



Malus

Journal of the International Ornamental Crabapple Society

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The sheer abundance of 'Evereste' blooms in spring makes it a sight to behold ...
and also a precious pollenizer for domesticated apples that are self-sterile.



On This Page. A *Malus PERPETU* 'Evereste' with an abundant display of luscious fruits that hang throughout winter. Photographed at Silva Tarouca Research Institute Dendrological Garden, Czech Republic.



International Ornamental Crabapple Society

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On The Cover. *Malus PERPETU* 'Evereste' photographed at Silva Tarouca Research Institute Dendrological Garden, Czech Republic. Developed in 1974 by the Institut National de la Recherche Agronomique (INRA) and registered under the trademark name *Malus PERPETU*.

This highly disease-resistant cultivar is popularly known in the trade as 'Evereste' and received the Royal Horticultural Society's Award of Garden Merit in 1993.

'Evereste' can grow up to 7m in height with a spread of 6m and forms a broadly conical outline. It has slightly lobed leaves and flowers that are red in bud and open white. Its fruits are yellowish-orange and red-flushed, and hang throughout winter. The sheer abundance of its blooms in spring makes it a sight to behold.

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On This Page. A spectacular view of Tianshan (Heavenly Mountains) and *Malus sieversii* in bloom. Photographed at the Wild Apple Germplasm Conservation Center within Yili Botanical Garden in Xinjiang Uygur Autonomous Region, China.

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From The Presidents

Dear Crabapple lovers:

It is a tremendous joy to see **Malus**, the official publication of the International Ornamental Crabapple Society (IOCS), being published again after a 20-year hiatus.

Crabapples are one of the most beautiful and useful ornamental trees. They have been adored for centuries, thanks to their attractive flowers, colorful fruit, fall foliage, as well as their range of growth habits, from weeping to strictly upright. Crabapples are also valuable edible plants, producing fruit that can be turned into delicious jams, jellies, and cider. It is wonderful to see that modern breeding initiatives are addressing all these traits, especially in China.

The strength of the IOCS is rooted in its history in fostering and maintaining collaborative relationships between crabapple experts and enthusiasts worldwide. The resumed publication of **Malus** is the result of multifaceted partnerships between botanical institutions in Asia, Europe, and the United States.

In April 2021, we held a successful International Ornamental Crabapple Symposium, both online and at the Chinese Crabapple Garden in Yancheng, Jiangsu Province, China. We also elected a new President, Professor Guo Ling from China National Botanical Garden who contemporaneously serves as the International Cultivar Registrar of Crabapple (excluding *M. domestica* Borkh.).

Restarting the publication of **Malus** is a fantastic opportunity to generate and share scientific knowledge of this interesting and important genus. **Malus** will be of benefit to many stakeholders, from breeders, growers, and other horticultural practitioners to educators and researchers. It will also help increase public knowledge and appreciation of ornamental crabapples.

James Chatfield
Erstwhile President

Dear friends:

It is with great excitement that I share this issue of **Malus** with you.

A big THANK YOU to all our contributors - thank you for sharing your crabapple experience, research, photographs, and cultivation insights through this publication.

A note of thanks, also, to the talented editorial and design team, for turning the written word and unspoken thoughts of the contributors into this magnificent feast for the eyes and mind.

Crabapples have fascinated the Chinese since time immemorial. Emperors have grown them in their imperial gardens, poets have celebrated them with their words; and now we are seeing a new generation of research scientists and horticulturists around the world working hand-in-hand to uncover the genetic and medicinal potential of crabapples.

In addition to the International Ornamental Crabapple Society website (www.crabapplesociety.org), you may wish to explore the International Cultivar Registration for Malus website (www.malusregister) which also holds a treasure trove of information for anyone interested in learning about crabapples.

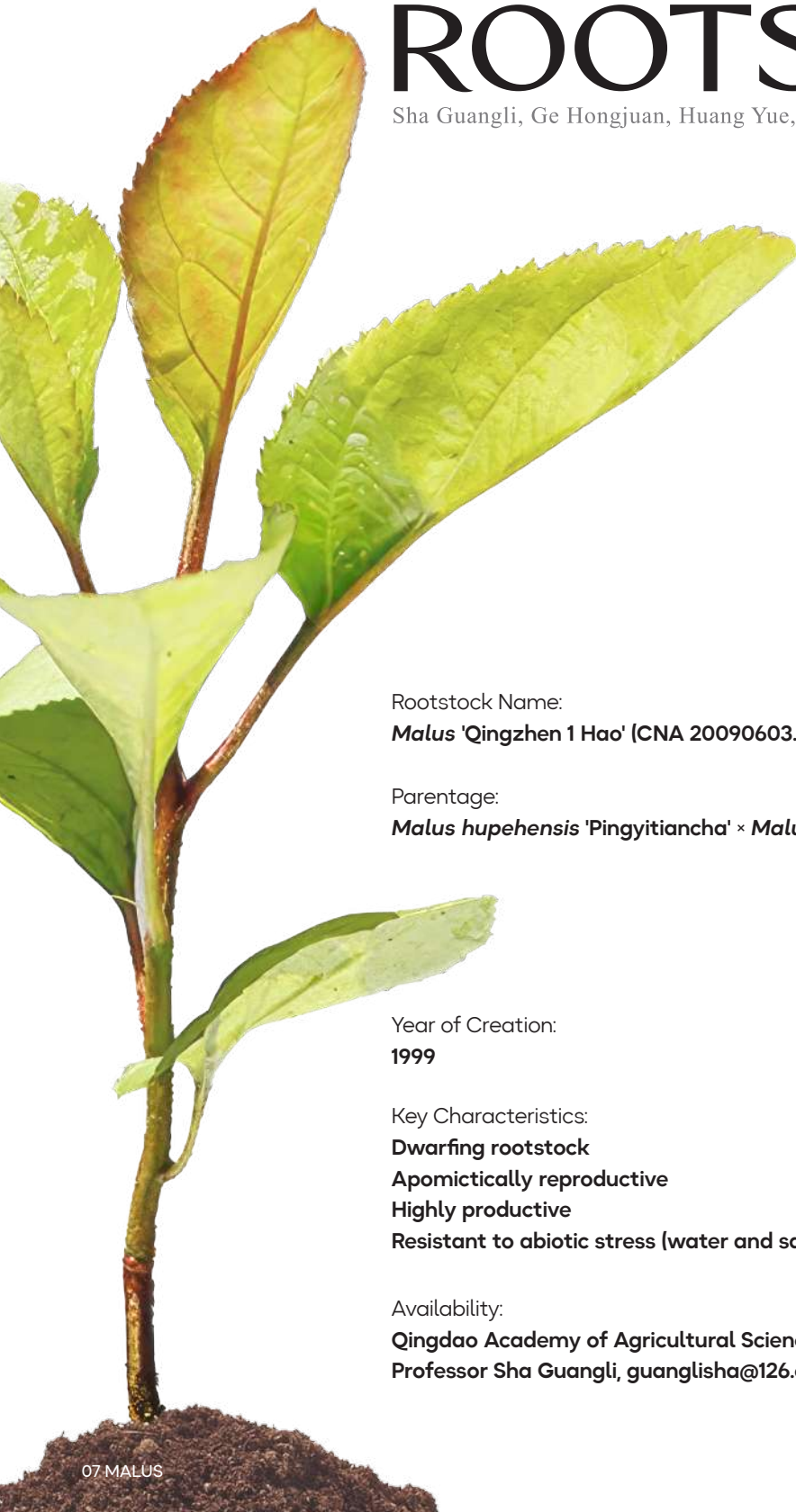
In our next issue, we will be featuring one of my favorite activities: birding with crabapples! What was your spark bird? Which crabapple tree have you discovered to have the most prolific number of birds? Please send us your pictures, videos, notes, sketches, journal entries, essays ... about birds and crabapples!

