# The Invasive Toringo Crabapple—Our Next ‘Bradford Pear’ in Kentucky?

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**Introduction**. Diverse cultivars of the common eating apple (*Malus domestica*, = *M. pumila*) have been planted across North America since early settlement during the 17th Century. This species sometimes persists for decades in recovering woodland, but it does not generally spread much by seed nor invade old fields in large numbers. Fruits and seeds are avidly sought by diverse mammalian herbivores and granivores (Spengler 2019, Spengler et al. 2023). After the Civil War, cultivars of the Siberian Crabapple (*M. baccata*) and related Eurasian species became widely grown as ornamentals. These crabapples do occasionally establish from seed, being dispersed mostly by birds, but they are not generally considered to be problematic invasive species in the native vegetation of Kentucky. EDDMapS (2024) shows only five precise sites with notable invasions of *baccata* in North America—although this is certainly an inadequate assessment.

Enter the "Toringo Crabapple"—*Malus toringo*! In its broad sense, this ornamental East Asian species includes plants known as *sargentii*, *sieboldii* or *zumi*. It is a shrub or small tree, usually 2-6 m tall but reported up to 10 m (then sometimes known as var. *arborescens*). Widely planted across northeastern states, *toringo* has become locally invasive, especially from New Jersey to Massachusetts, and also in Illinois, Indiana and Ohio (White 2012, Wilhelm & Rericha 2017, Kartesz 2024, EDDMaps 2024); see appended footnotes and maps. But in Kentucky and elsewhere, it has often been overlooked. Our first record of possibly naturalized plants within the state was a collection in 1978 by E.W. Chester from Trigg County, where it was "common on open roadside" of Land-Between-the-Lakes (APSC)—or was this just planted? More recently a self-sown tree, about 7-8 m tall and 15-20 cm dbh, was found in 2015 by the author at the edge of the wild woodland garden that has been established by Dr. D. Svetich of Fayette County. And shortly afterwards, we discovered that the species is spreading abundantly in nearby old fields and fencerows of Hisle Farm Park. The extent of naturalization by *toringo* in Kentucky remains largely unknown. Details of range and habitat have not been

presented in recent floristic publications nor even in unpublished reports. It has been ‘off the radar screen’, with almost no documentation of invasive status or of efforts to control.

**Taxonomy of the species**. Nomenclature here follows the Flora of North America (Dickson 2014) and Weakley et al. (2024). *Malus toringo*, broadly defined, is a variable species (Olien 1987, Gu & Sponberg 2003, Dickson 2014, Sutton & Dunn 2021, Ha et al. 2022). It typically has: white or pink flowers ca. 2 cm across, with 3-4 styles (versus 5 in most other *Malus*); relatively small fruits (ca. 4-8 mm wide), red or brownish-yellow; short pedicels (ca. 1.2-4 cm); short petioles (ca. 1.5-2.5 cm); leaf blades folded in bud, relatively narrow and often slightly to deeply lobed, especially on long shoots; branches often thorny on vigorous plants. Its leaf-lobing and thorniness can sometimes cause confusion with the native species of *Malus* or with hawthorns (*Crataegus*).

Both the East Asian *toringo* and the Siberian *baccata* have small fruits with deciduous sepals; whereas *domestica* [= *pumila*], *prunifolia* and the natives of eastern North America (*coronaria* etc.) have generally larger fruits with persistent sepals. *M. toringo* in its broad sense includes diverse variants distributed from western China to Korea to northern Japan, and there are also close allies that can probably interbreed (Gu & Spongberg 2003): *kansuensis*, *toringoides* and others; see appended notes. Some of these variants are apomictic triploids or tetraploids (Sax 1959). Possible hybrids of *toringo* with *baccata* known as× *zumi* have also been widely cultivated. Such hybrids have been collected in Ohio as well as more typical *toringo* (Vincent & Cusick 1998). Apparent hybrids between *toringo* and *baccata* are also known within their overlapping native ranges.

Recent analysis of DNA from within its native range has indicated that *toringo* in its broad sense may be hard to disentangle from *baccata* in the phylogeny (Cho et al. 2021, Ha et al. 2022). In its stricter sense, *toringo* is a largely Chinese diploid (2n = 34) that may be closest to

*kansuensis* (2n = 34), *toringoides* (2n = 51, 68) or other Chinese species. In contrast, some Korean or Japanese segregates of *toringo*, often named *sargentii* or *zumi*, may be closest to *baccata* or its allies.

If separated from typical *toringo*, *sargentii* (and perhaps some *zumi*) may be distinguished as follows (Koidzumi 1934, Fiala 1994, Schuster & Büttner 1995, Dickson 2014, Wilhelm & Rericha 2017): fruits larger on average (up to 10 mm wide), usually becoming dark red with slight bloom (versus often remaining brownish-yellowish); styles 4-5 (versus 3-4); flowers relatively large (up to 2.5 cm wide), with white suborbicular petals (versus white or pink, elliptic); leaves less deeply serrate or lobed (versus often deeply serrate to lobed); branches more horizontally spreading, dense and thorny; plants only up to 2.5-3 m tall (versus 6-10 m); 2n = usually 68 (versus 34). Most plants of the *toringo* complex that are cultivated in the U.S.A. may be referred to *sargentii*, but it remains uncertain whether the name *sargentii* should be applied to any of the invasive populations noted here.

Sutton & Dunn (2021) have provided further details of taxonomic issues within *Malus toringo*: "This is primarily a diploid, sexual species which readily produces hybrid seed when outcrossed in collections, although triploids and tetraploids also occur... Var. *sargentii* is one of these tetraploids. Fiala's (1994) claim that 'true' *M. toringo* is a yellow-fruited pentaploid, while *M.* × *zumi* (which he most unhelpfully calls *M. sieboldii* (Rehd.) Fiala) is a red-fruited diploid, is made without citing any reference, seems deeply suspect, and has been generally ignored. The status of *M.* × *zumi* (q.v.) is very uncertain; in Japan it has usually been treated as *M. toringo* var. *zumi* (Matsum.) H. Hara, with leaves not or scarcely lobed..."

Under var. *sargentii*, they stated: "It has often been noted that seedlings from Sargent's Crab are mostly true to type (Jacobson 1996), although this cannot be relied upon. This is a tetraploid plant showing facultative apomixis: almost all its seedlings are tetraploids,

genetically identical to the mother (Sax 1959). The fact that it can produce sexual offspring, mostly triploids resulting from crossing with sexual diploid species, explains the existence of cultivars and hybrids such as 'Rosea', a triploid with deeper pink buds raised at the Rochester Parks Department, NY before 1921 (Sax 1959); 'Tina' is an important modern cultivar (see 'Cultivars T-Z'), an open pollinated seedling of var. *sargentii*, which is even more dwarf. Whether or not any of these should be treated as belonging in this variety is debatable. 'Candymint Sargent' with its purple leaves is more obviously a hybrid (see 'Cultivars C')."

They continued on var. *sargentii*: "The horticultural literature has tended to list it as a full species (e.g. Bean 1981), and there is certainly a case for treating it as an apomictic microspecies in the orbit of *M. toringo*, but botanists have regularly sunk it entirely (e.g. Ohwi 1965; Royal Botanic Gardens, Kew 2020). A group of similar forms rather than a cultivar, this important garden plant requires a name, so we take a middle course following Cullen *et al.* (2011)."

**Development of cultivars**. The history of this species' cultivation and commercial spread is complicated by taxonomic issues and by the somewhat obscure or confusing documentation of crabapple cultivars. A central theme seems to be the foundational use of the *toringo* complex for rootstocks and breeding, especially tetraploid *sargentii* and triploid "*zumi*" as a putative hybrid with *baccata*. K. Sax (1959) noted: "Facultatively apomictic species of *Malus* include *M. sikkimensis*, *M. rockii*, *M. hupehensis*, *M. toringoides*, *M. sargentii* and its var. *rosea*. All are polyploids: the tetraploid species produce maternal tetraploids and hybrid triploids or pentaploids; the triploid species produce maternal triploids and hybrid tetraploids; both tetraploids and triploids also produce some aneuploids near the diploid level. Facultative apomixis is a dominant trait in the F1 hybrids between the facultatively apomictic polyploids and sexual diploids... Several of these apomictic apple species are excellent ornamental and *M.*

*toringoides* and *M. sargentii* are usually propagated from seed. For many years the apomictic *Malus* species have been tested as rootstocks for ornamental and horticultural apple varieties. If such seedlings proved to be compatible with the clonal varieties they would provide rootstocks without the expense and long period of time needed uniform rootstocks by vegetative propagation." Olien (1987) reviewed the importance of apomixis in more detail.

In his remarkably effusive synthesis of crabapple knowledge, Fiala (1994) extolled what he called the "Zumi Hybrids and Multibrids" as follows: "The discovery by hybridizers of the tremendous importance of a species once called *Malus sieboldii* var. *zumi* by some or *M.* × *zumi* by others brought into being a new race of crabapple known as the Zumi hybrids... Two of the clones—'Calocarpa' and 'Wooster'—have much smaller, colorful fruit and great disease resistance. Today there are so many single, red-budded, abundant, white-flowering, disease-resistant crabapples with every color of mini, small, and medium fruit that one wonders if there could be any room for more hybrids of this class. How many of these clones can nurseries continue to carry? It would seem that their introductions are at an end, yet more are named each day with nuances of differences." From a careful reading of Fiala's notes, it seems likely that the cultivars 'Calocarpa' (initially at Arnold Arboretum in 1890 then grown in Ohio after 1930) and 'Wooster' (an earlier flowering selection developed in Ohio after 1950) became widely promoted after 1960 and may have helped start the invasive trend.

