Plum Crazy: Rediscovering Our Lost *Prunus* Resources

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Recent utilization of genetic resources of peach [*Prunus persica* (L.) Batsch] and Japanese plum (*P. salicina* Lindl. and hybrids) has been limited in the United States compared with that of many crops. Difficulties in collection, importation, and quarantine throughput have limited the germplasm available. *Prunus* is more difficult to preserve because more space is needed than for small fruit crops, and the shorter life of trees relative to other tree crops because of disease and insect problems. Lack of suitable rootstocks has also reduced tree life. The trend toward fewer breeding programs, most of which emphasize "short-term" (long-term compared to most crops) commercial cultivar development to meet immediate industry needs, has also contributed to reduced use of exotic material.

Probably all modern commercial peaches grown in the United States are related to 'Chinese Cling', a peach imported from China over 100 years ago (Myers et al., 1989). More recently imported germplasm has not significantly impacted modern production. The relatively few available accessions of wild peach relatives have been useful primarily in development of peach rootstocks. In contrast, a large shipping plum industry in California has been developed based on plum cultivars imported 100 years ago from Japan and on hybrids of those plums with native species. Native American germplasm has unrealized potential to help solve current plum problems and stone fruit rootstock problems. However, few resources are devoted to this effort. This germplasm will be discussed in more detail in relation to the U.S. Dept. of Agriculture (USDA)–Agricultural Research Service (ARS) breeding program at Byron, Ga.

PEACHES

Since 1900, over 2100 accessions of both improved and primitive peach germplasm have been imported through the USDA Plant Introduction system as either seed or budwood (Werner and Okie, 1998). Unfortunately, most of this material was never utilized. At the Plant Introduction Station in Chico, Calif., ≈700 of these accessions were collected and catalogued in the 1950s. Support for this facility waned and it closed in the late 1970s. By the time the new National Clonal Germplasm Repository (NCGR) was established in Davis, Calif., in the 1980s, only ≈60 of the 700 Plant Introductions were still maintained in other collections and could be established in the Repository (Werner and Okie, 1998).

The use of exotic germplasm for peach improvement has been relatively limited for several reasons. The peach industry can rapidly adopt new cultivars because there is little cultivar recognition at the consumer level, and many orchards are short-lived. As a result, most breeding programs have been aimed primarily at cultivar improvement, leaving little time for germplasm enhancement. The relatively long generation time also inhibits the use of primitive germplasm, since multiple generations are required to regain commercial fruit qualities. In addition, in locales where peaches are most subject to biotic and abiotic stresses, keeping exotic germplasm alive long enough to adequately evaluate its potential is often more difficult.

Within *Prunus persica*, the most important use of imported (but not primitive) germplasm was the introduction of 'Chinese Cling' over 100 years ago; most commercial peaches are related to it (Myers et al., 1989). Imported canning clingstone peach cultivars from Australia and South Africa were crossed with local cultivars in the development of the canning cling industry in California. Imported nectarines ('Quetta' from India, 'John Rivers' from England, and 'Lippiatts' from New Zealand) were critical to the development of modern nectarines in California (Taylor, 1959). However, most fresh-market peach breeding programs in the United States have used germplasm developed in the United States for cultivar development (Okie, 1998). Only in New Jersey was there extensive hybridization with imported clones, and most of these hybrids have not resulted in named cultivars (Blake and Edgerton, 1946).

In recent years, interest in collecting and utilizing novel germplasm has increased. For example, non-melting clingstone peaches from Mexico and Brazil have been used in the joint USDA–Univ. of Georgia–Univ. of Florida breeding program for the development of early ripening, non-melting, fresh-market peaches for low-chill areas (Beckman and Sherman, 1996). Similar cling peaches from Brazil, such as 'Bolinha', are being used as a source of resistance to brown rot [*Monilinia fructicola* (G. Wint.) Honey] for canning cling peaches in California (Gradziel and Wang, 1993). Pillar or upright tree architecture is being developed at USDA–Kearneysville, W.Va., based on germplasm from Italy and China (Bassi et al., 1994). Evergreen peaches from Mexico have terminal buds with no chilling requirement. Because these trees continue to grow all winter whenever temperatures are warm enough, they are useful in the study of tree dormancy. Trees at Byron have withstood temperatures below –18 °C, with damage only to the tender terminal portions of the tree. Evergreen germplasm also has unusual ability to survive on a peach tree short-life site (Rodriguez et al., 1994).

