

Introgression of *Prunus* species in Plum

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“Introgression” is a big word meaning introduction of the genes of one species into the gene pool of another. This transfer can be a one-time thing, or if one parent is much better than the other, it may involve repeated backcrossing of an interspecific hybrid with one of its parents (generally the one with better fruit). Within *Prunus*, plums have had the most extensive mixing and matching of species. Use of exotic species for the other main stone fruits – peach, cherry, almond and apricot – has been minimal and mostly directed at rootstock development. So I will primarily address species mixing as it relates to plums, specifically Japanese plums.

Most of these Japanese plums are consumed as fresh fruit. Production in the United States is concentrated in California, where they are best adapted. Commercial production in California is dominated by a few major cultivars, and new cultivars become important only slowly. 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. Recent utilization of genetic resources of Japanese plum has been limited in the United States compared with that of many other crops. Difficulties in collection, importation and quarantine through-put have limited the germplasm available. *Prunus* is more difficult to preserve because of the large amount of space needed compared to 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” commercial variety development to meet immediate industry needs, has also contributed to reduced use of exotic material.

Origin

The ancestors of what we call Japanese plums actually originated in China. The term “Japanese plum” originally was applied to *Prunus salicina* imported from Japan in the late 19th century, but now includes all the fresh market plums developed by intercrossing various diploid species with the original species. Most plums are diploid (two sets of chromosomes) except for the European plums which are hexaploid (six sets). These plums were initially improved by selection in Japan and later, to a much greater extent, in the United States.

In China, *P. salicina* may have originated in the Yangtze River Basin but now is found across eastern China. The history of ‘Zhui Li’ cultivar goes back 2500 years. Numerous local selections have since been developed, but plum has never been as important in China as peach, either commercially or culturally. Plums in Southern China are concentrated in seven provinces, but especially in Fujian and Zhejiang, with over 20 million plum trees found there and about 200 cultivars grown. Truly wild stands are rare but are reported to still occur in Hubei and Yunnan, where some trees in Zhongdian County are over 100 years old. Low chilling types of *P. salicina* are found in Southern China and Taiwan. Cold hardy plums in Northern China have been classified as *P. ussuriensis* and *P. gymnodonta*, but are otherwise very similar to *P. salicina*. Modern breeding programs, especially in USSR., have utilized this source of hardiness (Okie and Weinberger, 1996).

Prunus simonii was described based on cultivated specimens by Western botanists. This species (probably the same clone each time) was used in developing

Plums have great potential as a commercial crop in regions outside of California. The wide range of native plum species provides an untapped source of genetic material. Results from hybridizations are very unpredictable. 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.

California cultivars because of its firm flesh and strong flavor. Chinese botanists describe it as native to North China, and occasionally cultivated. It has some characters reminiscent of apricot and was thought by some to have descended from a natural hybrid, but more likely is just an upright variant of *P. salicina*.

Plum stones have been found in Japan dating back to the Yayoi Era, about 2300 years ago. Japanese books dating back 1500 years mention cultivated plums. Plums have been common garden plants in Japan for centuries, but improvement efforts have only taken place in the last century. Plum culture in Japan and also Korea is very ancient, so that it is not possible to tell for certain if the countries were ever part of the native range for plums.

Plum Breeding - California

Trees of improved *P. salicina* cultivars ‘Kelsey’ and ‘Abundance’ were introduced into the United States from Japan over 100 years ago. Luther Burbank himself imported a second lot of Japanese plum seedlings and from them named

'Burbank' and 'Satsuma'. He then intercrossed these and other imports with *P. simonii* and North American species, resulting in 'Beauty,' 'Duarte,' 'Eldorado,' 'Formosa,' 'Gaviota,' 'Santa Rosa,' 'Shiro,' and 'Wickson' (Howard, 1945). These plums formed the basis for the world's shipping plum industry, and some are still widely grown. Pure *P. salicina* and related species have been little used as parents since Burbank's early hybridizations and few pure *P. salicina* clones are available outside of China. Most of Burbank's hybrid plums are thought to descend from crosses of—*P. salicina*, *P. simonii* and *P. americana*. In general, *P. salicina* contributed size, flavor, color and keeping ability; *P. simonii* contributed firmness and acidity; whereas the American species gave disease resistance, tough skin and aromatic quality.