Dosmann (2009) traced the long history of the Arnold Arboretum's crabapple collection and its importance for generation of new cultivars. He noted: "As the Arboretum shifted the focus of its collections policy towards acquisitions of known wild origin in the 1970s and 1980s, novel germplasm from Asia again crossed the threshold." In his filial account of *Malus* at the Arnold Arboretum, M. Sax (2011) noted *sieboldii* [perhaps = *toringo* sensu stricto] only once. But he did mention *sargentii* in several cases, with a favorite cultivar: "Select A (= Firebird®). This cultivar is of note because of its low, spreading form and the small, bright red

fruits that are retained well into the winter months. A Johnson Nursery introduction by Michael Yanny." Sax also emphasized a cultivar 'Mary Potter': "Named in honor of C.S. Sargent's daughter, this hybrid is a result of cross between *M. sargentii* 'Rosea' and *M.* × *atrosanguinea* [= *M. halliana* × *M. sieboldii*]." Curiously, he did not mention the "*zumi*" selections 'Calocarpa' and 'Wooster' that had been lauded by Fiala (1994).

The USDA has played a role in distribution of some crabapples. Their Plant Materials Program lists three "releases" promoted and distributed by the government at little or no cost to recipients (NRCS 2024): the 'Midwest' cultivar of *M. mandshurica* (Maxim.) Kom. in 1973 (a very hardy pubescent variant of *baccata*); the 'Roselow' cultivar of *sargentii* in 1978; and the 'Magenta' hybrid in 1990 (from *pumila* / *domestica*). Their 2014 brochure on 'Roselow' stated: "released as an open-pollinated, seed propagated cultivar. It exhibits excellent uniformity in size, form, and fruit color from seed... There are approximately 70,000 seeds per pound. Seedlings are easily propagated from seeds sown in nursery beds in late October."

Although *toringo* has often been promoted by the horticulture industry, it does have unpleasant features in some contexts. The widely spreading low branches, especially in var. *sargentii*, can make mowing and weeding difficult; alternatively a broad mulch zone may be desired (see image appended below). Vigorous shoots often develop short thorny branches that deter human access, and that presumably have evolved to reduce wholesale consumption of plants by larger mammalian herbivores such as goats. It is likely that resprouts after disturbance develop more thorniness. When *toringo* is used as grafting stock, the results may become confusing if the *toringo* root-collars eventually release sprouts. And when *toringo* is grafted onto a different root stock (such as *domestica*, the eating apple), other confusion can occur (see image below).

Current documentation of crabapple cultivars is challenging. Websites of the International Dendrological Society (IDS 2024) and Royal Horticultural Society (2024) provide details of some cultivars of *toringo* and related taxa, especially in Britain. And the taxonomic commentary in the IDS website is invaluable (e.g. Sutton & Dunn 2021). The International Ornamental Crabapple Society (2024) claims to have some central importance as a registry of cultivars—although it is not a listing of legal patents. Its current website (https:// www. crabapplesociety.org/ on 23 July 2024) has links to "About Crabapples", "Cultivar Checklist" and "Cultivar Registration" but these all lack relevant content or are broken. Their most recent reported event appears to be the 2021 symposium, with links to several talks. The talk by J.K. Iles (Iowa State University) noted the importance of *sargentii* in recent breeding.

Secrest Arboretum in Wooster, Ohio, claims to have "the largest crabapple collection in the US" (McClennan 2022): "The arboretum includes 84 different taxa of crabapples, replicated and randomized on a plot affectionately known as "Crablandia." One taxa may do well in one area, but fail in another – even within the same acre of land. Overall, 311 trees are residents of Crablandia. The arboretum boasts 555 trees and 167 taxa and the entire Wooster campus claims 701 total trees. Crablandia is the keystone plot of the International Ornamental Crabapple Society, a group of like-minded #malusmaniacs and #crabaholics who study disease resistance and ornamental features of crabapple. It's the product of nearly 40 years of work." But is this a prime breeding ground for new invasive genotypes?

And we still have basic questions about identification of cultivars.

1. Is there anywhere a definitive list of currently registered or patented cultivars?
2. How can a definitive list be maintained without reference to types and DNA sequencing?
3. Does identification of cultivars currently depend on opinion rather than biological data?
4. Who is most interested in such matters from scientific or commercial viewpoints?

**Records of invasion**. The first trees of *Malus toringo* (broadly defined) that were planted within North America appear to have been var. *sargentii* or × *zumi* in 1890–92 at the Arnold Arboretum (Fiala 1994; Dosmann 2009, Sutton & Dunn 2021). The first herbarium collection shown by SERNEC (2024) was from cultivation at the Arnold Arboretum in 1906 (Harvard A), then labeled as *M. sieboldii* var. *calocarpa* Rehder. There have been many subsequent records from cultivation. The first collections that indicate self-sown naturalization appear to date from 1977-82 (SERNEC 2024): by M. Nee in Wisconsin (WIS); W. Lampa in Illinois (MOR); E.W. Chester in Kentucky (APSC); R.L. Angelo in Massachusetts (GH); P.F. Siza in Vermont (VT); etc.

Local abundance of naturalized populations was indicated after 1990. In Ohio, Vincent & Cusick (1998) reported collections of naturalized *toringo*, *zumi* and other crabapples during the 1990s. After 2010 *toringo* has become locally abundant in unmowed fields and fencerows of the 2000-acre Dawes Arboretum and nearby (D. Brandenburg, pers. comm.). In Michigan, there is collection in 2006 by S. C. Garske, who noted a "well established population along an edge of a wetland in Ontonagon Co." (Reznicek et al. 2011). In Illinois, White (2012) reported dense invasion by seedlings of *toringo* at Meadowbrook Park in Urbana; his notes are appended below. For the Chicago area, Wilhelm & Rericha (2017) noted under *toringo*: "Far more common than our records indicate; vegetative whips of this species are common in shrubby old fields, pastures, and along hedgerows on fine to coarse textured soils... The American Robin, European Starling, and Hermit Thrush disperse the fruits. Flocks of the first two species can be seen on this crab apple at the end of the summer into autumn." Forest Preserves of Cook County (2021) noted: "Japanese crab apple (*Malus toringo*) has already been found in a few Forest Preserves locations and in surrounding communities".

One wonders if crossing between new cultivars in midwestern states has promoted invasion, as indicated for *Pyrus calleryana* by Vincent (2005), Culley (2017) and others. The Dawes Arboretum at Newark, Ohio, recently hosted a meeting: "Non-native CrabApple Research Collaborator DocumentationWorkshop" (30 April 2024). This meeting was led by Shana Byrd and David Brandenburg, who presented information on the extensive invasion by *toringo* (broadly defined) into old fields at the arboretum. Staff here have been observing, researching and attempting to control this invasion for up to a decade, but they have not yet published results.

In Kentucky, the first plantings of *Malus toringo*, as *sargentii*, may have been at Bernheim Forest (Johnson 2024): "One of the great treasures of the Bernheim Arboretum is its outstanding Crabapple Collection. This collection greets everyone who visits with its astonishing beauty, just a few short yards inside the entrance. The collection is among Bernheim's earliest, dating back to the 1930s and 1940s, though most planting records for that period were destroyed when the original Bernheim headquarters building burned down. Few, if any, of the original trees likely remain. Some trees have fallen victim to high winds and other severe weather, others succumbed to disease, and still others reached the end of their normal lifespan of 40-60 years." Bernheim Forest (2019) stated: "The crabapple collection on Crabapple Hill near the main entrance was planted in 1952 and is a part of the original Olmsted plan. Since then, the crabapple collection has been refined to only contain only the most beautiful, disease-resistant specimens." Their current list includes "*M. sargentii*" and "*M. sargentii* Tina". However, there is no evidence yet of significant invasion into nearby old fields or woods (A. Berry, pers. comm.).

The 1978 record from Land-Between-the-Lakes (see Introduction) may well have resulted from plantings by the Tennessee Valley Authority when they managed that area after 1965. The

TVA also planted other alien woody species, including several trees of *Pyrus calleryana* that were finally removed by the US Forest Service at the South Welcome Station in 2018! In Lexington, *M. toringo* (as *M. sargentii* 'Tina') has been planted at the University of Kentucky Arboretum; there are a few at corner of the parking lot, although one has recently been removed, perhaps due to fire blight. During 2024, J.Slade (pers. comm.) discovered that at least 100 seedlings had spread into this 50-acre arboretum, and they were destroyed. The same or similar cultivars have been planted at several other sites around Fayette County, including large groups in about 1990 near Krogers at Tates Creek Road and Man-O-War Boulevard, in about 2000 at Woodhill Shopping Center, and a few in about 2009 at the northern entrance to Lansdowne-Merrick Park. At that park, seedlings of *toringo* are scattered in unmowed areas, especially at the edge of thickets along the riparian zone. Seedlings appear to be slightly shade-tolerant.