In the meantime, I wish you a wonderful time reading this issue.

Guo Ling
President
International Ornamental Crabapple Society

SUPERB ROOTSTOCK

Sha Guangli, Ge Hongjuan, Huang Yue, Ma Rongqun, Sun Jilu, Zhang Ruifen



Rootstock Name:

Malus 'Qingzhen 1 Hao' (CNA 20090603.8)

Parentage:

Malus hupehensis 'Pingyitiancha' × Malus domestica 'CO 1'

Year of Creation:

1999

Key Characteristics:

Dwarfing rootstock

Apomictically reproductive

Highly productive

Resistant to abiotic stress (water and salt)

Availability:

Qingdao Academy of Agricultural Science

Professor Sha Guangli, guanglisha@126.com

M. 'Qingzhen 1 Hao' originated from a planned cross in 1999 between *M. hupehensis* 'Pingyitiancha' and *M. domestica* 'CO 1' in Qingdao, China. The resulting new cultivar is a highly productive apomixis dwarfing rootstock resistant to water and salt stress that can be propagated conveniently by seed and uniform seedlings.

The parent plant, *M. 'Pingyitiancha'*, a cultivar of *M. hupehensis*, was first discovered in the Meng Mountains of Shandong Province, China. Its characteristic apomictic trait and uniform seedlings population has enabled it to become one of the most widely used rootstocks in China. While *M. 'Pingyitiancha'*'s vigor as a rootstock renders it unsuitable for intensive apple production, it is however, highly suitable for use in grafting crabapple cultivars for visual splendor. The other parent plant *M. 'CO 1'* is a chance seedling of an unknown columnar apple.

Compared with its parents, *M. 'Qingzhen 1 Hao'* has a higher apomictic rate than *M. 'Pingyitiancha'*, and the population of one-year-old seedlings are uniform, dwarf and strong.

Tree. *M. 'Qingzhen 1 Hao'* has a columnar habit, and the height of a six-year-old mother tree is 265cm with a stem diameter of 6.1cm. The average length of one-year-old shoots is 56cm, significantly shorter than the 85cm of *M. 'Pingyitiancha'*. The average internode length of one-year-old shoots is 2.8cm, slightly shorter than the 3.2cm of *M. 'Pingyitiancha'*. The leaves of one-year-old shoots are green and turn dark brown in the second year. The vegetative buds are larger than that of *M. 'Pingyitiancha'*.

Leaves. The leaves are long and ovate (12.5cm long and 7.1cm wide), while the apex is acuminate and round at the base with sharply serrated margins. Leaf fall occurs towards the end of November in Qingdao, China.

Flower. Flowering starts in late April or early May with light pink flower buds gradually turning white at full bloom. The flowers have three to five yellow stigmas, yellow anthers and between 25 to 30 stamens.

Pollen quantity is very low. Inflorescence are composed of five to seven flowers and the chromosome number is $2n=3x=51$.

Fruit and Seed. Apomictic fruit setting ability over a three-year period is 97.6%. Fruits are round with a bright red blush when mature, with an average fruit weight of 9.2g. The average seed number is 4.1 per fruit with 100% plump seeds. The average weight of 1000 seeds is 41.42g, and after 45 days of stratification, 80% of treated seeds can germinate.

Seedlings. The average height of a one-year-old tree is 80cm with a stem diameter of 0.97cm. The population of seedlings grow up to be uniform in height, size and appearance.





M. 'Duojiao'
PVR/CN 20180291

OF GOLDEN LEAVES

Zhang Lulu, Mao Yunfei, Wang Yunyun, Yang Lu, Yin Yijun, Shen Xiang
Adapted from "Malus spectabilis 'Duojiao': A new yellow-leaf cultivar"
HortScience, Volume 55, Issue 7, 2020

Yellow-leaf mutants are well-documented in other plant species. However, despite the abundance of crabapple cultivar with attractive foliage colors, no cultivar prior to the discovery of *Malus spectabilis* 'Duojiao', a natural mutant of the species *M. spectabilis* 'Riversii', was reported to have golden-yellow leaves. Thus making this an important milestone in the breeding programs of color-foliage crabapples while adding a rare germplasm resource to physiological analysis, transcriptome sequencing, chlorophyll metabolism, and the interplay between the photoperiod and the circadian clock in colored-leaves.

Tree and Leaves. *M. 'Duojiao'* exhibits strong vigor and upright, fastigate growth habits. New, unfolded leaves are initially reddish-yellow, then gradually lighten to a bright yellow with strong leaf surface glossiness. Young leaves turn from yellow to yellowish-green with irregular green patching along their central veins, finally maturing into dark green. These foliage characteristics were found to be stable and consistent over a four-year observation period.

Flowers. Floral bud formation ability was strong in *M. 'Duojiao'*, having produced many axillary flower buds on long branches, with each umbel comprised of 4–8 flowers. Flowers were pink (RHS-63B) at balloon stage, each with 6–9 petals that

form a corolla in the shape of a shallow cup. Petals were elliptic or oblong-elliptic, arranged in two layers. Measuring 3.5–3.9cm in diameter, with petals flattened in a horizontal position. The flowers of *M. 'Duojiao'* also differed from those of *M. 'Riversii'* in color. The basal zone of the inner side of *M. 'Riversii'* was white (RHS-N999D), and that of *M. 'Duojiao'* was pink-violet (RHS-75D). The color of the marginal zone of the inner side of the petal of *M. 'Duojiao'* was pink (RHS-70C), the middle zone of the inner side was pink (RHS-68C), the basal zone of the inner side of the petal was pink-violet (RHS-75D), and the outer side was purple-red (RHS-N57A).



Despite the abundance of crabapple cultivar with attractive foliage colors, no cultivar prior to the discovery of Malus 'Duojiao' was reported to have gold-en-yellow leaves. Thus making this a key milestone in the breeding programs of color-foliage crabapples.

Flowers of *M.* 'Duojiao' had light green pistils, yellow anthers, and white filaments. Similar to *M.* 'Riversii', *M.* 'Duojiao' began flowering in early April and full bloom occurred in mid-April in Tai'an. Using UPOV terminology, it is considered 'a medium flowering' crabapple cultivar.