After Burbank, breeding was carried on by the University of California and USDA. In California, past emphasis of breeders has been on size and firmness for shipping, with a mild flavor preferred. Black skin color became very popular with the introduction of 'Friar' because it did not show bruises and was very productive. However, large, firm, highly colored fruit can be harvested prematurely resulting in reduced consumer quality. Plums showing some ground color may be easier to pick at the proper stage of maturity. Low prices and over production of black plums have increased interest in other colors. Current objectives include a wider range of skin color and better eating quality. Red or black skin color and yellow or red flesh color appear to be most acceptable although green skinned plums are shipped to Asian markets. Storage ability, particularly at the end of the season, is also important. Private breeders and growers in California have selected many important commercial plums (Table 2). Many of the commercial cultivars grown in California were found as chance or open-pollinated seedlings or mutations, rather than the result of hybridizations. Fred Anderson released 'Red Beaut,' 'Black Beaut,' and 'Grand Rosa.' John Garabedian developed 'Angeleno,' still the major late plum. Floyd Zaiger has released 'Joanna Red,' 'Betty Anne,' 'Hiromi Red,' and 'Autumn Beaut,' as well as 'Citation' rootstock, an interspecific hybrid, and numerous plum-apricot hybrids under the trademarked terms "pluot" and "aprium." Breeders at Sunworld International (formerly

Superior Farms) have named 'Black Diamond,' 'Black Flame,' 'Black Gold,' 'Black Torch' and 'Sweet Rosa.' Their program is the largest of the private breeders, and as with most private programs, the releases are patented (Okie and Ramming, 1999).

With the advent of Burbank's improved plums which were large and firm enough to ship long distances, a new industry developed in California where local industries in other states mostly died out. As local industries declined, breeding programs were closed. California-bred plum cultivars were tried around the world, but with the exception of a few places like Chile and some parts of Italy, they have not thrived as well as they did in California.

Plum Breeding - Southeast

As a result of the poor adaptability of these improved California plums, they were crossed with local plums in other parts of the country and world. In the Southeastern U.S., the Japanese plums were crossed with the local *P. angustifolia* resulting in plums such as 'Bruce' and 'Six Weeks.' Current breeding objectives in the Southeast United States (Georgia, Alabama, Texas, and Florida) are the same as those of California plus additional disease resistance. Fruit firmness is somewhat less important because many local markets are available. Resistance is required to three primary diseases: bacterial leaf and fruit spot and twig canker, bacterial canker, and plum leaf scald. The first two diseases are problems in many other countries that are trying to grow Japanese plums, such as Australia, New Zealand, Italy, and South Africa. Leaf scald is also a serious problem in Argentina and Brazil, and could be a problem in California in the future if the glassy-winged sharpshooter vector continues to spread. In general, later bloom is more desirable but regions such as Florida and parts of Texas, Australia, and Brazil require even lower chilling requirements than those common in Japanese plums.

A long-term breeding program has been conducted at Auburn University in Alabama, where Joe Norton began in 1955. Releases are 'Crimson' (1973), 'Purple' (1973), 'Homeside' (1975), 'AU Producer' (1977), 'AU Roadside' (1984), 'AU Cherry' (1989), 'AU Amber' (1989), 'AU Rosa' (1989) and 'AU Rubrum'

(1989). While most have improved disease resistance, only 'AU-Rubrum' has size and firmness adequate for commercial shipping. 'AU-Amber' is very sweet for an early plum, but crops erratically. Breeding has been discontinued with the retirement of Norton.

Plum Breeding - USDA-Byron

The United States Department of Agriculture (USDA) stone fruit breeding in Georgia began in 1937 at the Horticultural Fruit Laboratory in Fort Valley, which is located in the center of the main peach production area. John Weinberger was the peach breeder from 1937-1954, when he transferred to Fresno, California to begin the peach breeding program there. Victor E. Prince continued the breeding in 1954. In 1964, the program was moved 20 miles east from Fort Valley to the newly opened Southeastern Fruit and Tree Nut Research Laboratory in Byron. Prince began testing plums in 1958 and started making crosses in 1964 after moving to Byron. Much of the early seed for evaluating came from Weinberger in Fresno, who was also breeding plums at that time. This California plum germplasm was crossed with southern varieties such as 'Morris', 'Methley', 'Bruce' and the native wild plum, *Prunus angustifolia*. Unfortunately the large attractive California plums would not survive in the humid climate of Georgia. In 1972 J. M. Thompson took over the plum breeding. Before he retired in 1986, Thompson released four plums - 'Robusto', 'Segundo', 'Byrongold' and 'Explorer' - plus BY69-1637P plumcot. Three more plums, 'Rubysweet', 'Black Ruby' and 'Ruby Queen' have been released since then, along with 'Spring Satin' plumcot.