The population of *toringo* at the 280 acre Hisle Farm Park in Fayette County is remarkable. There are 100s or 1000s of plants, which may originate from a small planting near the pond at northeast corner of the park. The most obvious trees are in fencerows and unmowed edges of the old fields. If unmowed for three or more years, these plants flower and fruit in profusion. In much of the park, south of the railroad, there is a three-year mowing rotation, and *toringo* is mixed with other trees and shrubs in the resprouts, especially black walnut, hackberry, Bradford / Callery pear, white mulberry, bush honeysuckle and multiflora rose. The plants become at least 4-6 m tall; they appear to be typical *toringo,* not *sargentii*. Across the railroad, the old fields are mowed annually in summer, but *toringo* has become common in the stubbly growth along with briars and poison ivy etc. The *toringo* there suckers laterally and puts up shoots. Management plans for this park remain uncertain. It would be wise to consider the potential problem with *toringo* invasion. Where mowing is relaxed, it would be desirable to spot kill all toringo sprouts before they grow more than a year old. We do not want this species

to become a new ‘Bradford Pear’ but ‘Pandora’s Box’ is now opened! We have limited planning and resources for control of invasive species across the landscapes of central Kentucky. But at least small groups of committed managers and volunteers could maintain a few relatively alien-free arboreta, parks and preserves. And we should of course grow much more of the native crabapples.

Continental mapping of *toringo* has been slow to catch up. Kartesz (2024) has included the species in BONAP only after 2010; see map appended below. Other national mapping projects have included it, especially EDDMapS (2024), but with curious inconsistencies; see appended downloads from invasiveplantatlas.org, invasive.org and eddsmaps.org. Local impressions within particular states are often interesting; for example, Gilman & Watson (2006) stated that *sargentii* has “little invasive potential” in Florida. Ideally, there would be more transparent sharing and comparing of data between different local and global mapping projects.

The inadequacy of EDDMapS (2024) to indicate naturalized *toringo* is particularly notable given the purpose of this system, established in 2007: “The central focus of the Early Detection and Distribution Mapping System (EDDMapS) is to foster the collection, amalgamation and sharing of these data to show a more complete map of the threat of invasive species and how this issue impacts the nation as a whole” (Wallace et al. 2022). However, there has not been comprehensive synthesis with records in iNaturalist, GBIF, SERNEC and BONAP, partly because those other websites sometimes include records of cultivated plants that are not differentiated from records of truly naturalized plants.

Given the concentrations of alien genetic material and breeding programs for crabapples in major arboreta and botanical gardens of North America, it is surprising that so little has been written about potential invasions. One of the few relevant publications is an article by

Tietmeyer & Bristol (2002), but their purpose was only "to collect baseline data to assist in the evaluation of the potential invasiveness of this small tree and some of its varieties and cultivars in the Chicago region." They reported on numbers of viable seeds per fruit, but provided no data on numbers of fruits per tree or on actual occurrence of naturalized seedlings across the landscape. There are zero comments on potential invasiveness by alien crabapples in the publications of Fiala (1994), Dosmann (2009), Sax (2011) and the whole 2021 issue of "Malus"—Journal of the International Ornamental Crabapple Society. This journal was revived in 2021 under its new "patron", the China National Botanical Garden (IOCS 2024).

There has not yet been a thorough investigation into the potential role of apomixis, defined as clonal production of seeds from maternal tissue without pollination. It is likely that the reported apomictic reproduction of *sargentii* and so-called "*zumi*" has facilitated their invasion (Sax 1959, Olien 1987, Fiala 1994). Several papers have attempted to correlate invasive behavior of woody species in North Temperate regions with functional traits (e.g. Herron et al. 2007, Widrlechner et al. 2009, Boyce 2010, Dehnen-Schmutz 2011, Grotkopp et al. 2010, Pyšek et al. 2014). There has been little to no mention of apomixis in such papers, except for those dealing with *Rubus* (e.g. Clark et al. 2013). However, in a broader global context, and covering all vascular plants, there has been much research that indicates a major role for apomixis in some cases of invasive species (e.g. Rambuda & Johnson 2004, Hörandl 2010, Pannell et al. 2015).

**Divergent interests of varied 'plants-people'**. This inquiry into potential invasion by *Malus toringo* in eastern North America touches on an underlying human problem among 'plants-people' in general. People with intense interests in plants are divisible into three broad intergrading classes: taxonomists or others interested in appropriate naming; horticulturalists and others interested in growing for food or aesthetics; restorationists or others interested in

promoting more or less native species. The general public, without deep education in these matters, is easily confused by the plethora of professional recommendations for naming, buying and planting diverse types of plants. There is often inadequate consensus-building among these three groups, as the case of crabapples.

The complex taxonomy of *Malus*, including *toringo*, has resulted in a long history of uncertain nomenclature. Problems remain unresolved at the genus or subgenus level (e.g. Liu et al. 2022, Zhang et al. 2023) and at the species or variety level, as in *toringo* (e.g. Sutton & Dunn 2021, Cho et al. 2021). The avid horticultural interest in diverse cultivars has resulted in hundreds of names for plants that are often difficult to distinguish or document, yet that are often promoted for commercial use without mention of potential invasiveness (e.g. Fiala 1994, IOCS 2024). Restorationists and conservationists should be interested in focussing on native species of *Malus*, rather than alien species, although aliens are often marketed for feeding birds. However, there is little current commercial propagation of natives in eastern North America. The largest living collection of crabapples in the USA, at Secrest Arboretum, does not list *angustifolia* or *coronaria* or *ioensis* (https://secrest.arboretumexplorer.org/). Until recent years, there has been virtually no propagation of natives in Kentucky. Moreover, vegetation that has abundant native *Malus* has almost disappeared from eastern North America. NatureServe (2024) lists such vegetation (with *ioensis*) only from northern Illinois (under their code CEGL 5073). Yet historical records, place names and occasional remnants suggest that “crab orchards” and crabapple-lined trails used to be scattered through the landscape, especially on the west side of the Alleghenies and Appalachians. Large herbivores may have been a major factor promoting *Malus*.

No state or federal agency has listed any type of *Malus* as an invasive species or noxious weed (Kartesz 2024). In contrast, *Pyrus calleryana* is prohibited from sale in Ohio (ODNR

2023) and Pennsylvania (PDA 2021). A proposal to add *M. toringo* (or at least some of its cultivars) to the list of legally controlled invasive species in Ohio may be pending, but some opposition from the nursery industry is anticipated (S. Byrd, pers. comm.). In Kentucky and most other southeastern states, with the notable exception of Florida, there are no legally prohibited woody plant species.

Despite divergent interests of varied 'plants-people' there may be some agreement that the native species deserve a lot more interest for taxonomic treatment, for propagation in horticulture, and for recovery in the wild. These species are notable for their unusually strong floral odors, allowing detection from distances of 100 m or more. There was some intense local interest in cultivation and breeding of native species a century ago (e.g. Crandall 1928). Fiala (1994) listed several named cultivars that were initially grown at the Morton Arboretum or elsewhere. However, there has been little development of this initial interest. Based at the University of Kentucky, Durham et al. (1999) promoted many cultivars of alien crabapples, including several cultivars of *sargentii* or *zumi*. But they included the native species their list of "Flowering crabapple cultivars that should not be planted because of extreme susceptibility to several diseases. These crabapples would be a liability in most Kentucky landscapes." The NRCS (2024) has distributed native *coronaria* from Georgia but a recent blog stated (Elizapples 2015): "This apple (the variety is called "Big O") was last seen in 2006 at the USDA/NRCS Jimmy Carter Plant Materials Center in Americus, Georgia. They distributed these trees to people who inquired and have since stopped distributing. The breeding program is over and the trees no longer exist in Americus..." The detailed work of Dickson (1995) led to her treatment for the Flora of North America (Dickson 2014), but there has been little other published research on the *coronaria* complex (with *angustifolia* and *ioensis*) since 1995. There has been a recent publication on DNA-sequencing (Svara et al. 2024). We now need to revive collection and analysis of diverse material for better understanding.

**Conclusion**. The East Asian species of crabapple, *Malus toringo* (broadly defined), has recently been found to form an invasive population at Hisle Farm Park in Fayette County, Kentucky. This is the first report of a clearly invasive population in Kentucky, although there are possible records of self-seeded plants as early as 1978. Based on a review of records from across eastern North America, it appears that this species has indeed become invasive during the past 10-20 years, at least across east-central states from Illinois to New Jersey.

Introductions of *Malus toringo* and allied taxa into North American arboreta and for associated breeding programs have been occurring since the 1890s, but may have accelerated after 1980, with the revived cultural exchange between China and the U.S.A. Some of the most popular cultivars have been derived from var. *sargentii*, a tetraploid segregate that is native to Korea and Japan. However, it also appears likely that crosses of var. *sargentii* with typical diploid *M. toringo* or *M. baccata* have produced apomictic triploids. Such triploids may include some of the popular cultivars sometimes known as *M. sieboldii* or *M. zumi*, both being confused or invalid names. The identity and phylogeny of *Malus* cultivars remains an intractable matter, without clear detailed descriptions and type specimens. Analysis of DNA sequences would enable much better understanding.