Fruits and Seeds. The fruit set of *M.* 'Duojiao' was significantly lower compared to *M.* 'Riversii'. The fruit shape was obloid with a vertical diameter between 1.5–2.0cm and a transverse diameter between 1.7–2.3cm. The skin color was yellow-green (RHS-145A) and the pericarp was abscised. The pedicel was 2.20–3.75cm in length, yellow-green (RHS-145A) in color, and glabrous. The fruit pulp was yellow-green (RHS-145C). Under Tai'an climatic conditions (36° 15' N, 117° 16' E; temperate monsoon), the fruits ripened in late September to early October. The seeds were ovoid and pale-brown in color. The most readily assessable indication of maturity was the change in the color of the skin from green to light yellow-green. The calyx, always present, was erect and shallow.

Etymology. Named after Mr. Zhang Duoqiao by his father, Mr. Zhang Canhong, owner of Zhendong Nursery where this cultivar was first discovered in 2014.

Availability. Mr. Zhang Duoqiao, Zhendong Nursery, 1170345630@qq.com

Cultivation and Pest Management. *M.* 'Duojiao' has strong adaptability and is suitable for cultivation in Shandong Province in Northeastern China, and areas with similar climatic conditions. Full summer sun exposure and excessive watering must be avoided. This cultivar performs well when grown in calcareous media and in an environment with relative humidity no greater than 60 percent. Using an asexual propagation method, the plant was primarily propagated by budding using *M.* *robusta* and *M.* *hupehensis* as the rootstock. The trees in the nursery were planted at distances of 1.0m by 1.3m apart. The crown shape of the tree was regular and natural. The trees were pruned regularly to improve wind-flow and light transmission. No significant plant diseases or insect pests were observed in the natural planting; aphids were occasionally found and controlled by spraying pesticide. *Juniperus sabina* should be kept away from planting to avoid rust.



Above: Phenotypes of mutant leaves from a same shoot of *M.* 'Duojiao' in June.

Young *M.* 'Duojiao' at Zhendong Nursery in Tai'an, Shandong Province, China.



Fleeting

Quan Jian

Beauties



M. 'Fen Balei'
'粉芭蕾'
PVR/CN 20170082



M. 'Guo Zhi Xin Yan'
'国值新艳'
ICRA/M 202200A



M. 'Lianyi'
'涟漪'
PVR/CN 20190167

Ornamental crabapples or flowering crabapples of the genus *Malus* in the Rosaceae family, are woody plants from the temperate zone cultivated mainly for their luscious display of flowers in spring as well as attractive fruits in autumn and winter. The diversity of growing habits and tree shapes available also contributed to their immense popularity in North American suburban

garden landscapes. In China, ornamental crabapple trees are a representation of one's financial prowess and social standing, and symbolize everything good in Chinese painting, poetry, and the garden arts.

The breeding of Chinese ornamental crabapple is primarily carried out by hybridizing cultivars imported from North America and Europe. Since 2016, China's Ministry of Forestry awarded 80 new cultivars registrations, of which 44 were completed by the team lead by Nanjing Forestry University's Professor Zhang Wangxiang.

The commercial market waits with bated breath to see how adaptable these new cultivars will be to climate changes, or how resistant they will be to pests and diseases. With modern plant breeding technologies, perhaps it will not be too long – arguably within the decade – that select but highly valuable cultivars will arise from this flock of fleeting beauties.



Perhaps it will not be too long – arguably within the decade – that select but highly valuable cultivars will arise from this flock of fleeting beauties.

M. 'Yi Hong Lian'
'亿红莲'
PVR/CN 20190364

M. 'Yin Bei'
'银杯'
PVR/CN 20170097

M. 'Xue Qin'
'雪琴'
PVR/CN 20170108

M. 'Cha Hua Nu'
'茶花女'
PVR/CN 20210208

M. 'Chun Li'
'春丽'
PVR/CN 20150051

M. 'Fen Hong Ni Shang'
'粉红霓裳'
PVR/CN 20190077

M. 'Yan Ying'
'胭影'
PVR/CN 20180002X

M. 'Hong Yi'
'红屹'
PVR/CN 20150052

M. 'Shu Yuan'
'淑媛'
PVR/CN 20170107





M. 'Chang Hui'
'昌辉'
PVR/CN 20160058

*In China, ornamental crabapple trees
symbolize everything good in Chinese
painting, poetry, and the garden arts.*



Malus spontanea

RARE & DISTINCTIVE

Matthew Lobdell

The Morton Arboretum's *Malus* collection is nationally accredited by the American Public Gardens Association's Plant Collections Network, a distinction it has held since 1995. The focus of the collection has changed over time, from one of selecting cultivars under trial for local cultivation, to building a germplasm collection for native *Malus coronaria* and *Malus ionensis*, to its current state with a dual focus on collecting species of documented wild origin and cultivars suitable for the region

My experience with *Malus spontanea* began shortly after I began serving as Curator of The Morton Arboretum in 2014. While walking through the *Malus* collection in hopes of identifying key specimens from the 154 species and cultivars present within, I came across a trio of white-flowering crabapples with a clean, broad, and rather short-thickset habit around Crabapple Lake. Perhaps this is simply my personal preference, but I have always been partial to the smaller crabapples with a relatively flat crown. Upon examining the labels, they were revealed as the then-new-to-me species *Malus spontanea*.

Searching for more information, I began with John Fiala's seminal 1994 monograph on the genus. He did not seem to share my enthusiasm for the species. Though he complimented it as "completely disease resistant", he also rated it as "not a meaningful ornamental", apparently due to its wider than tall habit and tendency to only bloom profusely in alternate years. The desire for a second opinion led me to Miles Sax's 2011 review of Arnold Arboretum's *Malus* collection. Sax not only described the rarity of the species both as a spontaneous and cultivated tree, but also discussed one notable specimen growing by Peters Hill at the Arnold Arboretum.

When observed from a distance it appeared to have a short and broad habit. However, closer inspection revealed the trunk was felled at some point in the past, and the tree is now growing parallel to the ground.

I recall this tree, though not by name, from my

brief tenure at Arnold Arboretum from 2007 to 2008 and enjoyed hearing the colorful theories as to the cause of its unique habit, ranging from being shaped by hurricane-force winds to having been struck by a stolen car. Regardless of the myriad of trauma inflicted upon it, the tree has proven resilient, and at the time of writing this article, is a centenarian.

That attempts to learn about the species often circle back to Arnold Arboretum is unsurprising, given that its history in western cultivation is decidedly intertwined with Arnold Arboretum's. Only a few years after being formally described, it was introduced to western horticulture through the efforts of Ernest Henry Wilson. Wilson visited the Ebino plateau in the Kirishima Mountains of Kyushu during his 1918 expedition to Japan, collecting seeds and plants for Arnold Arboretum. The materials Wilson collected were accessioned in 1919 as '10796', and the centenarian *M. spontanea* on Peters Hill was designated '10796-2-A'.

The Morton Arboretum was founded in Lisle, Illinois, USA in 1922, just a few short years after the first *M. spontanea* were accessioned at Arnold Arboretum. The Morton Arboretum's founder Joy Morton corresponded heavily with Arnold Arboretum's Director Charles Sprague Sargent, hoping to use the respected and established institution as a model for his fledgling Arboretum. Fortunately, Arnold Arboretum was equally generous in sharing their plants as they were their experiences, and The Morton Arboretum received a vast number of accessions of documented wild origin through this exchange. *Malus spontanea* was one such species.