The only use of other *Prunus* species in U.S. peach breeding is in development of peach rootstocks. 'Nemaguard' rootstock, resistant to root-knot nematode (*Meloidogyne* sp.), was originally reported to be *P. davidiana* (Carr.) Franch., although the fruit and tree do not resemble the pure species (Okie, 1998). 'Guardian' rootstock, also selected at Byron, is descended from 'Nemaguard' (Okie et al., 1994). 'Flordaguard' rootstock, selected in Florida for resistance to a novel local root-knot nematode, descended from a cross of peach with a different clone of *P. davidiana* (Okie, 1998). *Prunus ferganensis* (Kost. & Riab) Kov. & Kost comes from the dry Ferghana Valley in central Asia (now Tajikistan, Kyrgyzstan, and Uzbekistan). This species resembles *P. persica* except for having long, unbranched leaf veins and longitudinal grooves on the pit. The leaf character seems to be controlled by a single recessive gene, so *P. ferganensis* is only a subspecies of peach. This leaf morphology apparently predominates in its region of origin, suggesting that it may be advantageous, perhaps in terms of water relations. Mark Reiger (pers. comm.) at the Univ. of Georgia will be comparing water relations in trees with and without this leaf character. None of our *P. ferganensis* accessions have good fruit quality, but the leaf character facilitates selection from segregating progenies.

PLUMS

Plums (excluding the hexaploid European types) contrast with peaches in several ways. The commercial industry is based on cultivars descended from four or more species. There are few breeding programs outside California, where the primary goals of increased size, firmness, and quality have required no further use of primitive germplasm. Commercial production in California is dominated by a few major cultivars, and new cultivars become important only slowly. Many of the major cultivars originated as mutations or open-pollinated seedlings of existing cultivars. The only significant use of imported germplasm since the Luther Burbank era has been by the Univ. of Florida, where plums from Taiwan were a source of low-chilling in the development of 'Gulfblaze' and 'Gulfbeauty'.

Much native U.S. plum germplasm exists. No native fruit was as

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extensively collected and selected by early settlers in the United States as plums, primarily because of the wide range of native species readily at hand and the shortage of suitable alternative fruits. Wight (1915b) lists 623 named plum cultivars derived solely from American species. Most arose in Iowa, Texas, Minnesota, Nebraska, and South Dakota from *P. americana* Marsh., *P. hortulana* Bailey, *P. angustifolia* Marsh., *P. munsoniana* Wight & Hedr., or combinations thereof. A few of these improved selections were used by Burbank when he crossed them with imported *P. salicina* and *P. simonii* Carr. to develop the plums we now know as "Japanese" plums, the predominant shipping plums in the United States (Howard, 1945). Unfortunately for modern plum breeders, only a handful of these native cultivars are still available, since cultivation of native plums is now rare. The National Research Support Project (NRSP-5; formerly IR-2) has about five species and some hybrid cultivars, while the NCGR has ≈13 American plum species, mostly as one or two accessions each. These small numbers are surprising considering that there are ≈20–25 native North American plum species, depending on the taxonomic treatment (Mason, 1913; Wight, 1915a; there is no comprehensive reference for North American *Prunus* species). The recent retirement of Joe Norton at Auburn Univ. leaves the USDA–ARS/Byron program as the last major plum breeding program outside of California, with modest, sometimes intermittent efforts in Florida, Texas, and recently, Wisconsin (Okie and Ramming, 1999).