The invasive plants of *Malus toringo* in Illinois (especially at Meadowbrook Park of Urbana), Ohio (especially at the Dawes Arboretum) and Kentucky (especially at Hisle Farm Park) have been observed for several years to form thickets in unmowed old fields. Bush-hogging at intervals of several months or a few years allows plants to form lateral suckers, spreading at least 1 m from original seedlings. Scattered seedlings of *toringo* have been observed within a mile or more of plantations in parks and arboreta. There appears to be a real potential for this species to become as problematic of *Pyrus calleryana*. *M. toringo* may be slightly more shade tolerant and slower growing. Its gradual spread should be monitored and control should be planned, at least on public lands.

**Footnotes from other states**

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**Illinois**

John White (2012); this obscure report is now on the internet but it has not been cited before! "Japanese Crab [*M. sieboldii*] and Siberian Crab [*M. baccata*] are the two most invasive crab species in Meadowbrook Park [Urbana, Illinois], and Japanese Crab is the worst. Counting both planted and wild trees, I estimate that there are roughly 10 to 15 times as many mature Japanese Crabs as Siberian Crabs. There are thousands of times more Japanese crab seedlings than Siberian crab seedlings, and Japanese crab saplings are perhaps 50 times more common than Siberian crab saplings.

"In May of 2011, I chose an average, representative spot near the big Japanese Crabs along the Wildflower Walk and counted 92 crab seedlings in a square foot. Most of the seedlings died as the growing season progressed, and only a few might survive to the sapling stage, but Japanese Crab obviously can dominate the vegetation if left uncontrolled.

"Various species of apples and crabs (the genus *Malus*) have been hybridized and selected to produce scores of ornamental varieties, resulting in confusion about their identification and naming. For instance, Zumi Crab is variously considered to be a distinct species, or the same as Japanese Crab, or a variety of Japanese Crab, or a form of Siberian Crab, or a hybrid between Japanese Crab and Siberian Crab. The origin of many horticultural varieties and crosses is so mixed or uncertain that nursery growers often do not attempt to name the parents, simply calling them "*Malus* species" – as can be seen on some of the tree labels in Timpone Grove."

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**Indiana**

Scott Namestnik (Indiana Natural Heritage Program) in email to JC on 5 July 2023.
“I collected what I think is the specimen upon which the Indiana record of *M. toringo* in Flora of the Chicago region is based in Lake County (see Consortium of Midwest Herbaria, under *Malus sieboldii*). The collection was from a site where restoration was going to be taking place. I saw it at another Lake County site where restoration was going to be taking place; here it was forming a pretty dense thicket. I’ve also collected it in LaPorte County, Indiana, at a site near Ambler Flatwoods (and maybe part of the site now). At all sites, it seemed to be a spontaneous introduction. I’ve also thought that it could be a bad invasive.”

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**Ohio**

Shana Byrd (Dawes Arboretum) in email to JC on 14 June 2024; regarding Malus toringo sensu lato. “We also have a robust, multi-year conservation resource management plan that aims to systematically control established populations and prevent further spread. Although not published, these early findings suggest that standard herbicide treatments used on almost all common woody invasive species are effective to varying degrees. Mowing alone, without chemical treatment, is not effective and only serves to mask the invasion. This is reflected in your comments within the publication and our research supports this as well. The main thrust that would be valuable to convey from our standpoint is that we are taking a proactive approach to control this plant's invasion into natural areas, despite the lack of official designation as an invasive species, based on our organization's conservation ethic to prevent spread and raise awareness.”

**Abbreviations for herbaria in text.**

APSC: Austin Peay State College (Clarksville TN)
GH: Gray Herbarium, including Arnold Arboretum collections (Boston MA)
MOR: Morton Arboretum (Chicago IL)
OS: Ohio State University (Columbus OH)
VT: University of Vermont (Burlington VT)
WIS: University of Wisconsin (Madison WI)

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A popular cultivar from  mixed parentage: ‘Mary Potter” (USDA Forest Service Fact Sheet 393). Up to 3 m tall and 5 m wide [https://www.cirrusimage.com/tree_toringo_crabapple/]

Ripe fruit 6-8 mm wide, brownish yellow to red, hard, persistent; winter bird food (Robel et al. 1981, Herron et al. 2007) [https://www.barcham.co.uk/store/products/malus-toringo].

Typical appearance of vigorous shoots with more lobed leaves; Hisle Farm Park. Fayette County Kentucky [JC 2023/6/22].

Closeup of lobed leaves [https://gobotany.nativeplanttrust.org/species/malus/sieboldii/]

Thorny short branches formed on vigorous sprout; Lansdowne-Marrick Park [JC 2023/6/22].

Welcome to the glorious New Circle Road NE! At the entrance to Woodhill Shopping Center. Betwixt these fine equine eggheads, admire the long line of alien crabapples! 11 Aug 2023.


The long line of dwarf *toringo* crabapples (presumably the *sargentii* variant), loaded with fruit. along New Circle Road NE. To right: Japanese quince (*Chaenomeles speciosa*). 11 Aug 2023.

*Malus toringo* about 15 years old at east side of Lansdowne-Merrick Park; these two plants had been grafted onto root-stock of the common eating apple (*M. domestica*), which has now sprouted to form the upper halves and produces its own larger fruits. 21 Jun 2023.

*Malus toringo* on graft at Lansdowne-Merrick Park; showing fruits of typical apples (*domestica*) on the rootstock that have sprouted to overtop the *toringo*. 22 Sep 2023.

Closeup of the two apples grafted into one “Frankentree”. Regular apples are eaten by squirrels and other mammals. The small crabapples are eaten by birds much later in winter. 22 Sep 2023.

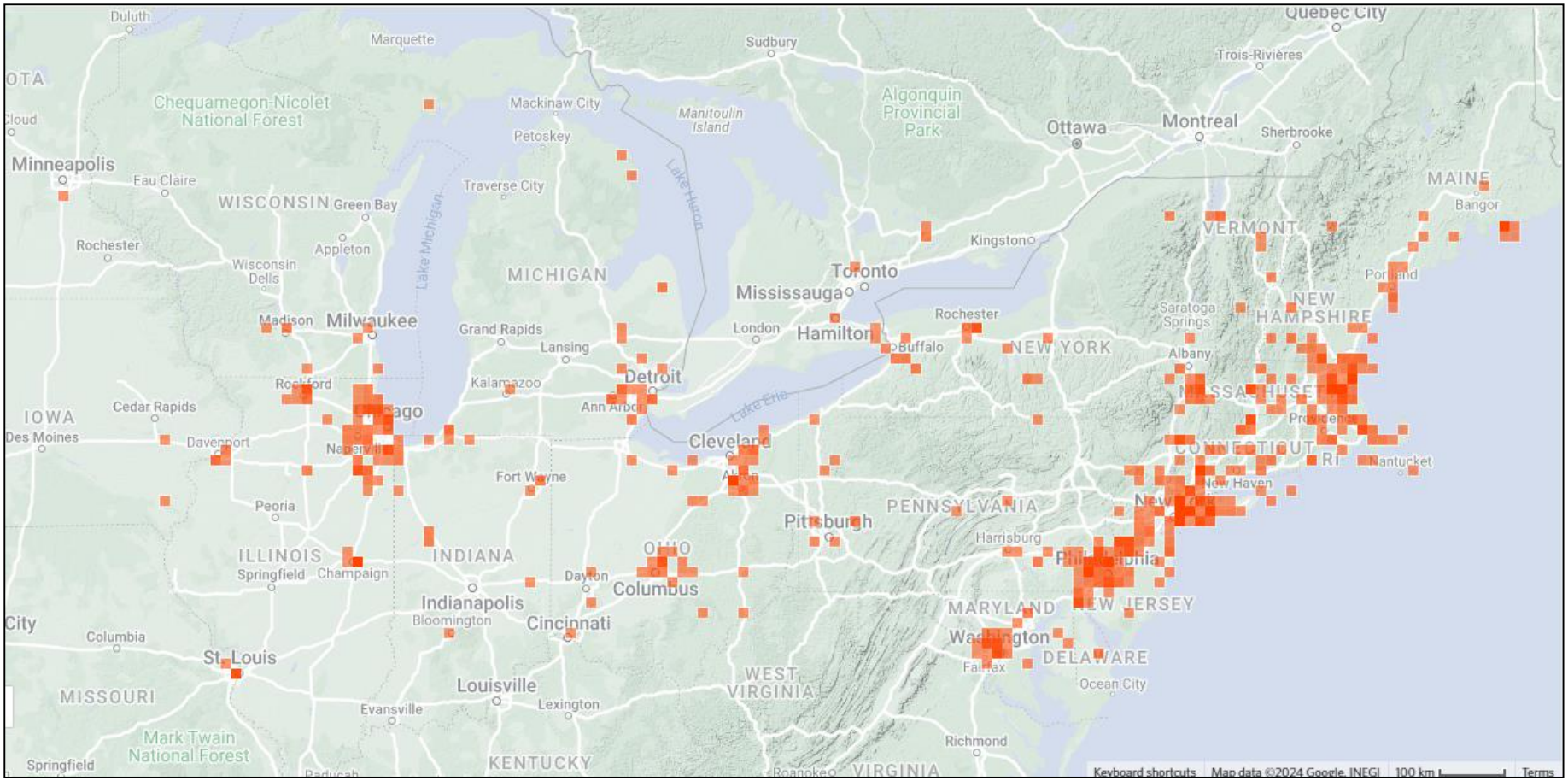
The relatively large wild tree at edge of Svetich Woods, Briar East Road: 38.01426, -84.37802. About 8 m feet tall and the main trunk 20 cm dbh. It should be cut down! 23 Jun 2023.