Since 1964 we have grown over 56,000 plum seedlings and named eight varieties, or one variety per 7,000 seedlings. This ratio is higher for plums than peaches because a greater percentage of plum seedlings regress back to a weak tree or wild-type poor fruit quality. Some of the current plum selections are very promising if they stay alive, and should result in several named varieties. Our current goals in both plum breeding are to combine good quality, large, firm fruit with consistent production on a healthy long-lived tree. Resistance is needed to *Pseudomonas syringae* (bacterial canker), *Xanthomonas pruni* (bacterial leafspot and twig canker) and *Xyella fastidiosa* (plum

leaf scald). Most of our selections are highly resistant to the first two but only tolerant of the last, which is the disease that finally kills them. Combined with a disease-resistant tree we need fruit that is large, firm and of good flavor and texture. Late blooming is needed to ensure a crop every year. Although we have a few good plums with most of these characteristics, we do not yet have good ones for the entire season, especially the extremes. As new improved selections are made, many of the older selections once thought to be fairly good are perceived to be sub-standard by the latest standards. In plums, the current desired target requires excellent fruit similar to those from California, but with more flavor. In recent years we have planted many seedlings of 'Spring Satin' and various other parents in an effort to produce a range of freestone plumcots.

Named Plum Varieties from Byron, GA

Robusto. Parentage: *BY4-1537 (=Queen Ann x Barstow) x BY7-335 (=Ozark Premier x P. angustifolia)*. Very vigorous tree. Eaten green like Bruce. Quality is fair when ripe but fruit is too soft and juicy for shipping.

Segundo. Parentage: *BY4-1236 (=Queen Ann x Santa Rosa) x BY7-335*. Similar to Robusto - a "green" plum eaten firm. Ripe quality mild and watery. Very big tree.

Byrongold. Parentage: *BY68-87 op (=Gaviota op x BY7-335)*. Vigorous tree with golden fruit. Good eating quality if fully ripe. Colors early so don't pick too soon. Mixed consumer acceptance for yellow plums.

Rubysweet. Parentage: *Mariposa x Methley*. Bronze skin color is less attractive but eating quality of red flesh is excellent. Skin slightly bitter. Locally popular in Southeast U.S.

Explorer. Parentage: *Queen Ann x Santa Rosa*. Attractive black plum but has not been a reliable cropper most years. Not grown commercially.

Black Ruby. Parentage: *BY4-95 op (=Queen Ann x Santa Rosa)*. Large, firm black fruit on healthy upright tree. Slightly sour skin.

Ruby Queen. Parentage: *BY7607-10 op =Frontier x Redroy*. Latest good plum, ripe about three weeks after Santa Rosa. Red-

black skin with red flesh, very tasty. Less vigorous tree and very attractive to deer.

Spring Satin. Parentage: *BY4-601 (=Queen Ann x Santa Rosa) x Frontier*. Early ripening plumcot. Red-black skin with yellow-red flesh, good quality when soft, light fuzz. Productive.

Advanced Plum Selections from Byron, GA

BY8154-58. Parentage: *BY69-123 op (=Mariposa x Methley)*. Ripens 1 1/2 weeks before Santa Rosa, about with Methley. Large, reddish-bronze skin with red flesh. Very good quality, sticky wax bloom. Consistent production not certain. Very good tree.

BY8158-50. Parentage: *BY69-409 op (=Mariposa x Morris)*. Ripens a few days before Santa Rosa. Attractive red color and firm flesh. Tends to overbear, dwarfing the tree.

BY91M937. Parentage: *BY8154-242 = Mariposa x Methley*. Ripe slightly after Methley. Red black skin with red flesh. Productive. Good flavor for early but slightly sour skin.

BY91M961. Parentage: *BY8304-27 op*. Ripe two months after Methley. Dark red skin with red flesh. Productive. Mild flavor.

BY95M1094. Parentage: *BY8334-16 x BY8327-65*. Ripe with Methley. Dark red skin with whitish-red flesh. Good cropper. Sweet when soft.

BY98Z1204. Parentage: *Spring Satin x cots*. Ripe with Methley. Dark red fuzzy skin with yellow-orange flesh. Tastes good firm, freestone. Resembles apricot tree.