M. spontanea 32-2002*1 at The Morton Arboretum, exhibiting flowers darker pink in bud.



Propagules from Arnold Arboretum's '10796' were received at The Morton Arboretum on November 16, 1922, and accessioned as '2465-22'. Unfortunately, no further information on this accession was found, as it had most likely died prior to planting. A second attempt with additional material from Arnold Arboretum five years later found little success as the plants (1127-1128) died after three to four years of planting.

Left: *M. spontanea* exhibiting promising fall color, turning a deep orange red in mid-October.



M. spontanea exhibiting promising fall color, turning a deep orange red in mid-October at The Morton Arboretum.

Malus spontanea was first formally described by Japanese botanist Tomitaro Makino in 1910, as a variety of *Malus floribunda*. Makino later elevated it to the level of species, hypothesizing it may be a wild progenitor of *M. floribunda*, a species long cultivated in Japan, but of uncertain wild origins. In 1926, German-American botanical taxonomist and dendrologist Alfred Rehder took issue with Makino's taxonomic placement, preferring to instead

consider it a variety of *Malus halliana* (based on poor morphological characteristics for separation), and that Makino had apparently confused *M. floribunda* with *M. halliana*. In 1994, celebrated horticulturist John Fiala upheld Rehder's taxonomic treatment and conjectured that the species is a natural hybrid. Leading Japanese botanists, including Jisaburo Ohwi and Kunio Iwatsuki, however, elected to uphold the species designation.

It would be over twenty years before The Morton Arboretum attempted to cultivate this species again, and we were successful! Once again scions were requested from Arnold Arboretum's '10796' and grafted at The Morton Arboretum. The plants (413-49) survived for 35 years until they were removed due to space constraints. Fortunately, this lineage has been kept alive through repropagation. 413-49 was in turn grafted to produce accession 544-66, which would then be propagated twice, by budding in 1990 (211-90) and by grafting in 1993 (276-93). One plant from the former and two from the latter accessions remain, forming the trio currently planted around Crabapple Lake.

In addition, The Morton Arboretum also holds

other accessions which may or may not be attributed to Wilson's 1918 expedition. In 1945, we received a plant from Arie den Boer, offering only the identification number 'WW-36-A-1940'. It seems probable that this plant may have originated from Wilson's collection as there was apparently little other *M. spontanea* available in the United States at that time. We have attempted to propagate this particular accession twice in the hope of developing a dwarf form of the species but have had little success to date.

In 2002, we received a seed collection (32-2002) of *M. spontanea* from Japan National Institute of Fruit Tree Science (NIFTS). The collection site is not noted, but it seems likely these could be traced

to the only documented population on Ebino plateau. The trees' habit is less broad compared to the older accessions, and the flowers also have more pink in the bud. It is uncertain whether either characteristic is more attributable to age or planting location as opposed to genetic diversity. Miles Sax (of Arnold Arboretum) would later request seeds from Dr. Hiroyuki Iketani, the head of the genetic laboratory at NIFTS, in hopes of bolstering the diversity of the species represented in North American collections. We received one of these seed disbursements (206-2013), and just planted out the resulting trees in the fall of 2020. One of the trees is already developing an attractive habit and should make an outstanding specimen.

All accessions have shown a promising degree of disease resistance. We have noticed little to no damage from apple scab, cedar apple rust, or fire blight. 2020 was a particularly severe year for scab and rust at The Morton Arboretum, and *M. spontanea* was one of the few crabapple taxa to hold its foliage for the entire growing season. It even exhibited some promising fall color, turning a deep orange red in mid-October.

In the wild, however, the situation for the species is rather grim, with only one population found on Ebino plateau. The area is a popular tourist destination and was designated a Japanese 'National Natural Monument' in 1923, with a limited degree of protection. In their 2013 survey of plant genetic resources in Kyushu, Drs. Iketani and Mase noted there were no formal conservation measures in place until around 2000, and the number of recorded *M. spontanea* individuals fell from 504 in 1967 to 334 in 1998 and 296 in 2013. The remaining trees demonstrate poor vigor, potentially due to the heavy overstory of *Pinus densiflora* in the location, as well as foraging damage by Sika deer (*Cervus nippon*).

Though considered 'Vulnerable', when last rated by the International Union for Conservation of Nature, L. Worcester (pers. comm., 2021) suggested that the small size and restricted locality of the population may see it being elevated to 'Critically Endangered' when the red list assessment is updated.

Adding to the urgency and complexity of conserving this species, the molecular analyses

of both in-situ and ex-situ *M. spontanea* trees undertaken by Dr. Iketani and his team revealed that all the specimens, save for variations in alleles at a couple of loci, perhaps due to mutation, share the same genotype. This leads Dr. Iketani to believe that the species is apomictic.

Despite its well documented representation at The Morton Arboretum and Arnold Arboretum, *Malus spontanea* is rarely accessioned in botanical gardens. At the time of writing, a search on Botanic Gardens Conservation International PlantSearch database yielded less than five institutions with a living plant of the species. It is my hope that more botanical institutions will acquire this distinctive and rare species for their plant collections or consider it as a breeding parent for ornamental selections of superior disease resistance.

Works Cited:

Fiala, J. 1994. Flowering Crabapples: The Genus *Malus*. Timber Press. Portland, OR, USA. 132.

Iketani, H. and Mase, N. 2013. Exploration and collection of two crabapple species, *Malus spontanea* Makino and "Takanabe kaido," in southern Kyushu, Japan. Annual Report on Exploration and Introduction of Plant Genetic Resources 29: 119-125.