Left: respouted *Malus toringo* 2-3 m tall, 1-2 years after mowing at Hisle Farm Park.
Right: low ground cover of *toringo* sprouts, < 30 cm tall, mowed once or twice per year.
21 Jun 2023.

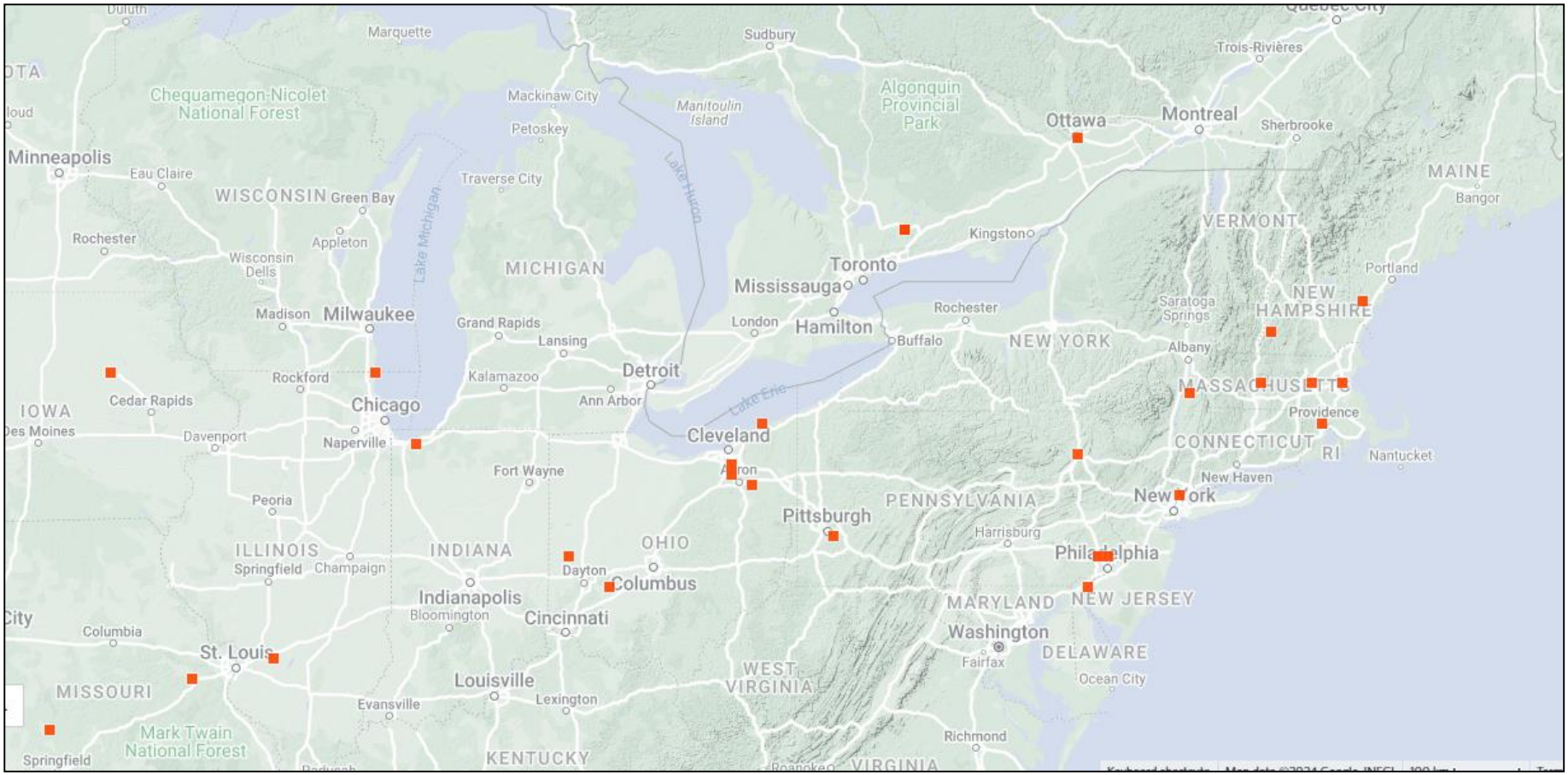
An excavation of typical bush-hogged clump at Hisle Farm Park (6 May 2024). These pieces were all connected by laterally running roots. Imaged area is approximately 2 m wide.

Example of invaded old field at Dawes Arboretum, Newark, Ohio (30 Apr 2024). Arboretum staff have become aware of this serious problem during the past decade or so.

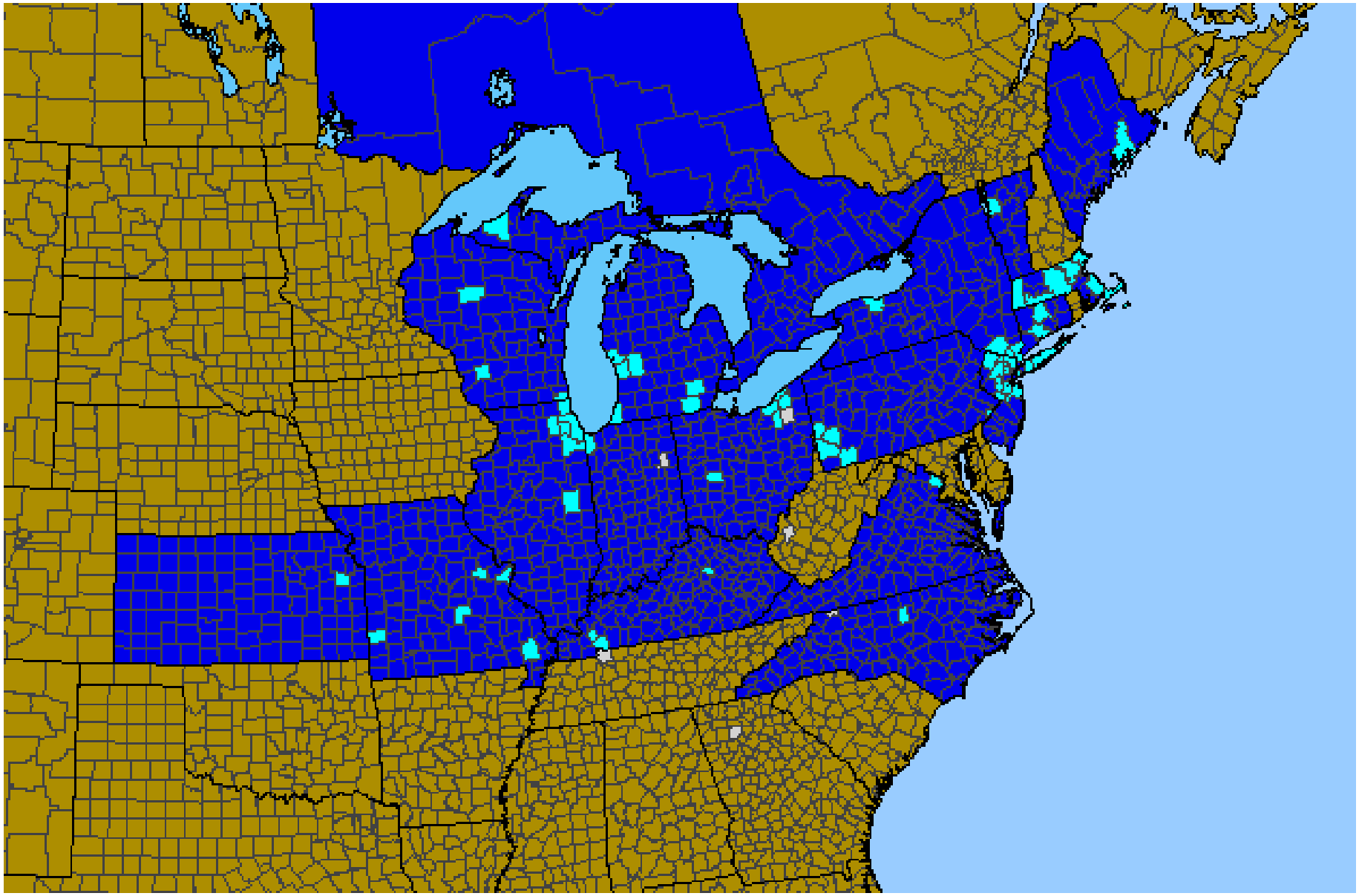
Example of seedlings from same maternal collection at Dawes Arboretum (30 Apr 2024). Note variation in degree of lobing,