Plums can have quite an allure for the breeder, for several reasons. They have great potential as a commercial crop in regions outside of California. Cultural management for plums is similar to that for peaches, which are already widely grown, and consumers are familiar with the fruit. Fruit quality exceeding that commonly available in the supermarket would make locally grown fruit readily marketable. The wide range of native species provides an untapped source of genetic material, albeit in a "collect-your-own" format, as few accessions are currently available in collections. Results from hybridizations are very unpredictable. The current cultivar arrays for most regions outside California are sorely lacking, which makes potential progress by the breeder easy to visualize and appreciate. The remainder of this paper describes some of this intriguing germplasm maintained at Byron, Ga., and summarizes our efforts to collect it and use it in scion and rootstock development.

Prunus angustifolia (Table 1) is the most common roadside plum in the southeastern United States (Fig. 1). Native Americans and later, European settlers, selected larger, more palatable types particularly from the western forms. Some of these are still grown in the midwest for jelly (Reid and Gast, 1993). Hybrids with Japanese plum, such as 'Bruce', had better size but only slightly better fruit quality, and became the predominant plums in the region because they were able to survive local disease pressure. Unfortunately, disease resistance and tree vigor appear closely linked with small fruit size and poor fruit quality. This hybrid material has continued to be used to breed adapted plums, such as 'Robusto' and 'Byrongold' developed at Byron.

One of the most southern-ranging plum species is *P. geniculata* Harper, which is localized in central Florida on very sandy areas known as scrub (Fig. 2). This unique ecosystem follows a relict sand ridge, and is very inhospitable for plants, with sand to a depth of 1.5 to 4 m. *Prunus geniculata* was widespread in the area when originally described by Harper (1911). A few years later he was already decrying the loss of natural vegetation in Florida, citing the following quote from C.T. Simpson (Harper, 1927).

"We advertise the beauties and attractions of Florida; we send out agents and literature to call the people of the northland to come and spend their winters or to be permanent residents with us. Then we destroy every vestige of its natural beauty, we cut down hammocks, drain the lakes and mutilate the rivers.... The only attraction belonging to the state that we do not ruin is the climate and if it were possible to can and export it we would do so until Florida would be left as bleak and desolate as Labrador."

Since that time much of the original habitat has been turned into citrus groves or housing developments, resulting in a federal endan-

Table 1. Plum species with germplasm worthy of exploitation. Bolded species are represented in NRSP-5/IR-2 or NPGR-Davis collections. Cultivars italicized are hybrids with *P. salicina*.

Species	Common name	Origin	Subspecies/synonyms	Cultivars extant
P. alleghaniensis	Allegheny plum, sloe	Northeastern U.S.	*davisii*	
P. americana	American plum, wild goose plum, hog plum	Central + eastern U.S.	*lanata, mollis*	Anderson's Early, *Ember*, Goff, Hazel, *Kahinta*, *Monitor*, *Red Coat*, *Underwood*, Wolf
P. andersonii	Desert peach	California, Nevada		
P. angustifolia	Chickasaw plum, sand plum, sandhill plum	Southern U.S.	*varians, watsonii*	*Bruce, Six Weeks*
P. besseyi	Sand cherry	Canada, northern U.S.	*cuneata, depressa, pumila, susquehanae*	*Alace*, Black Beauty, *Convoy*, *Deep Purple*, *Hiawatha*, *Manor*, *Mansan*, *Sapa*, Sioux
P. fasciculata	Desert almond, desert peach-brush	Southwestern U.S.		
P. fremontii	Wild apricot, desert apricot	Southern California		
P. geniculata	Scrub plum	Florida		
P. glandulosa	Chinese bush cherry	China, Japan		
P. havardii	Havard wild almond	Texas, Mexico		
P. hortulana	Wild goose plum, hortulan plum	Central U.S.	*mineri*	Miner, Wayland
P. humilis	Manchurian dwarf cherry	Northern China		
P. japonica	Flowering almond, Japanese bush cherry	Eastern Asia		
P. maritima	Beach plum, shore plum	Coastal northeastern U.S.	*gravesii*	Hancock, Jersey, Patricia, Raribank, Squibnocket
P. mexicana	Big-tree plum, Mexican plum	South central U.S., Mexico		
P. minutiflora	Texas wild almond, small-flower peach-brush	Texas, Mexico		
P. munsoniana	Wild goose plum	South central U.S.		Late Goose, Whitaker
P. nigra	Black plum, Canada plum	Northern U.S., Canada		Aitken, Assiniboine, Bounty, *Grenville*, Norther, *Pembina*
P. salicina	Japanese plum	China	*bokhariensis, gymnodonta*	Abundance, Burbank, Kelsey, Satsuma
P. subcordata	Pacific plum, sierra plum	Northwestern U.S.	*kelloggii, oregana*	G.M. Clark, Kelly Sierra #2
P. texana	Texas almond cherry, Texas peach-brush	Texas	*glandulosa*	
P. umbellata	Flatwoods plum, hog plum, sloe	Southeastern U.S.	*injucunda, mitis, tarda*	