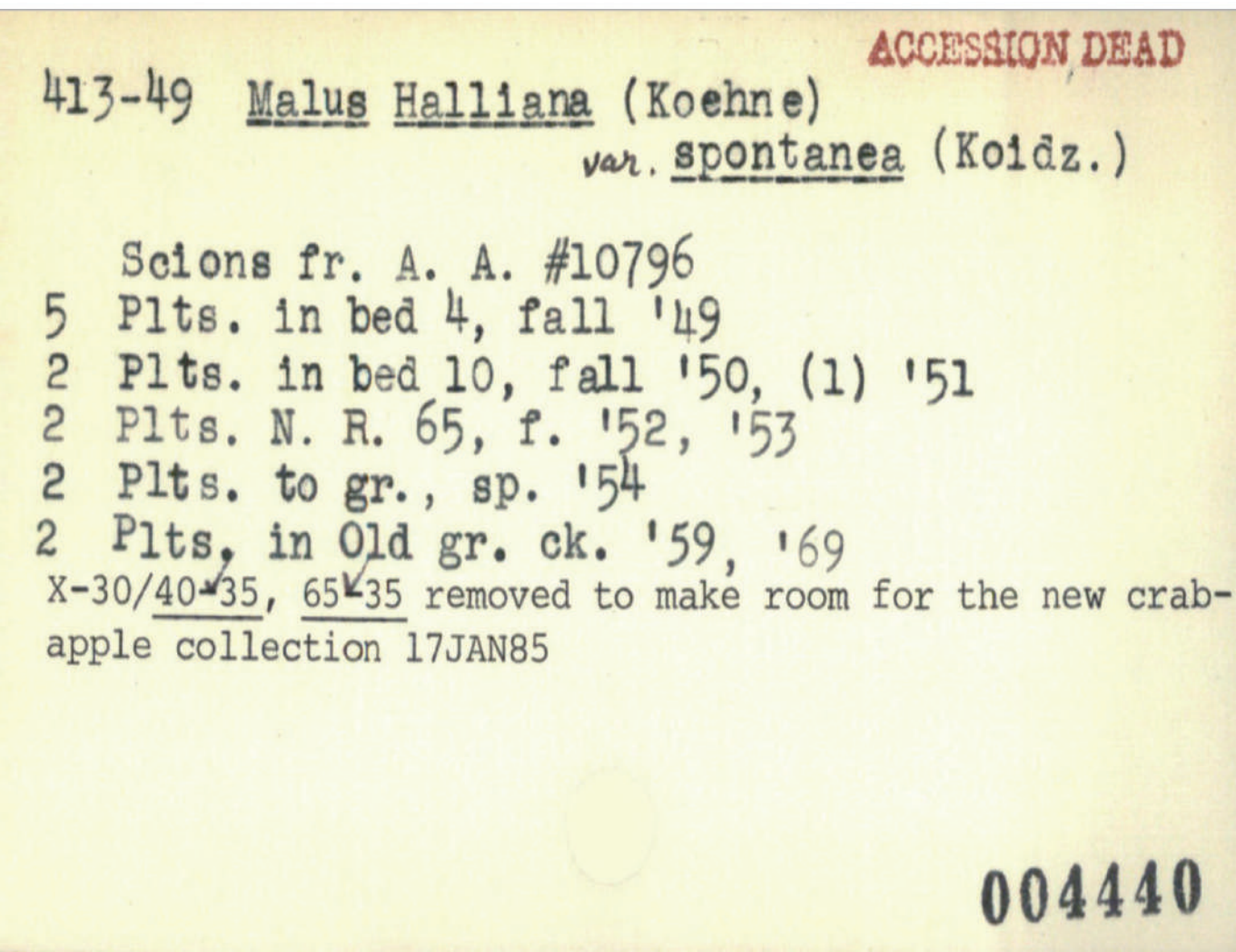
Iwatsuki, K., T. Yamazaki, D. Boufford, and H. Ohba. 2001. Flora of Japan, Vol. IIb. Kodansha, Tokyo, Japan.

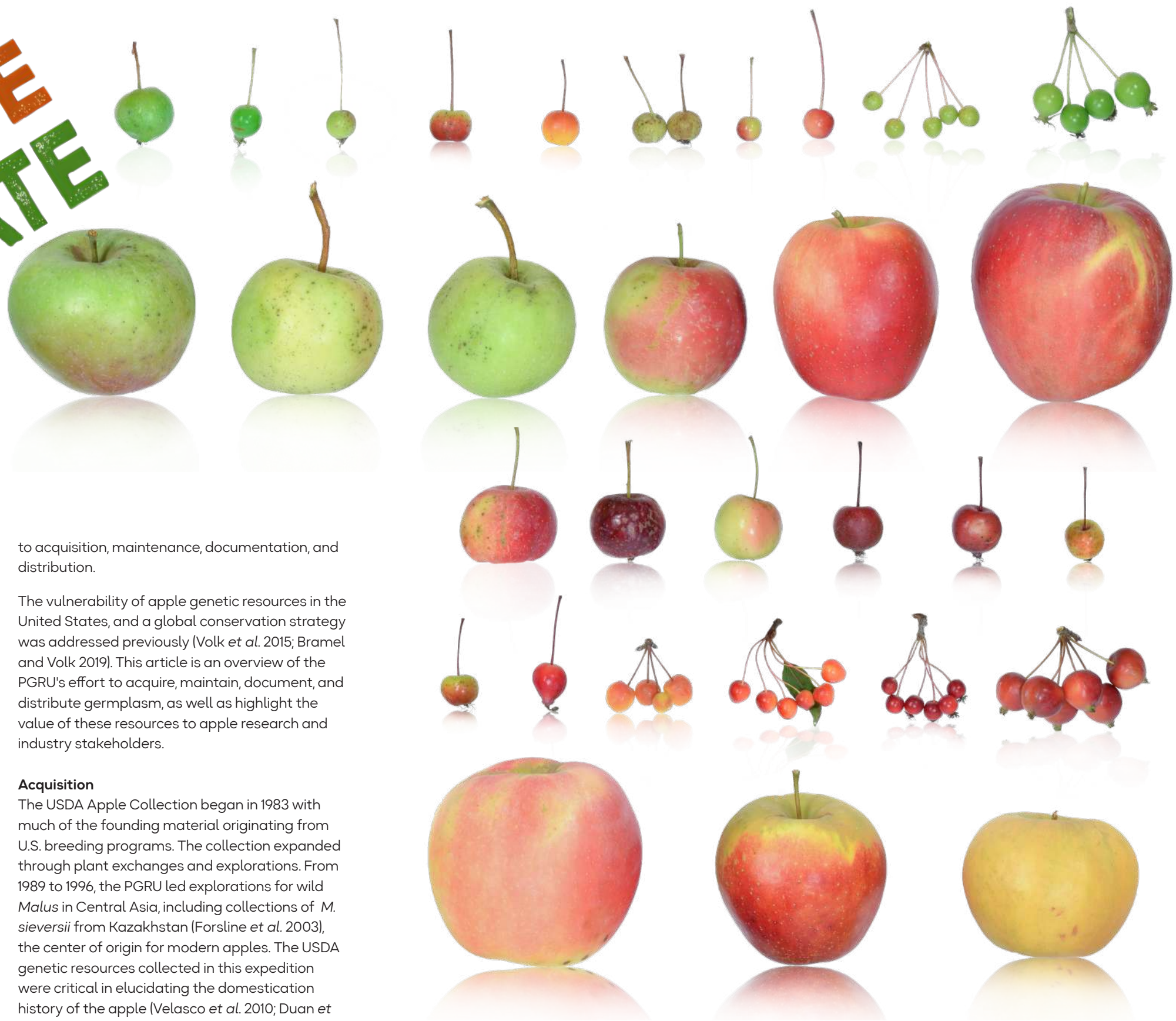
Ohwi, H. 1965. Flora of Japan (in English). Smithsonian Institution. Washington, DC.

Makino, T. 1914. Observations on the Flora of Japan. The Botanical Magazine 28(384). 288-295.

Rehder, A. 1926. New species, varieties and combinations from the herbarium and the collections of the Arnold Arboretum. Journal of the Arnold Arboretum 7: 22-37

Sax, M. 2011. A year with the apples of the Arnold Arboretum. *Arnoldia* 69(2): 29-39.