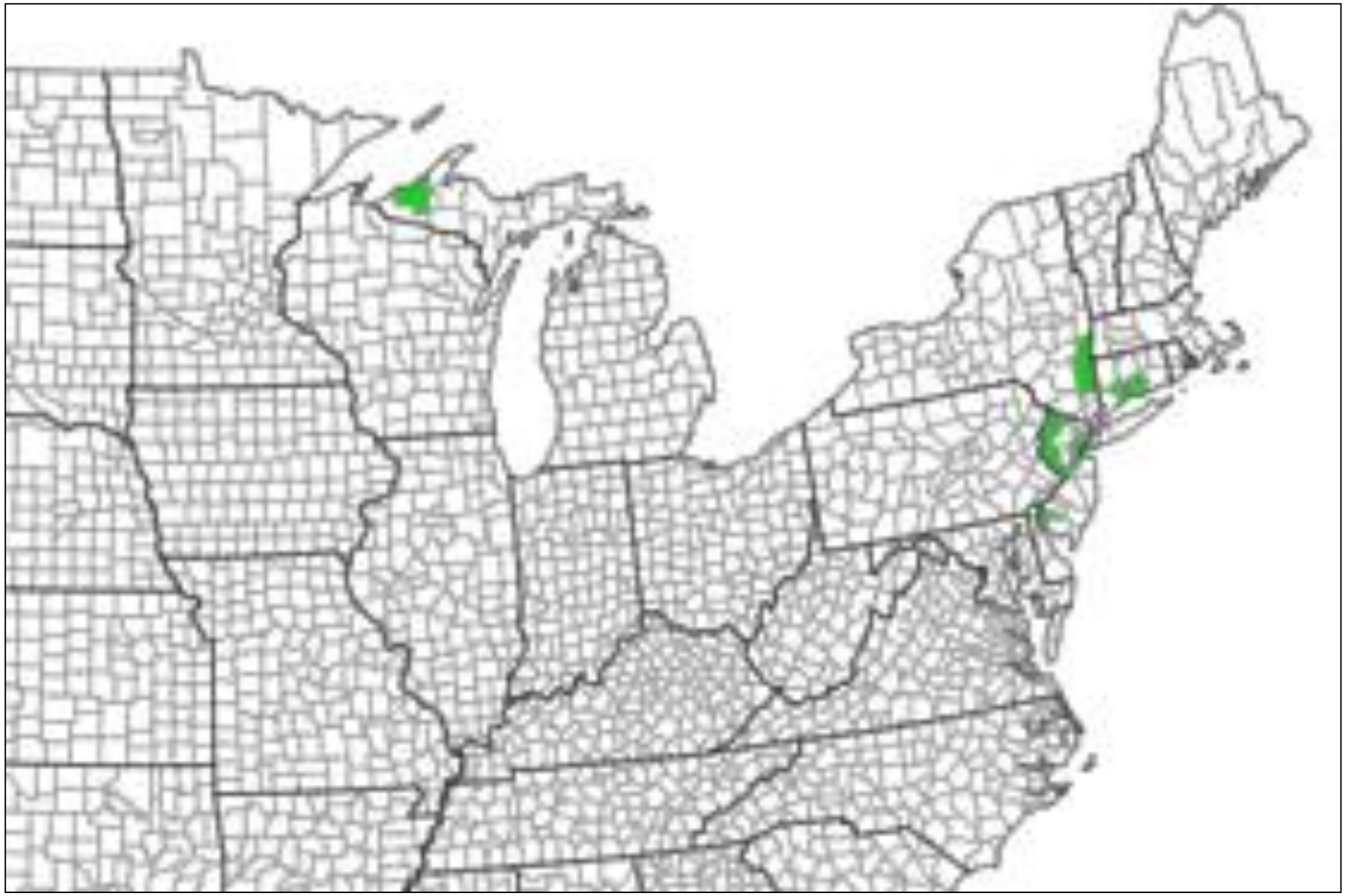

Mapped records of *Malus toringo* in iNaturalist.org. These data include *M. sieboldii* but not *M. sargentii*. (5 May 2024).



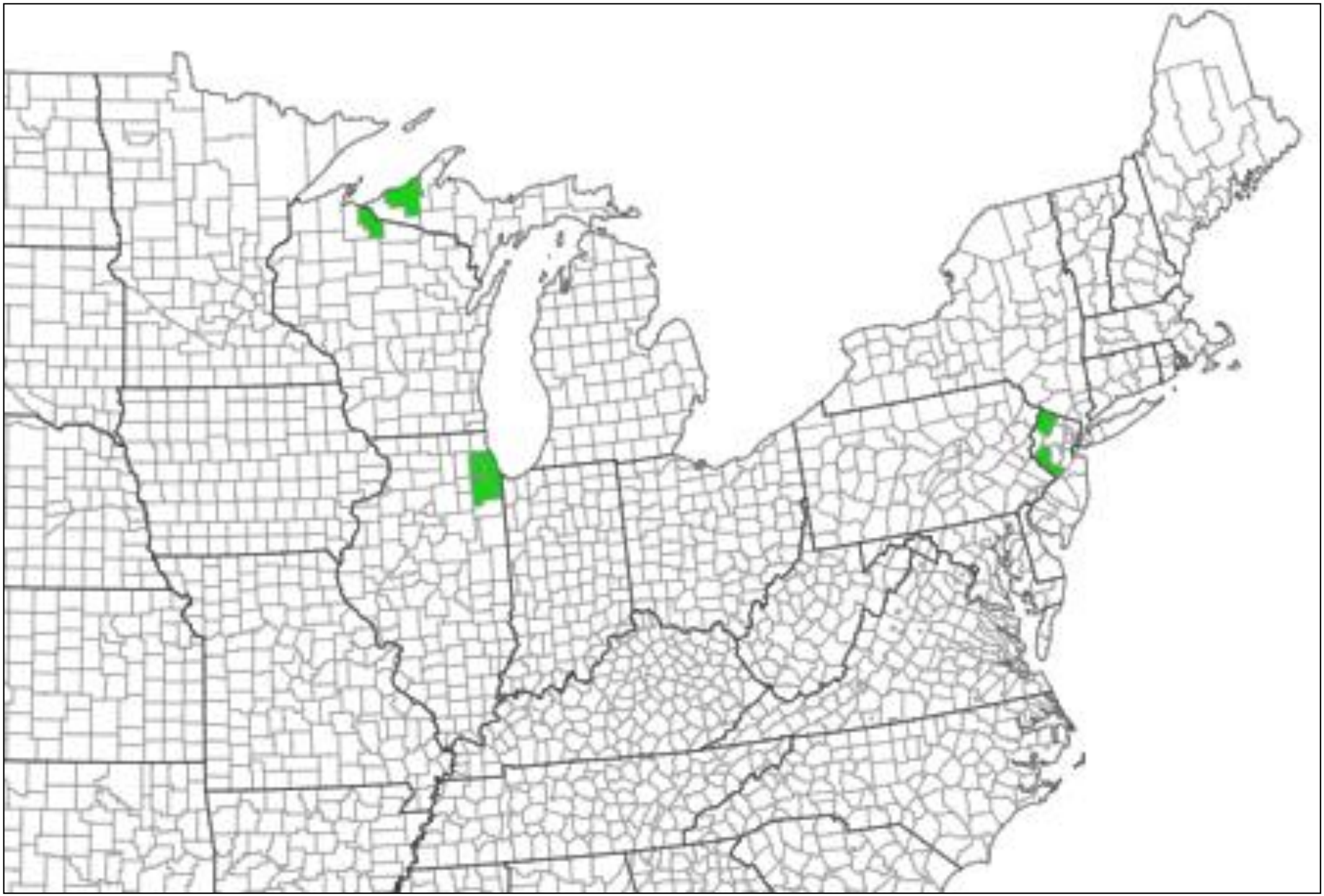

Mapped records of *Malus sargentii* in iNaturalist.org (5 May 2024)



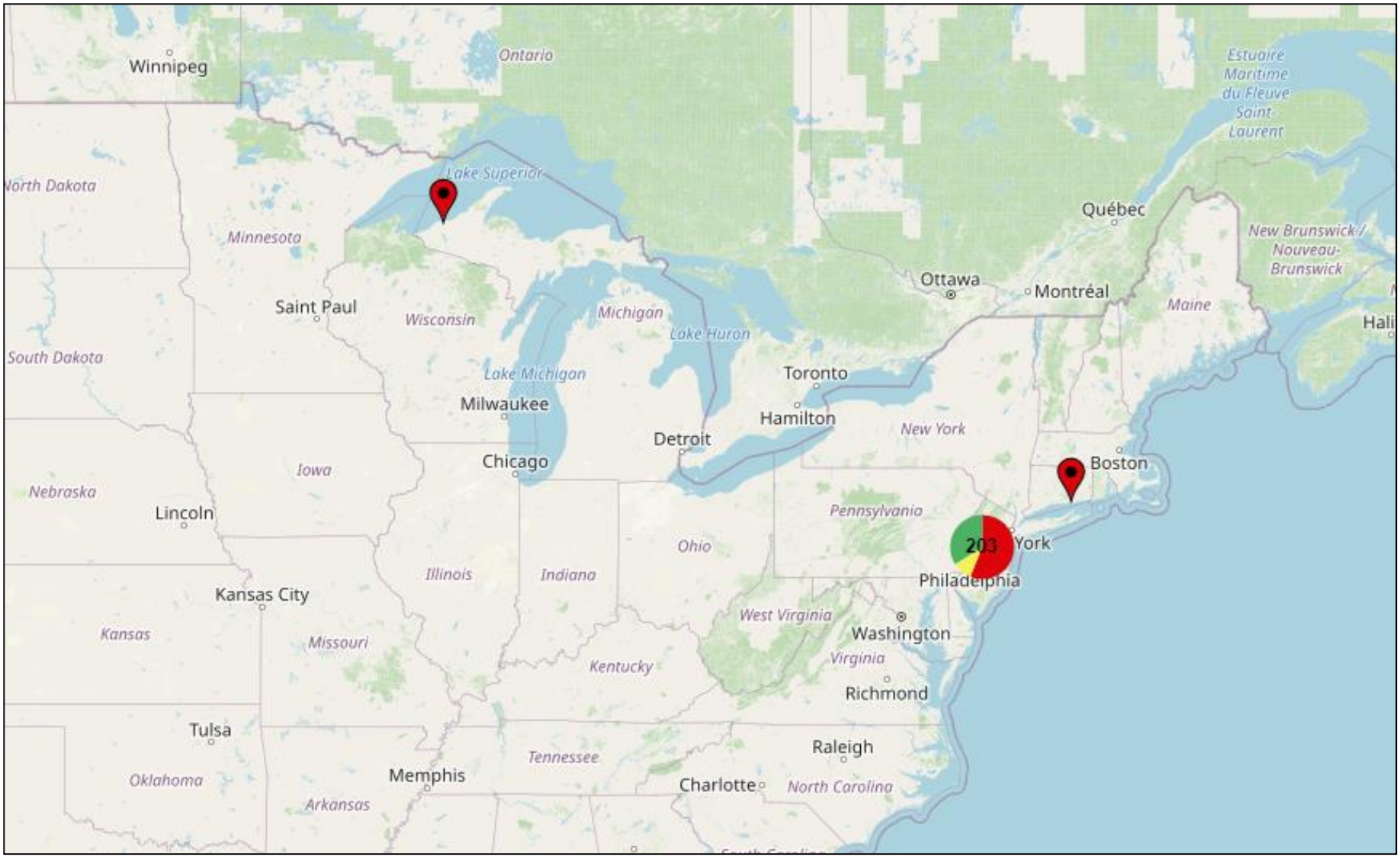
Documented distribution of *Malus toringo* in BONAP (Kartesz 2023): 15 Jun 2023 [http://bonap.net/MapGallery/County/Malus%20toringo.png]. Sources are provided but the records from Lyon Co. KY and Stewart Co. TN remain uncertain or dubious.