BY98Z1281. Parentage: *Spring Satin x self*. Ripe four weeks after Methley. Black fuzzy skin with red flesh. Tastes Ok firm, mostly freestone.

BY98M1698. Parentage: *BY8327-65 x Black Ruby*. Ripe 21 days after Methley. Red black skin with red flesh. Good cropper. Medium size. Can eat firm.

Plum Breeding - Northeast

None of the historic public breeding programs developing cold-hardy plum hybrids are still active. Many

cultivars were released before 1950, especially from South Dakota and Minnesota Agriculture Experiment Stations, using the most cold hardy plum species: *P. nigra*, *P. besseyi*, and *P. salicina* (from Manchuria) (Kadir and Proebsting, 1994). 'Sapa' (= *P. besseyi* x Sultan) and its many hybrid offspring, although poor in quality, are widely adapted (Anderson and Weir, 1967; Hansen, 1937). These hybrids are often called "cherry plums"; the same terms used for *P. cerasifera*, and are now used more for rootstock development than for fruit production. The University of Minnesota breeding program, long inactive, recently released an old selection as 'Alderman'.

New York and Ontario, Canada have also had Japanese plum breeding as a minor adjunct to European plum breeding. 'Vanier', was released by Ontario in 1984. Neither program has continued much Japanese plum breeding. The most important northern variety has been 'Early Golden', a chance seedling found in Ontario over 50 years ago but still widely grown. Other programs developing cold hardy stone fruit were the Horticultural Experiment Station, Brooks, Alberta; Dominion Experiment Station, Morden, Manitoba; USDA Northern Great Plains Field Station, Mandan, North Dakota; and the University of Saskatchewan, Saskatoon, Saskatchewan (Okie and Weinberger, 1996). In general these hardy plums lack size, firmness and quality necessary for more than local use. Modest efforts to improve northern plums have been continued by private individuals and Brian Smith at the University of Wisconsin at River Falls.

Unfortunately for modern breeders, only a few of the improved native American selections are still available, since cultivation of native American plums is obsolete. These species are discussed later.

Plum Breeding - Foreign

Although *P. cerasifera* is likely an ancestor of European plums, it is a diploid species cross-fertile with Asian and American plum species. These "cherry plums" have not been used much in modern breeding outside Eastern Europe and the former USSR, although chance hybrids with *P. cerasifera* produced 'Methley' in South Africa and 'Wilson' in Australia. This species provides earliness, cold-hardiness and probably self-fertility,

but fruit size is small. Breeding programs in the Southern Hemisphere include South Africa and Australia. Their goals are development of large fruited, high quality plums with resistance to bacterial spot and bacterial canker, and the ability to store without internal breakdown. Storageability of four weeks is crucial to exporting the fruit by ship.

Japanese plum breeding in Europe is relatively new, but will be important as demand continues to increase for the large fruited Japanese plums. Breeders at Rome and Forlì are seeking smaller trees to reduce production costs in combination with large size, dark skin, and good eating quality. At Florence, goals are to develop self fertile, late blooming plums with high quality, particularly yellow skinned types. Recently a breeding program has begun near Avignon in Southern France where poor weather during pollination is a major problem. Sharka resistance is also important.

Genetic Resources

Much native United States plum germplasm exists (Little, 1976; Little, 1977; Okie, 2001). No native fruit was as 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*, *P. hortulana*, *P. angustifolia*, *P. munsoniana*, or a combination thereof. 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 varieties, while the NCGR has about 13 American plum species, mostly as one or two accessions each (Table 1). These small numbers are surprising considering there are about 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 University 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 is similar to 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 varietal 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.

Plum species and relatives

The *Prunus* described here can be loosely grouped into three sections: wild plum species, mainly in North America (Table 1); bush cherries, most of which might be better called "bush plums" and desert species. Where both parents have the same number of chromosomes, plum interspecific hybridization is generally successful. Many hybrids have been made, particularly with *P. cerasifera*, *salicina*, *simonii*, *besseyi*, *americana*, *angustifolia*, *hortulana*, *munsoniana*, and *nigra*. Hybrids between these nine species are mostly fertile and productive. Hybrids have also been made with *P. japonica*, Chinese bush cherry. The plums and bush cherries are mostly inter-compatible. Successful hybrids between the plums or bush cherries and the true cherry species are extremely rare, suggesting that those in Table 1 are better thought of as plums than cherries. Several of the diploid plum species have been hybridized with peach, but the offspring are usually sterile. *Prunus cerasifera* has also been hybridized with several almond species. Others of the species listed in Table 1 have apparently never been used in hybridization programs.

