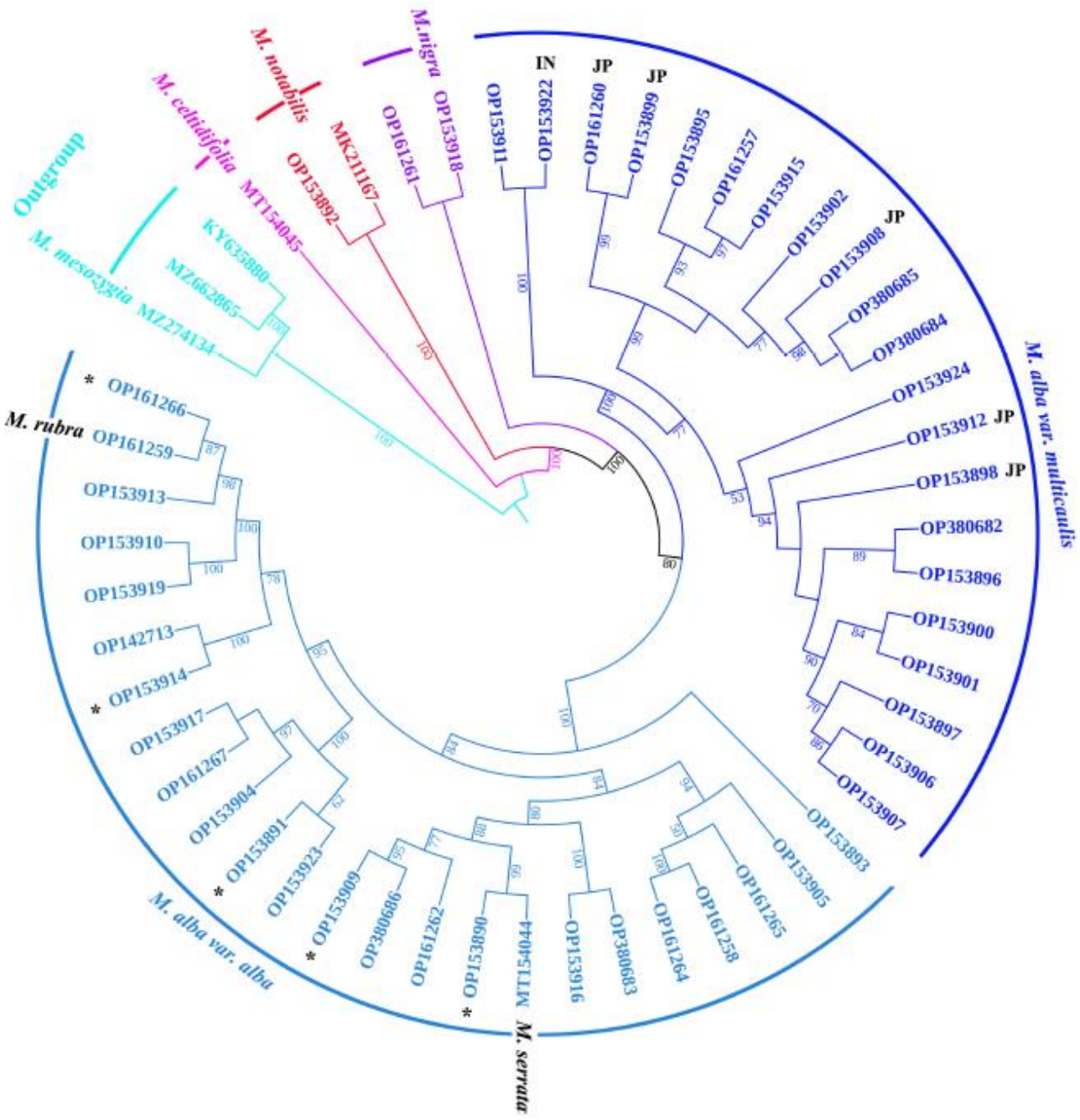
Zeng et al. (2022): "*Morus serrata* was collected from Jilong, Tibet Autonomous Region, China, and propagated at the Mulberry Germplasm Nursery at Southwest University. *Morus celtidifolia* was identified by Professor Elizabeth Makings from Arizona State University, USA. *Morus notabilis* was collected from a pristine forest in Ya'an, Sichuan Province, China. *Morus yunnanensis* was obtained from the Institute of Sericulture and Apiculture, Yunnan Academy of Agricultural Sciences, Mengzi, Yunnan Province, China. *Morus nigra* was collected from Yutian County, Xinjiang Uygur Autonomous Region, China. Other samples were obtained from the Mulberry Germplasm Nursery at Southwest University, China."

Figure 2. (a): Morus alba fruits, (b): Morus nigra fruits, (c): Morus rubra fruits.

From Can et al. (2021): their "*rubra*" appears to be a relatively red variant of *nigra*.

Fig.1 – The three shapes of the types of mulberry leaves.
a – *Morus rubra* 1 b – *Morus rubra* 2 c – *Morus nigra*.

From Rouz (2009): these leaves could all be from *alba* (or perhaps *australis* in the upper leaf). None of them could be typical *rubra*, which is not glossy as are these leaves.



From Zeng et al. (2022): their Figure 4 showing phylogenetic dendrogram based on chloroplast DNA; see their paper for detailed explanation.