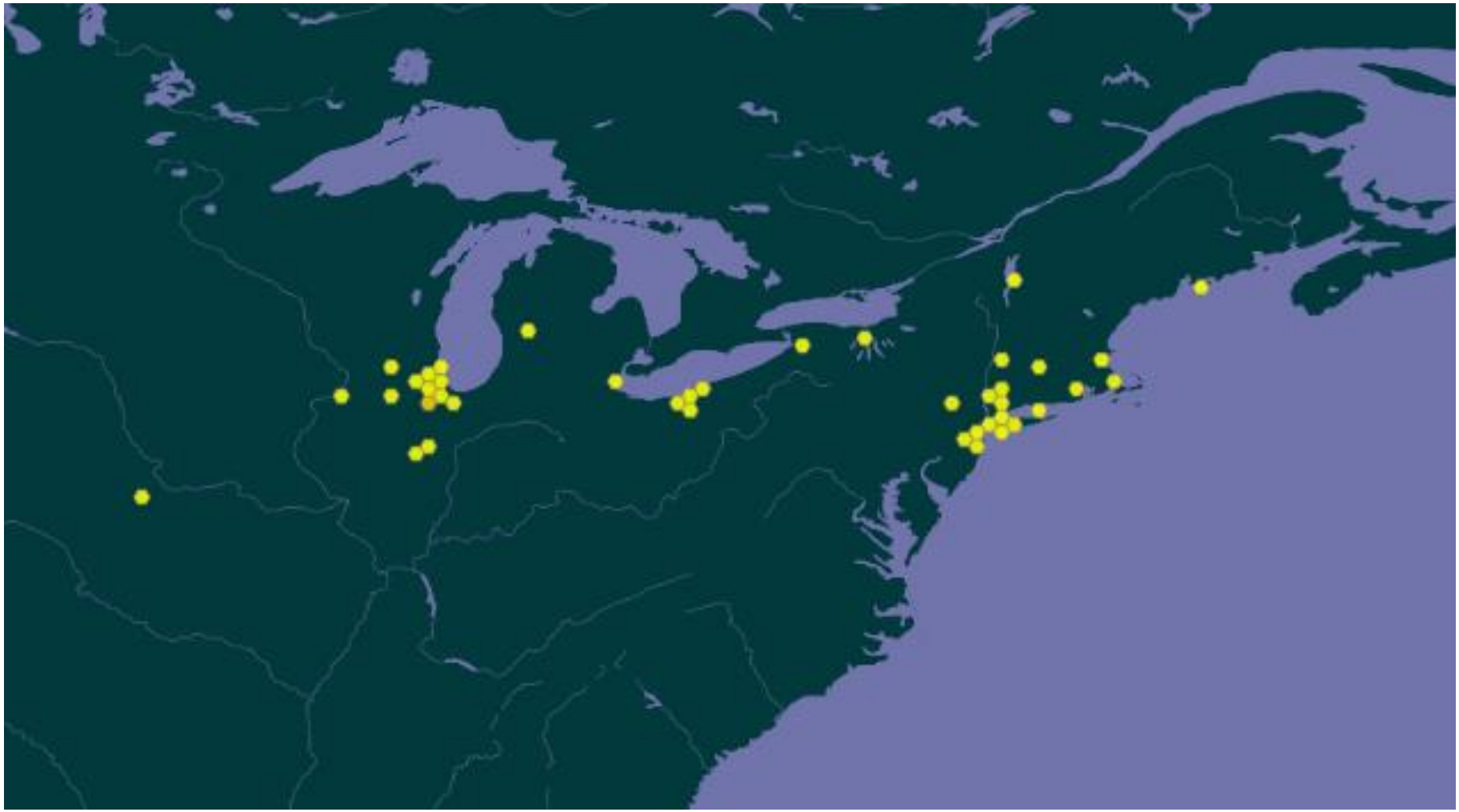
*M. toringo* in EDDMapS-A [https://www.invasiveplantatlas.org/subject.html?sub=52255]: viewed 24 Jun 2023. “This species does not appear on any state or national invasive species lists. Please contact us if a state or federal list needs to be updated.” No sources were provided.



*M. sieboldii* in EDDMapS-B [https://www.invasive.org/midatlantic/subject.cfm?sub=74340]: viewed 24 Jun 2023. There was no map for *M. toringo*. The rationale for this "midatlantic" map within the EDDMAPS system is not clear; see differences from A to B to C.



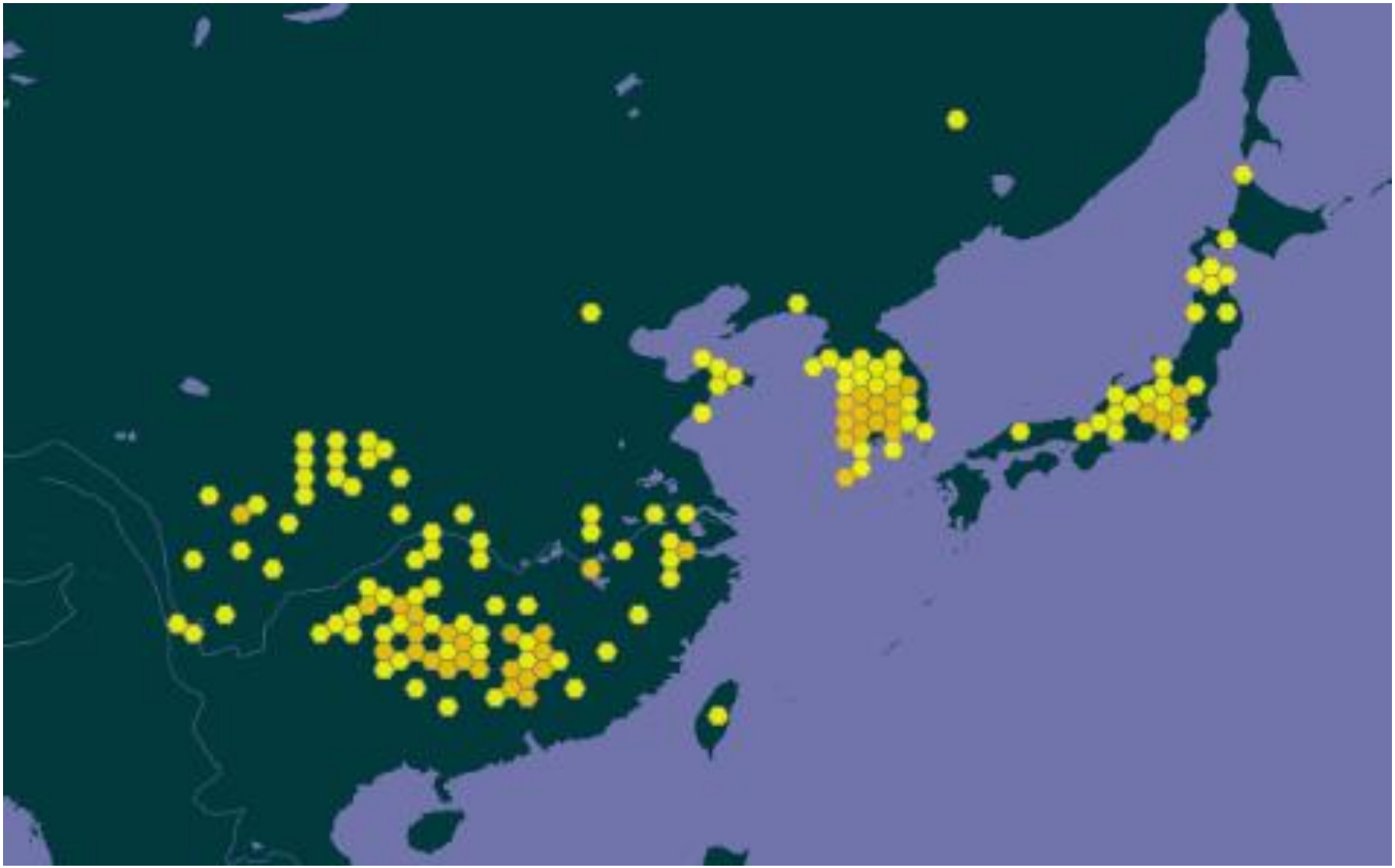

*M. toringo* in EDDMapS-C [https://www.eddmaps.org/distribution/viewmap.cfm?sub=52255]; viewed 24 Jun 2023. The pie-chart in New York City area shows breakdown into "positive" records, "treated" records, and "eradicated" records. If zoomed in, the maps shows much "eradication" in New Jersey between Trenton and Lambertville, especially in the "Fiddler's Creek Preserve". But who manages this preserve? What is its plan and history?