Chickasaw Plum *Prunus angustifolia* is the most common roadside and fence-row plum in the Southeastern United States, where it is often found on sandy soils. The original range is unknown, but likely was smaller than the current range from Texas, across Kansas to Maryland and New Jersey, and as far south as central Florida. It grows as a small twiggy tree or in a thicket, since it produces root suckers readily. Leaves are lance shaped, often rolling slightly at the margins to form a trough-like shape. Fruit is 1-2 cm across, usually red or yellow with yellow flesh. Most plants have fruit that is edible, with watery flesh ranging from sweet to tart. It is easily propagated by root sprouts, budding or seed. Birds and animals likely spread it initially, but its survival relates to its ability to re-sprout profusely when the above-ground part of the plant is destroyed. Native Americans, and later European settlers, selected larger, more palatable types particularly from the western range of the species. Some of these are still grown in the Midwestern USA for jelly. In many areas local people eat the fruit fresh. 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 USDA, Byron, Georgia. In Alabama and Georgia, there is a market for "green plums" which are local varieties picked while green and prized for their sour flavor. Perhaps this market reflects the childhood experience of locals eating the wild plums green, before the "worms" got them.

Scrub Plum One of the rarest as well as most southern-ranging plum species is *P. geniculata*, which is localized in central Florida on very sandy areas known as scrub. This unique ecosystem follows a relict sand ridge, which is very inhospitable for plants, with sand to a depth 1.5-4 m. *Prunus geniculata* was widespread in the area when originally described by Harper in 1911.

Since that time much of the original habitat has been turned into citrus groves or housing developments, resulting in a federal endangered 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. The scrub plum is not hardy at Byron, Georgia, having only a minimal chilling requirement. Locally it is occasionally used for jelly as the fruit is surprisingly edible.

Hog Plum *Prunus umbellata* is an obscure southeastern plum that is noticeable primarily during bloom, which occurs several weeks after that of *P. angustifolia*. This plum grows with a single trunk, in contrast to 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 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, Georgia, fruit of F₁ hybrids with Japanese plums retain the bitter flavor and small size. Leaves are elliptic to lanceolate, 4-7 cm long. Some trees have very hairy leaves and twigs, others have no hair. Flowers are similar to *P. angustifolia*, but borne in clusters (umbels) of 2-6 from a bud. Fruit is small and usually bitter, 1 cm in diameter on a long stem, so it resembles a blueberry. Fruit color ranges from black to purple to red to yellow. Because of the resemblance to *P. spinosa*, the species is frequently called "sloe plum". Trees are vigorous, but less prone to recolonize than Chickasaw plum. As a scion it is not consistently compatible with peach rootstock, which reduces its value in rootstock breeding, despite local adaptability. Hog plum has bitter or tart fruit so must be processed, as jelly for instance, for human consumption, such as in jellies.

Alleghany Plum *Prunus alleghaniensis* is mainly restricted to the mountains from Connecticut to Pennsylvania to Virginia and resembles *P. umbellata*. 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 extinct until "rediscovered" in the last decade by Sylvia Taylor of the Michigan Department 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 trees are assembled on a hillside overlooking a sandy plain reputed to have had a single daily temperature extreme of 24° to 104° F, with occasional lows of -26° F. This Michigan subspecies has been placed on some endangered species lists. *Prunus alleghaniensis* is marginal in chilling at Byron but several hybrids with commercial plums have been obtained. It is collected locally for jellies.

Beach Plum The beach plum, *P. maritima*, occurs along the Eastern U.S. coast from Maine to Maryland and once formed the basis for numerous cottage industries (Bailey, 1944; Uva and Whitlow, 1997). This species is the latest to bloom at Byron, often nearly two months after commercial plums. Its ability to fruit at Byron suggests the late bloom is partly

TABLE 1

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

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

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 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 varieties 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.

American Plum *Prunus americana*, the third Southeastern US species, is widespread across the eastern states, and is the common roadside plum in more northern regions. In the far north it intergrades into *P. nigra*, which has produced some of the most cold-hardy plums. In the west it blends into *P. mexicana*. In the deep south down to Florida, 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*. The inability of *P. americana* to re-colonize 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. American plum has large leaves with a coarse margin. Older trees may have grey, scaly bark. Flowers are also large, 2-3 cm across and in groups of 2-5. Fruit is usually 2-3 cm in size, with sometimes dry, but usually palatable flesh and bright red color. Fruit usage is similar to Chickasaw plum, being consumed fresh and processed, often from wild plants.