Malus species grown for fruit or as ornamentals have substantial economic value and cultural significance. The domesticated apple, *M. domestica*, is one of the world's most valuable fruit crops. Centuries of selection and propagation across Asia, Europe, and North America resulted in an array of apple and crabapple cultivars rich in quality. Modern apple breeding continues to enhance fruit and ornamental qualities to meet consumer preferences, while addressing changing horticultural practices to ensure future production. Genetic diversity is essential for long-term crop improvement and promotes the sustainability of world markets.

The United States Department of Agriculture (USDA) Apple Collection is maintained by the Plant Genetic Resources Unit (PGRU) in Geneva, New York, USA as part of the National Plant Germplasm System (NPGS). The PGRU maintains one of the world's largest apple collections with 6,086 diverse accessions of cultivated and wild apples, including 48 species and hybrids. Accessibility of apple genetic resources is the central focus of the PGRU and drives approaches

to acquisition, maintenance, documentation, and distribution.

The vulnerability of apple genetic resources in the United States, and a global conservation strategy was addressed previously (Volk *et al.* 2015; Bramel and Volk 2019). This article is an overview of the PGRU's effort to acquire, maintain, document, and distribute germplasm, as well as highlight the value of these resources to apple research and industry stakeholders.

Acquisition

The USDA Apple Collection began in 1983 with much of the founding material originating from U.S. breeding programs. The collection expanded through plant exchanges and explorations. From 1989 to 1996, the PGRU led explorations for wild *Malus* in Central Asia, including collections of *M. sieversii* from Kazakhstan (Forsline *et al.* 2003), the center of origin for modern apples. The USDA genetic resources collected in this expedition were critical in elucidating the domestication history of the apple (Velasco *et al.* 2010; Duan *et al.* 2017).

Above: Fruit diversity from the USDA Apple Collection.

More recently, the PGRU actively pursued wild North American *Malus* species, *M. angustifolia*, *M. coronaria*, and *M. ioensis*. These species are unique in their relationship to other *Malus* species, forming their own section, Chloromeles (Liu *et al.* 2022), but have rarely been explored for fruit breeding and research. As such they may hold valuable traits to improve fruit quality, disease resistance, or climate adaptability.

Additionally, plant explorations acquired *M. sylvestris* from Romania and *M. doumeri* from Vietnam. Seeds obtained from exploration and exchanges are grown-out for evaluation and select genotypes are introduced into the collection as permanent accessions. The composition of the USDA Apple Collection is unique, with nearly 77% (n=4,676) representing wild *Malus* species.

Incorporation of wild species into breeding programs allow for introgression of beneficial traits, such as disease resistance, into modern apples (Brown 2012). Some of the North American species are particularly interesting as ornamentals, such as *M. ioensis* 'Bechtel Crab' PI 588991.

Maintenance

The USDA Apple Collection is primarily field based, which is vulnerable to environmental pressures such as disease and weather. This vulnerability was evident during an outbreak of fire blight (Dougherty *et al.* 2021). To preserve the apple collection, accessions are propagated as two trees on 'EMLA7' semi-dwarf rootstock at 12ft x 20ft spacing. As trees establish in the field, one tree is removed to reduce crowding. Each year, an annual collection inventory records the status of each tree in the field. Trees that are weak are flagged for additional observations and grafting. To safeguard against losses, accessions are duplicated through cryopreservation (Volk *et al.* 2020). Some wild apple germplasm is preserved as seed accessions held in cold storage.

Documentation

Germplasm documentation includes the acquisition, management, and storage of

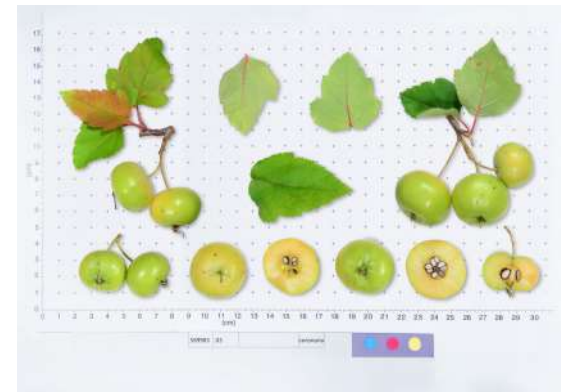
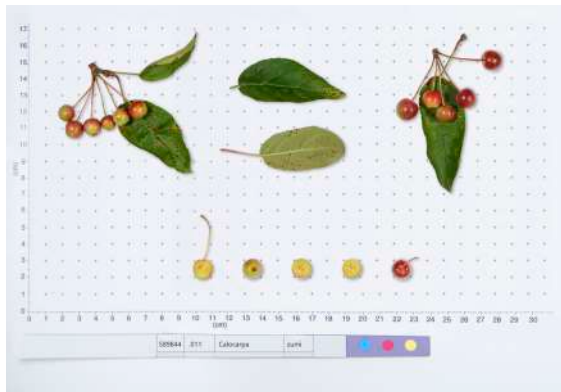
information about genetic resources. The depth, accuracy, and accessibility of this information increases the value of germplasm and facilitates utilization. Documentation and data for the USDA Apple Collection is primarily maintained on GRIN-Global (Germplasm Resources Information Network 2020) and is accessible by the public. This includes passport information, accession narratives, images, descriptor data, and genetic markers. Descriptors for the apple collection were assembled and defined by the Apple Crop Germplasm Committee. There are 111 Apple descriptors, divided into eight categories: Chemical, Cytologic, Disease, Growth, Molecular, Morphological, Phenological, and Production. Nearly half the descriptors are for fruit. Currently, descriptor data is available for 3,763 accessions, representing 62% of the collection, with an average of 36 traits. Close to 2,500 accessions have digital images. Recently, imaging efforts have been on wild germplasm, with an emphasis on capturing botanical features.

Distribution

Distribution of PGRU germplasm is managed through GRIN-Global. Requestors review, select accessions, and submit requests through the public website. Distribution of germplasm is limited to genuine research, conservation, commercial development, and genetic enhancement programs. Requests for personal use are declined and requestors are encouraged to seek commercially available germplasm. The PGRU distributes plant material such as scions, leaves, fruit, DNA, pollen, and other tissues for research and commercial applications. Distribution is limited due to seasonal availability of tissues for evaluation or propagation. The window for requests is communicated to stakeholders on individual accession pages on GRIN-Global. Full implementation of GRIN-Global to receive and manage germplasm requests will significantly improve distribution, communication to stakeholders, and documentation of utilization. Foreign requests are coordinated through the Department of Agriculture and Markets of New York State.

*Incorporation of wild species into breeding programs allow for introgression of beneficial traits, such as disease resistance, into modern apples. Some of the North American species are particularly interesting as ornamentals such as *M. ioensis* 'Bechtel Crab' PI 588991.*





Above: GRIN-Global Images.

Left to right: PI 5898-40 *M. zumi*; PI 590102 *M. toringio*; PI 589983 *M. coronaria*; PI 589983 *M. fusca*.

Conclusions

Plant genetic resources are essential for the sustainability of American agriculture. Continual development of elite apple cultivars and rootstocks with durable disease resistance and novel qualities involves detailed evaluations of apple germplasm and utilization of genetic and genomic tools (Evans and Peace 2017; Luo

et al. 2020). The PGRU supports this process by providing plant material for research, breeding, and industry development. To meet stakeholders' current and future needs, the USDA Apple collection need to be fortified against pests and pathogens. Additionally, improved evaluation and documentation of apple genetic resources are critical for increasing their value and accessibility.