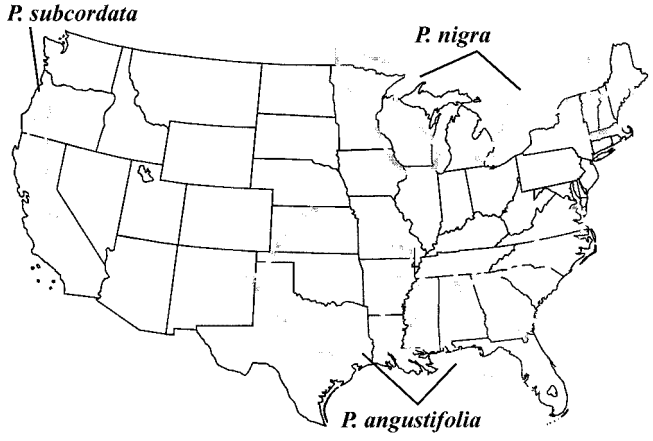

Fig. 1. Distribution of *Prunus angustifolia*, *P. subcordata*, and *P. nigra* in the United States (after Little, 1976; Wight, 1915a).

gered plant status of G2-3. Local efforts to preserve it are coordinated by Bok Tower Gardens in Lake Wales, Fla. Young plants seem rare in the wild, suggesting that natural recolonization is difficult. The small fruit are palatable and are borne in profusion on bushes with a minimum of foliage. The scrub plum is not hardy at Byron, having only a minimal chilling requirement. We do have a few plants that appear to be successful hybrids with commercial plums but they have not yet fruited.

Prunus umbellata Ell. is an obscure southeastern plum (Fig. 3) that is noticeable primarily during bloom. This plum grows with a single trunk, in contrast with the tendency of *P. angustifolia* to form thickets along the roadside. Apparent natural hybrids between these two species are common, and have intermediate leaf, bloom, and fruit characters. At the southern fringe of its range, there appears to be some introgression of *P. geniculata*, as the leaves resemble those of that species and are distinct from those of more northern accessions of *P. umbellata*. Because of its poor fruit quality, *P. umbellata* has not been used by breeders; at Byron, fruit of F_1 hybrids with Japanese plums retain the bitter flavor and small size. Trees are vigorous, but some are highly prone to defoliation. As a scion it is not consistently compatible with peach rootstock, which reduces its value in rootstock breeding, despite local adaptability. Trees planted in seedling rows at Byron are not as long-lived as trees in the wild, possibly because of herbicide sensitivity.