These results are discordant with analysis of Nepal (2008) in relation to the sample of "*rubra*".

M. rubra is probably closest to Central American *M. celtidifolia* sensu lato (with *M. microphylla*),

The sample of "*rubra*" depicted here may have been a red-fruited variant of *alba*, not true *rubra*.

Literature Cited for Appendix Five (supplementary to that for core text above)

Aljane, F., N. Sdiri, I. Hannachi, R. Ben Slimen & S. Rezgui. 2016. Morphological, phytochemical and antioxidant characteristics of white (*Morus alba* L.), red (*Morus rubra* L.) and black (*Morus nigra* L.) mulberry fruits grown in arid regions of Tunisia. Journal of New Sciences [Tunisia] 35: 1940-1947.

Al-Salihi, A.A.M., M. Olgaç, E. Dinçer, H. Polatcı & O. Saraçoğlu. 2022. Comparison of some quality parameters in fresh and dry samples of *Morus rubra* fruits. Turkish Journal of Agriculture - Food Science and Technology 10: 3008-3013.

Awasthi, A.K., G.M. Nagaraja, G.V. Naik, S. Kanginakudru, K. Thangavelu & J. Nagaraju. 2004. Genetic diversity and relationships in mulberry (genus *Morus*) as revealed by RAPD and ISSR marker assays. BMC Genetics, 5:1-9.

Can, A., A. Kazankaya, E. Orman, M. Gundogdu, S. Ercisli, R. Choudhary & R. Karunakaran. 2021. Sustainable mulberry (*Morus nigra* L., *Morus alba* L. and *Morus rubra* L.) production in Eastern Turkey. Sustainability 13: 13507. 13 pages.

Ebrahimi, A., A. Poursalavati, M.M. Esboei, S.R. Monfared, M. Sahebi, M.R. Amerian & H.H. Khoshro. 2021. Population and individual multivariate analysis of white (*Morus alba*), red (*Morus rubra*) and black (*Morus nigra*) mulberry genotypes: applications for breeding, conservation and development. Euphytica 217: 152. 27 pages.

Erarslan, Z.B, S. Karagöz & S. Kültür. 2021. Comparative morphological and anatomical studies on *Morus* species (Moraceae) in Turkey. Turkish Journal of Pharmaceutical Sciences 18: 157-166.

Ercisli, S., & E. Orhan. 2007. Chemical composition of white (*Morus alba*), red (*Morus rubra*) and black (*Morus nigra*) mulberry fruits. Food Chemistry 103: 1380-1384

Iqbal, S., U. Younas, D.R. Sirajuddin, K.W. Chan, R.A. Sarfraz & K. Uddin. 2012. Proximate composition and antioxidant potential of leaves from three varieties of mulberry (*Morus* sp.): a comparative study. International Journal of Molecular Sciences 13: 6651-6664.

Koca, I., N.S. Ustun, A.F. Koca & B. Karadeniz. 2008. Chemical composition, antioxidant activity and anthocyanin profiles of purple mulberry (*Morus rubra*) fruits. Journal of Food Agriculture and Environment 6: 39-42.

John, V.L., A.R. Nayana, T.R. Keerthi, A. Krishnan, B.C.P. Sasidharan & T.P. Vinod. 2023. Mulberry leaves (*Morus rubra*)-derived blue-emissive carbon dots fed to silkworms to produce augmented silk applicable for the ratiometric detection of dopamine. Macromolecular Bioscience : 2300081. <https://doi.org/10.1002/mabi.202300081>

*Jose, J.C., M.N. Dolina & M.C. Tan. 2021. The remediation potential of biochar derived from *Morus rubra* Linn. bark. Malaysian Journal of Analytical Sciences 25: 324-340.

Rouz, A.L. 2009. Effect of feeding with three mulberry varieties and their semi synthetic diets on the silkworm *Bombyx mori* L. Journal of Agricultural Sciences of Mansoura University [Plant Protection and Pathology] 34: 8193-8199.

*Singh, S., D.P. Maurya, A. Shoaib, A. Tripathi & D. Singh. 2021. Phytochemical analysis and antidiabetic efficacy of *Morus rubra*. Journal of the Indian Chemical Society 98: 100170. 9 pages.

Thabti, I., N. Marzougui, W. Elfalleh & A. Ferchichi. 2011. Antioxidant composition and antioxidant activity of white (*Morus alba* L.), black (*Morus nigra* L.) and red (*Morus rubra* L.) mulberry leaves. Acta Botanica Gallica 158,: 205-214.

Wang, H-Y, Z-R. Tang & W.L. Zhou. 2016. A method for dyeing cotton fabric with anthocyanin dyes extracted from mulberry (*Morus rubra*) fruits. Coloration Technology 132: 222-231.

Wang, H-Y., M. Hussain & W-L. Zhou. 2017. A novel method for natural dyeing of cotton fabrics with anthocyanin pigments from *Morus rubra* fruits. Textile Research Journal 8: 1896-1911.

Zeng, Q-W., M. Chen, S-C. Wang, X-X. Xu, T. Li, Z-H. Xiang & N-J. He. 2022. Comparative and phylogenetic analyses of the chloroplast genome reveal the taxonomy of the *Morus* genus. Frontiers in Plant Science 13: 1047592. 12 pages.

END