Below: Fire blight infection in apple.



The USDA Apple Collection is primarily field based, which is vulnerable to environmental pressures such as disease and weather. This vulnerability was evident during an outbreak of fire blight.

References

- Bramel P, Volk GM (2019) A global strategy for the conservation and use of apple genetic resources. Global Crop Diversity Trust Bonn, Germany. <https://doi.org/10.13140/RG.2.2.34072.34562>
- Brown S (2012) Apple. In: Badenes ML, Byrne DH (eds) Fruit Breeding. Springer US, Boston, MA, pp 329–367
- Dougherty L, Wallis A, Cox K, Zhong G-Y, Gutierrez B (2021) Phenotypic evaluation of fire blight outbreak in the USDA *Malus* collection. *Agronomy* 11:144. <https://doi.org/10.3390/agronomy11010144>
- Duan N, Bai Y, Sun H, Wang N, Ma Y, Li M, *et al.* (2017) Genome re-sequencing reveals the history of apple and supports a two-stage model for fruit enlargement. *Nat Commun* 8. <https://doi.org/10.1038/s41467-017-00336-7>
- Evans K, Peace C (2017) Advances in marker-assisted breeding of apples. In: Evans K (ed) Achieving sustainable cultivation of apples. Burleigh Dodds Science Publishing, pp 165–191
- Forsline PL, Aldwinckle HS, Dickson EE, Luby JJ, Hokanson SC (2003) Collection, maintenance, characterization, and utilization of wild apples of Central Asia. In: Janick J (ed) Horticultural Reviews. pp 1–61
- Germplasm Resources Information Network (2020) Beltsville (MD): United States Department of Agriculture, Agricultural Research Service. <http://www.ars-grin.gov/>. Accessed 1 Sep 2021
- Liu B-B, Ren C, Kwak M, Hodel RGJ, Xu C, He J, *et al.* (2022) Phylogenomic conflict analyses in the apple genus *Malus* s.l. reveal widespread hybridization and allopolyploidy driving diversification, with insights into the complex biogeographic history in the Northern Hemisphere. *Journal of Integrative Plant Biology* 64:1020–1043. <https://doi.org/10.1111/jipb.13246>
- Luo F, Evans K, Norelli JL, Zhang Z, Peace C (2020) Prospects for achieving durable disease resistance with elite fruit quality in apple breeding. *Tree Genet Genomes* 16:21. <https://doi.org/10.1007/s11295-020-1414-x>
- Velasco R, Zharkikh A, Affourtit J, Dhingra A, Cestaro A, Kalyanaraman A, *et al.* (2010) The genome of the domesticated apple (*Malus × domestica* Borkh.). *Nat Genet* 42:833–839. <https://doi.org/10.1038/ng.654>
- Volk G, Jenderek, M., Chen K (2020) Cryopreservation of dormant apple buds. In: Volk G (ed) Training in plant genetic resources: Cryopreservation of clonal propagules. Colorado State University, Fort Collins, Colorado
- Volk GM, Chao CT, Norelli J, Brown SK, Fazio G, Peace C, *et al.* (2015) The vulnerability of US apple (*Malus*) genetic resources. *Genetic Resources and Crop Evolution* 62:765–794. <https://doi.org/10.1007/s10722-014-0194-2>

Garden Of Gardens

Yang Fan and Bao Zhiyi



The **Chinese Crabapple Garden** is located in the city of Yancheng, Jiangsu Province, approximately 260km northwest of Shanghai. Renowned for its salt production, the name of the city literally means 'salt city'. As part of Yancheng's urban development plans, 1600 hectares south of the city was designated as the expansion zone. Named 'Nanhai Future City', the zone would feature state-of-the-art technology parks, modern housing facilities, advanced public amenities, and world-class services.

Nestled in the heart of this new city, the Garden spans 150 hectares (90 hectares landmass, 60 hectares freshwater lake). The Garden features contemporary landscape designs steeped in ancient philosophies and showcases a mesmerizing cornucopia of horticultural creations – the largest in China connected to "Crabapples". Since time immemorial, the Chinese have used the Chinese name for *Malus* (**Hai Tang 海棠**), *Begonia* (**Qiu Hai Tang 秋海棠**), *Chaenomeles* (**Tie Geng Hai Tang 贴梗海棠**) indiscriminately to describe the wondrous scenes of trees and shrubs with masses of similar looking blooms, and it is in this tradition, that the horticultural theme and content of the Garden is curated.

In total, 71 varieties of ornamental crabapple, 21 varieties of flowering quince, and 15 varieties of floriferous begonia were planted.

Design Concept

The landscape design of the Garden is organized into three regions, six zones, and eighteen sceneries. Collectively, they integrate the rich history of Yancheng as well as the horticultural significance of ornamental crabapples to create the green heart of Nanhai Future City.

The three regions are "art and culture", "west waterfront", and "east waterfront". Anchored by Yancheng Exhibition Hall as the central architecture, the six zones each have a distinct theme: "Crabapple Varieties", "Crabapple Memories", "Crabapple Beauties", "Crabapple Amusement", and a children's play area named "Crabapple Enjoyment". Of the eighteen sceneries, thirteen are based on ornamental crabapples and are given lyrical names such as "Crabapple Aspirational Beauty" and "Crabapple Enchanting Bonsai".

The "Crabapple Varieties" zone is located on the first peninsula of the Garden, and is characterized by a landscaped waterfront, Chinese pavilions, and long corridors. A large variety of crabapple cultivars are planted on both sides of the main corridor and visitors are afforded encyclopedic views of ornamental crabapples of different forms, flower colors, and tree shapes as they stroll along the corridor. The "Crabapple Enchanting Bonsai" garden, located in the southwest corner, showcases the Chinese horticultural art of growing and training miniature trees using crabapples.



Since time immemorial, the Chinese have used the Chinese name for *Malus* (Hai Tang 海棠), *Begonia* (Qiu Hai Tang 秋海棠), *Chaenomeles* (Tie Geng Hai Tang 贴梗海棠) indiscriminately to describe the wonderful scenes of trees and shrubs with masses of similar looking blooms, and it is in this tradition, that the horticultural theme and content of the Garden is curated.

- Chaenomeles japonica*
- Chaenomeles sinensis*
- Chaenomeles speciosa*
- Chaenomeles* 'Alpina'
- Chaenomeles* 'Crimson and Gold'
- Chaenomeles* 'Jet Trail'
- Chaenomeles* 'Karl Ramcke'
- Chaenomeles* 'Moerloosei'
- Chaenomeles* 'Nicoline'
- Chaenomeles* 'Nivalis'
- Chaenomeles* 'Orange Beauty'
- Chaenomeles* 'Orange Trail'
- Chaenomeles* 'Pink Trail'
- Chaenomeles* 'Plena'
- Chaenomeles* 'Rosea'
- Chaenomeles* 'Rubra Grandiflora'
- Chaenomeles* 'Salmon Horizon'
- Chaenomeles* 'Sanguinea'
- Chaenomeles* 'Sargentii'

- Begonia boliviensis*
- Begonia cucullata*
- Begonia grandis*
- Begonia tuberhybrida*
- Begonia* 'Bossa Nova'
- Begonia* 'Cocktail'
- Begonia* 'Dragon Wing'
- Begonia* 'Fairylana'
- Begonia* 'Illumination'
- Begonia* 'Inferno'
- Begonia* 'Nonstop'
- Begonia* 'San Francisco'
- Begonia* 'Santa Cruz Sunset'
- Begonia* 'Stara'
- Begonia* 'Super Olympia'

Chaenomeles



Malus

Crabapples of different tree forms, heights, flowering times and fruit colors were planted together to create a rhapsodic landscape.