Prunus americana, the third southeastern species, is widespread across the eastern states, and is the common roadside plum in more northern regions (Fig. 2). In the far north it intergrades into *P. nigra* Ait. (Fig. 1), which has produced some of the most cold-hardy plums (Table 1), but is poorly adapted to the climate at Byron. In the deep south, where *P. americana* is typically found in river bottoms, it is now rare, possibly as a result of extensive roguing of wild plums by the government over the last 40 years to reduce inoculum of peach phony disease (caused by *Xylella fastidiosa* Wells et al.). The inability of *P. americana* to recolonize may relate to limited root suckering, to erratic cropping, or to its being at the limits of its natural distribution. Although superior fruit types of this species were selected by early settlers, little if any of this germplasm came from southern sources. Hence, most surviving cultivars (Table 1), as well as seedlings from commercial seed sources, are better adapted to more northern areas. The locally collected accessions at Byron are much more vigorous and healthy than the northern types, which suffer from lack of chilling and are highly susceptible to leaf scald (caused by *X. fastidiosa)*. Seedlings are not precocious, so we have yet to produce successful hybrids with commercial plums.

Two other regional species resemble *P. umbellata*. *Prunus alleghaniensis* Porter is mainly restricted to the mountains from Connecticut to Pennsylvania to Virginia (Fig. 3). Again, the small bitter fruit has left the species completely unused by breeders. Curiously, there is a remnant population in central Michigan, which was described long ago and presumed to be extinct until "rediscovered" in the last decade by Sylvia Taylor of the Michigan Dept. of Natural Resources (Taylor, 1990). Scattered trees are seen along roadsides, with a few spots of local abundance. The most curious collection is at the "Big Frost Pocket," where dozens of diverse genotypes are assembled on a hillside overlooking a sandy plain reputed to have had single daily temperature extremes of –4 to 40 °C, with occasional lows of –32 °C. This Michigan subspecies has been placed on some endangered species lists. *Prunus alleghaniensis* is marginal in chilling at Byron and no hybrids with commercial plums have been obtained.

The second species resembling *P. umbellata* is the beach plum, *P. maritima* Marsh., which occurs along the eastern U.S. coast from Maine to Maryland (Fig. 3) and once formed the basis for numerous cottage industries (Bailey, 1944). This species is the latest to bloom at Byron, often nearly 2 months after commercial plums. Its ability to fruit at Byron suggests that the late bloom is partly due to high heat requirement rather than strictly to high chilling requirement. Late bloom, but with a low chilling requirement, would be a desirable addition to our commercial fruit types, as plum flowers are often killed by frost in the Southeast. The species probably also tolerates salt (Mark Rieger, pers. comm.) and waterlogging, given its preferred habitat in the sand dunes along the ocean. Efforts to utilize this species for fruit, jelly, wildlife food, and ornamental use have recently been revived in the Northeast by Richard Uva and others (Uva and Whitlow, 1997). Several named cultivars exist, some appearing to be hybrids with *P. americana*. After numerous attempts, we have a few seedlings that appear to be hybrids of *P. maritima* with commercial plums.

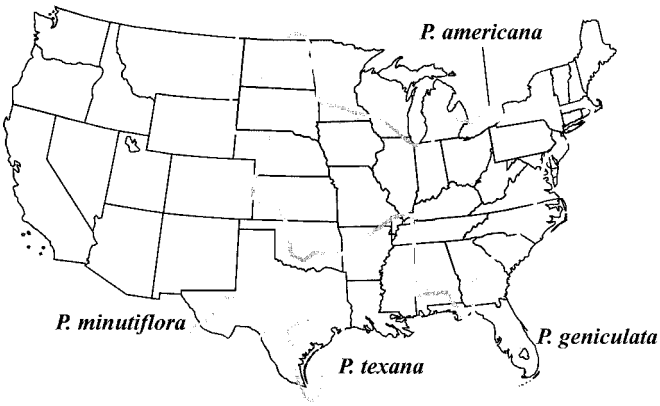

Fig. 2. Distribution of *Prunus americana*, *P. geniculata*, *P. texana*, and *P. minutiflora* in the United States (after Little, 1976; 1977; Mason, 1913; Wight, 1915a).