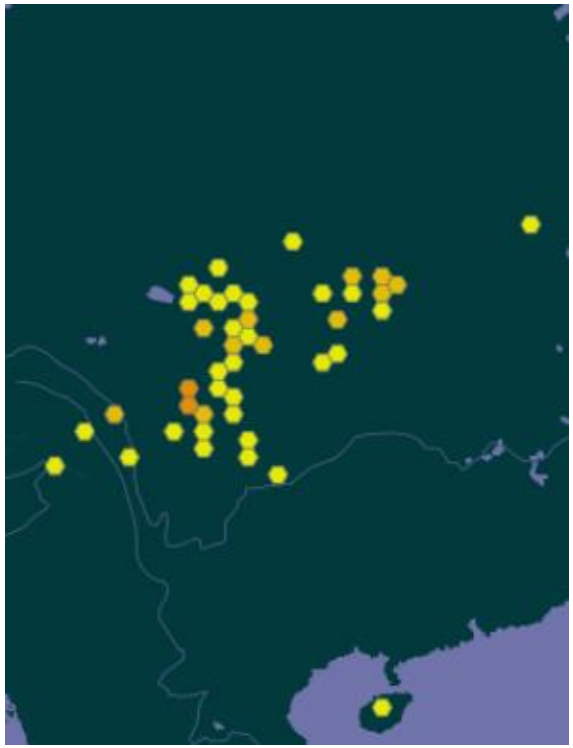
Records of *Malus toringo* mapped for eastern North America in gbif.org (Global Biodiversity Information Facility). These data are combined from varied sources, including herbaria and iNaturalist data, but apparently not up to date. There are no data from eastern Canada. (22 Jun 2023)

Records of *Malus sieboldii* mapped for eastern North America in gbif.org (Global Biodiversity Information Facility). These data are combined from varied sources, including herbaria and iNaturalist data, but apparently not up to date. There are no data from eastern Canada. (22 Jun 2023)

Records of *Malus sargentii* mapped for eastern North America in gbif.org (Global Biodiversity Information Facility). These data are combined from varied sources, including herbaria and iNaturalist data, but apparently not up to date. There are no data from eastern Canada. (22 Jun 2023)



Native range of *Malus toringo* in East Asia, as mapped by GBIF (Global Biodiversity Information Facility 2023); viewed 22 Jun 2023 [https://www.gbif.org/species/3001650]. These data appear to include records of *M. sargentii* and *M. sieboldii*, which have been considered distinct species in Japan with different chromosome numbers. However, Dickson (2014) indicated that *sieboldii* is not a valid name.

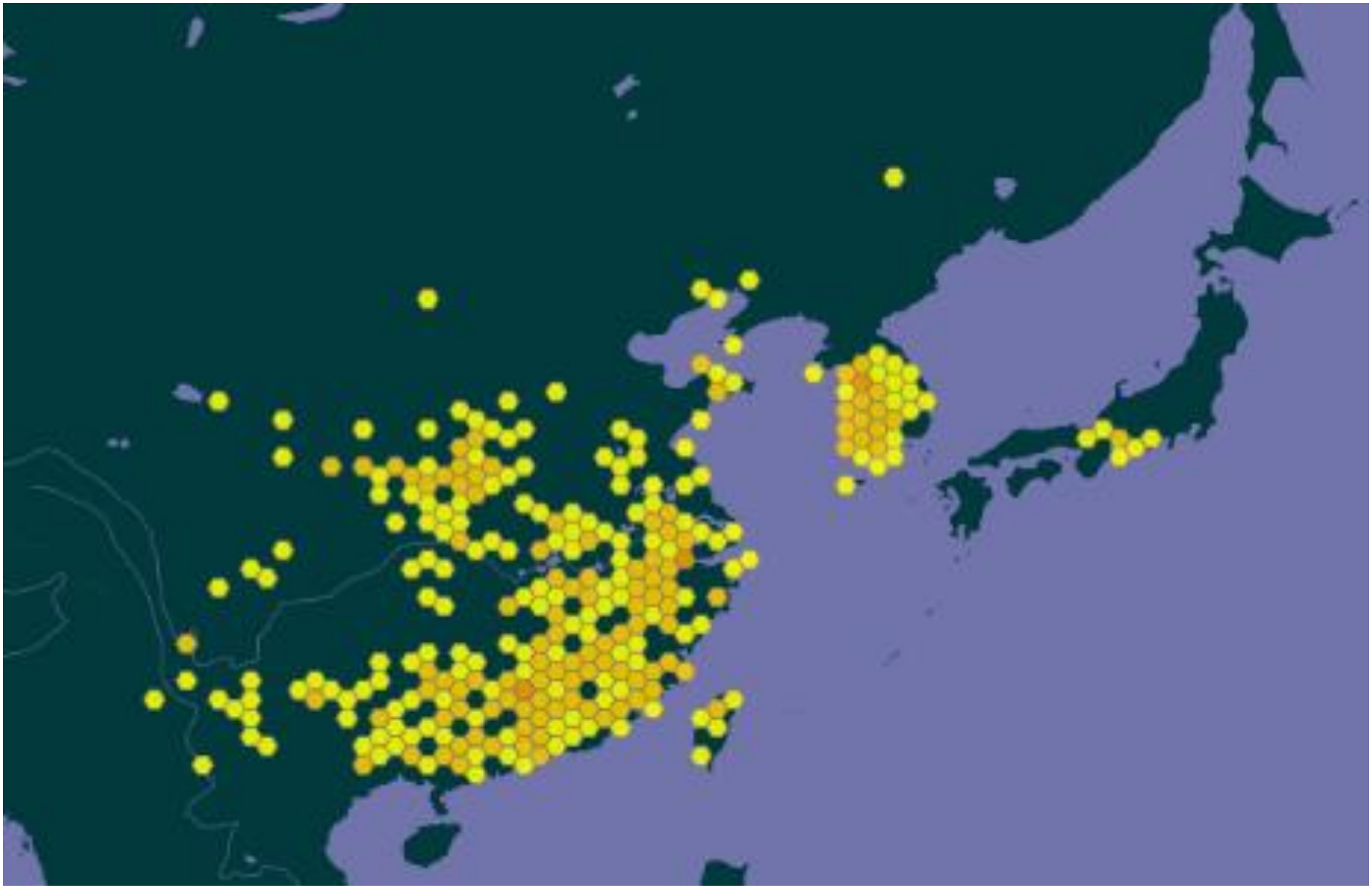




*M. kansuensis* [including *toringoides*] *M. transitoria* *M. komarovii*

These are native ranges of species that are closely related to *toringo*, as mapped by GBIF.

Gu & Sponberg (2003) distinguished these species from *M. sieboldii* (including *toringo*) as follows.

| | | |
|---|---|---|
| 17 (16) | Styles basally villous; pome subglobose. | 15 *M. sieboldii* |
| + | Styles basally glabrous; pome ellipsoid or obovoid, rarely subglobose. | (18) |
| 18 (17) | Leaf blade often 3–5-lobed, doubly serrate at margin; pome with few stone cells. | (19) |
| + | Leaf blade 3–5-parted, not doubly serrate at margin; pome without stone cells. | (20) |
| 19 (18) | Lobes of leaf blade triangular-ovate; leaf blade rounded or truncate at base; fruiting pedicel 2–3.5 cm. | 16 *M. kansuensis* |
| + | Lobes of leaf blade oblong-ovate; leaf blade cordate or subcordate at base; fruiting pedicel 1.2–1.5 cm. | 17 *M. komarovii* |
| 20 (18) | Young branches puberulous, soon glabrescent; leaf blade undivided or sometimes parted, both surfaces pubescent; flower 2–2.5 cm in diam. | 18 *M. toringoides* |
| + | Young branches tomentose; leaf blade parted, tomentose on both surfaces; flowers 1.5–2 cm in diam. | 19 *M. transitoria* |



Native range of *Pyrus calleryana* as mapped by GBIF [https://www.gbif.org/species/5363119]. Note similarity to the *Malus toringo* complex. (22 Jun 2023)