- Malus spectabilis* 'Riversii'
- Malus* 'Adam'
- Malus* 'Branzani' (BRANDYWINE)
- Malus* 'Butterball'
- Malus* 'Calocarpa'
- Malus* 'Candymint'
- Malus* 'Cardinal'
- Malus* 'Coralcole' (CORALBURST)
- Malus* 'Dolgo'
- Malus* 'Donald Wyman'
- Malus* 'Golden Hornet'
- Malus* 'Hargozani' (HARVEST GOLD)
- Malus* 'Hillier'
- Malus* 'Hopa'
- Malus* 'Indian Magic'
- Malus* 'Indian Summer'
- Malus* 'Liset'
- Malus* 'Louisa'
- Malus* 'Pink Spires'
- Malus* 'Professor Sprenger'
- Malus* 'Profusion'
- Malus* 'Radiant'
- Malus* 'Red Barron'
- Malus* 'Red Jade'
- Malus* 'Red Jewel'
- Malus* 'Red Sentinel'
- Malus* 'Red Splendor'
- Malus* 'Robinson'
- Malus* 'Royal Beauty'
- Malus* 'Royalty'
- Malus* 'Rudolph'
- Malus* 'Selkirk'
- Malus* 'Shotizam' (SHOWTIME)
- Malus* 'Snowdrift'
- Malus* 'Spring Bride'
- Malus* 'Spring Glory'
- Malus* 'Spring Snow'
- Malus* 'Strawberry Parfait'

The second region, "Crabapple Memories", located on the second peninsula of the Garden features the confluence of crabapple culture and Yancheng regional culture. In addition to being the center of salt production, Yancheng was also the former headquarters of the New Fourth Army. To manifest this unique intertwining of history and culture, a replica of the former residence of Chinese Premier Zhou Enlai, the "West Flower Lodge" (西花厅) – two full-sized *Malus spectabilis* 'Riversii' planted in front of the Lodge just as the original is in Beijing – was chosen as the design anchor. The scene of flowering crabapple against classical Chinese architecture encapsulates Premier Zhou's love for his wife and their shared love for crabapples.

In classical Chinese culture, allusions such as "Napping Under a Crabapple Tree" and "Crabapple Poetry Society" reflect the Chinese penchant for crabapples as a medium to express their poetic pursuit of otherworldly beauty. To further illustrate the profound cultural connection between the Chinese and ornamental crabapples, one of Yancheng's famed peony varieties, *Paeonia* 'Withering Branch' was utilized as a stark contrast to ornamental crabapples' sublime magnificence in full bloom, and as a complementary symbol of wealth to ornamental crabapples' coveted status symbol of eternal prosperity.

The "Crabapple Beauties" region offers magnificent views of the lake. Crabapples of different tree forms, heights, flowering times and fruit colors – *Malus spectabilis* 'Riversii', *Malus robusta*, *Malus* 'Adams', and *Malus* 'Profusion' – were planted together to create a rhapsodic landscape. The Skywalks takes visitors on an elevated walkway and offers panoramic views of the region, while the Viewing Towers provide visitors with a breath-taking bird's eye view of the region during the blooming and fruiting seasons.

The fourth region, "Crabapple Enjoyment", is designated as the children's play area. To reflect as well as attract the enthusiasm and vigor of our young and young-at-heart visitors, a variety of shapes were employed to create three-dimensional flower beds planted with plants that all had the strikingly similar Chinese name **Hai Tang**: ornamental crabapple (*Malus*), flowering quince (*Chaenomeles*), and floriferous begonia (*Begonia*). Although all three are from completely different genera, their Chinese names are identical and for this reason they are commonly mistaken to be from the same genus by the general public. Through this innovative concept, the design team aims to help the public finally tell the three genera apart. In addition to their contribution to botanical science education, broad swathes of begonia were utilized to create an illusionary extension of the flowering period of crabapples to the summer months, thus presenting visitors with a visual feast of an almost seamless flowering season all year around.





Crabapple Blossom

Carl August Sandburg

Somebody's little girl—how easy to make a sob story
over who she was once and who she is now.

Somebody's little girl—she played once under a
crabapple tree in June and the blossoms fell on the
dark hair.

It was somewhere on the Erie line and the town was
Salamanca or Painted Post or Horse's Head.

And out of her hair she shook the blossoms and went
into the house and her mother washed her face and her
mother had an ache in her heart at a rebel voice, "I don't
want to."

Somebody's little girl—forty little girls of somebodies
splashed in red tights forming horseshoes, arches,
pyramids—forty little show girls, ponies, squabs.

How easy a sob story over who she once was and who
she is now—and how the crabapple blossoms fell on her
dark hair in June.

Let the lights of Broadway spangle and splatter—and
the taxis hustle the crowds away when the show is over
and the street goes dark.

Let the girls wash off the paint and go for their midnight
sandwiches—let 'em dream in the morning sun, late in
the morning, long after the morning papers and the milk
wagons—Let 'em dream long as they want to ... of June
somewhere on the Erie line ... and crabapple blossoms.

Carl August Sandburg (January 6, 1878 – July 22, 1967) was an American poet, biographer, journalist, and editor. He won three Pulitzer Prizes: two for his poetry and one for his biography of Abraham Lincoln. During his lifetime, Sandburg was widely regarded as a major figure in contemporary literature. When he died in 1967, President Lyndon B. Johnson observed that "Carl Sandburg was more than the voice of America, more than the poet of its strength and genius. He was America."

Flowering Crabapples 海棠

Su Shi 苏轼 Translated from Chinese by Daniel B. Dickel

While the full spring was floating upon the air,
blew a gentle breeze to the east,
the moonbeam spread within the great hall,
like a sweet moist evening mist.
Afraid that the flowers might fall asleep,
with the dark approaching night,
I sent thick globed candles aloft,
to shine below on the beauties bright.

东风袅袅泛崇光，
香雾空蒙月转廊。
只恐夜深花睡去，
故烧高烛照红妆。



Su Shi 苏轼 (January 8, 1037 – August 24, 1101) is widely regarded as one of the most accomplished figures in classical Chinese literature, having produced some of the most well-known poems, lyrics, prose, and essays. His poetry has a long history of popularity and influence in China, Japan, and Korea. Amongst the topics he wrote on was cuisine, where he is considered to have had a profound influence. Dongpo pork, a scrumptious dish, was created by him during his stint as an official in Hangzhou.

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