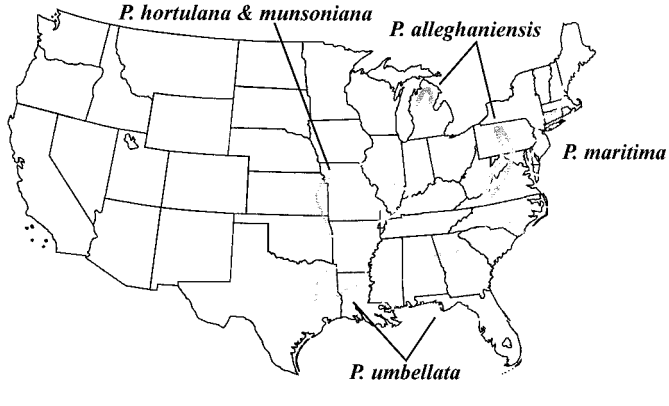

Fig. 3. Distribution in the United States of *Prunus alleghaniensis*, *P. maritima*, *P. umbellata* and *P. hortulana* combined with *P. munsoniana* (after Little, 1976; Wight, 1915a).

Although *P. hortulana* and *P. munsoniana* were used by the early plum breeders, they have been neglected in recent years, except for an occasional test of the former species as a rootstock, since it does not sucker (Okie, 1987). These species are found around old home sites across the midwestern states (Fig. 3), making it difficult to distinguish wild trees from descendants of cultivated trees. Species identification can be a problem, as the species intergrade naturally and as a result of human efforts. *Prunus hortulana* has potential as a rootstock and is also useful for its late bloom, late ripening, and bright skin color. We have several late-blooming hybrids with 'Angeleno', but size is small and quality mediocre.

The major U.S. west coast plum is *P. subcordata* Benth., which is found in southern Oregon and northern California (Fig. 1). Although the subject of cultivar testing and cultural research at Oregon State Univ. in the 1950s, and still used locally in Oregon for producing jelly, it remains obscure. *Prunus subcordata* appears to have substantial drought tolerance (Rieger and Duemmel, 1992), which is not surprising based on its often xeric habitats. Efforts to establish it at Byron have been frustrated by its high chilling requirement and susceptibility to disease in our humid climate. Roberts and Hammers (1951) describe their fruitless efforts to track down certain subspecies mentioned in taxonomic descriptions. This is an example of how somewhat misleading information can creep into the literature and be perpetuated, complicating life for the collector.

Prunus mexicana S. Wats. produces the largest tree of the native plums, growing up to 10 m tall. Its range extends from the lower midwestern United States into Mexico (Fig. 4). Since it does not sucker, it was tried as a peach rootstock, and was found to be dwarfing but with variable compatibility (Okie, 1987). Although fruit size is medium for a wild plum, quality is generally poor and it has not been used by breeders until recently in Texas and at Byron. Using bees and caged trees, we produced a large F_1 population that was very uniform in seedling morphology, but variation is now apparent in fruit size, color, and quality.

Six *Prunus* species native to desert regions from Texas to California have pubescent fruit and unclear taxonomic affinities (Mason, 1913). Most are not well-adapted to eastern conditions. Not surprisingly, *P. andersonii* Gray (Fig. 4) has high levels of drought tolerance (Rieger and Duemmel, 1992), but it does not grow well in our climate. Two other species have useful characters. *Prunus texana* Dietr. (Fig. 2) has fair fruit quality, is highly precocious, fruiting in Florida in 12 months from seed (Wayne Sherman, pers. comm.), and hybridizes readily with plum. *Prunus minutiflora* Engelm. (Fig. 2) is one of the few dioecious *Prunus* species. As its name indicates, it has extremely small flowers. The F_1 hybrids with commercial plums have been fully fertile at Byron, with an intermediate, shrubby growth habit. Since this species occurs on calcareous soils, it may be useful in breeding rootstocks tolerant to high pH, allowing peaches and plums to be grown on such sites.

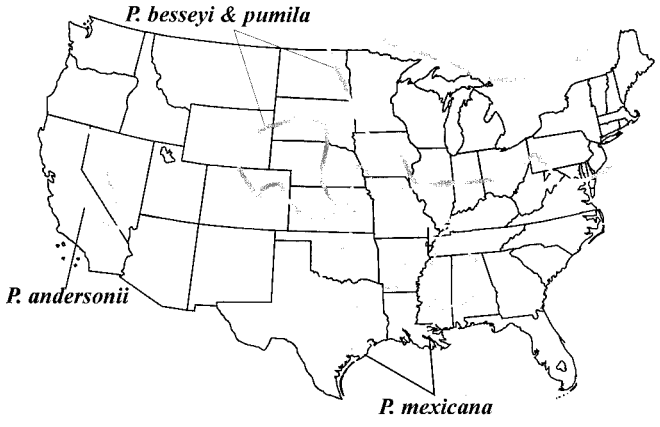

Fig. 4. Distribution in the United States of *Prunus andersonii*, *P. mexicana*, and *P. besseyi* combined with *P. pumila* (after Little, 1976; Wight, 1915a).

Finally, two species traditionally misclassified as cherries [*Prunus* subgenus *Cerasus* (Adans.) Focke] are also interesting. *Prunus besseyi* Bailey (also known as *P. pumila* L. in its eastern range) is one of the most cold-hardy *Prunus* species (Okie, 1987). It was used extensively by Hansen in South Dakota to develop cold-hardy plums (Hansen, 1937), with more than a million seedlings grown. 'Sapa' (Table 1) was his most important release, as it has been used as a parent of other hybrids and for rootstock development. All the breeding work appears to have been done with western forms of *P. besseyi*, as they had better fruit quality. Unfortunately, these forms have high sensitivity to blossom and twig blight caused by *Monilinia* sp., making them short-lived in humid climates. Recently, we collected *P. besseyi* from the pine barrens of central Michigan, where *P. alleghaniensis* also occurs. The species also ranges into the northeastern United States and south to Virginia, with an unconfirmed report from the mountains of North Carolina (Fig. 4). Other accessions have recently come from New York. It will be interesting to see how hybrids with these eastern accessions suit our climate. They are much smaller-statured plants than western accessions even in good soil, and plant health seems good so far. Their late-bloom is at least partly due to higher post-rest heat accumulation (Werner et al., 1988), enabling them to fruit well in lower-chilling zones.

A second "cherry" is *P. japonica* Thunb. and relatives *P. glandulosa* Thunb. and *P. humilis* Bge., which are from China. This group is best known in the ornamental form, *P. glandulosa*, or flowering almond. Accessions from China were quite prolific and crossed readily with plum to produce a range of fruitful hybrids. This species appears to have some resistance to plum curculio [*Conotrachelus nenuphar* (Herbst)], but whether or not this is true resistance that can be transferred and utilized remains to be seen (Yonce et al., 1995). It also has been crossed with plum in Japan (Kataoka et al., 1988), as well as used as a dwarfing rootstock (actually interstem) for peach.

CONCLUSION

Much of the work described here is admittedly observational and not driven by obvious immediate benefits or supportive of an established industry. Nevertheless, the use of native *Prunus* germplasm for improvement of scions and rootstocks of our cultivated plums appears to have great potential. In fact, in the last 50 years, these species may have been used more outside the United States than within. Domestically, the limited number of programs involving plum breeding, and especially germplasm collection and enhancement, means progress will be slow. State quarantines in California make it difficult to acquire and preserve native *Prunus* germplasm in the national collection. Better representation of native species in national collections would also provide more material for exchange with other countries. To meet this goal, efforts of breeders, local collectors, botanical gardens, and the Soil Conservation Service should be coordinated.

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