Prunus nigra is the northernmost plum species in North America, with a range extending into Canada. It was also selected by local farmers, and the better varieties crossed with Japanese plums to

create hardy hybrids, such as ‘Pembina’, ‘Brookred’, ‘Perfection’ and ‘Patterson’s Pride’. These are among the hardiest plums that don’t have sand-cherry blood in them.

Prunus mexicana produces the largest tree of the native plums, growing up to 10 m tall. Its range extends from the lower Mid-western United States into Mexico. Where it overlaps with American plum the species may intercross. Generally it is distinguished by having a larger tree, purplish-black fruit, and a more rugged leaf compared to American plum. Fruit quality is poorer than American plum, so fruit is more often processed rather than eaten fresh. Since it does not sucker, it was tried as a peach rootstock, and was found to be dwarfing but with variable compatibility. 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 Georgia. Again, poor quality is apparent.

Wild Goose Plum *Prunus hortulana* and *P. munsoniana* were used by the early plum breeders and fruit growers, and were a source of many cultivars. The name refers to the origin of one of the first cultivars from a seed found in the body of a wild goose that had been killed. Because these species were described after they were already in use by settlers, their natural status is unclear. Although there are clearly defined species types, there are many intermediates that represent a continuum from one species to another, making it difficult to be certain of the taxonomy. Local farmers would have had trees of several popular cultivars, making hybrids likely. Seed were often collected and passed around so many slightly different cultivars were named. Currently these plums are still found around old home sites across the Mid-western USA, making it difficult to distinguish wild trees from descendants of cultivated trees. *Prunus hortulana* is distinguished by one of the largest leaves of the plums, being oblong – ovate, up to 11 cm in length – similar to sweet cherry. Fruit is 2-3 cm in diameter, distinctively shiny red or yellow, due to the absence of bloom (the waxy exterior layer common on most plums which can be buffed off to make the plum glossy). *Prunus munsoniana* has a more lanceolate leaf, smaller fruit usually with bloom, and frequently spreads by root suckers. This species also

Cultivar	Nursery Sales (%)	Production (1000 Tonnes)	Release Year	Originator
Angeleno	9.5	30.7	1967	Garabadien
Friar	3.1	23.7	1968	USDA-Fresno
Blackamber	1.2	14.8	1980	USDA-Fresno
Fortune	6.0	13.4	1990	USDA-Fresno
Red Beaut	1.6	7.2	1965	Anderson
Santa Rosa	1.2	6.3	1906	Burbank
Howard Sun	4.9	5.5	1982	Chamberlin
Royal Diamond	0.8	4.1	1989	Kitahara
Catalina	2.1	3.9	1982	Krause
Black Beaut	0.9	3.6	1975	Anderson
Moyer Prune	0.1	3.2		
Simka	0.4	3.0	1959	Kazarian
Grand Rosa	1.1	2.9	1959	Anderson
Casselman	0	2.8	1959	Casselman
French Prune	0	2.6		
Joanna Red	9.5	2.2	1998	Zaiger
Betty Anne	0.9	2.1	1993	Zaiger
Hiroimi Red	10.1	1.7	1997	Zaiger
Autumn Beaut	0.1	1.6	1993	Zaiger
Laroda	0.1	1.2	1954	UC-Davis
Earliqueen	1.9	1.2	1994	Zaiger
Showtime	0.6	1.2	1992	Wuhl
Kelsey	0	1.1	1870	Japan
Rosemary	0	1.0	1975	Anderson
Primetime	0	1.0	1994	Wuhl
Freedom	0	0.7	1980	USDA-Fresno
Autumn Giant	0	0.2	1986	Zaiger
Other cultivars	23.4	18.3		

intergrades into types resembling vigorous Chickasaw plums. For both species fruit quality is often good, although sometimes tart. *Prunus hortulana* has potential as a rootstock, since it does not sucker, and is also potentially useful for its late bloom, late ripening, and bright skin color. It is likely that these species were used by Burbank in developing his shipping plum hybrids from crosses with *P. salicina*.

Sierra Plum The major Western U.S. native plum is the Sierra plum, also called Pacific plum or Klamath plum. *Prunus subcordata* is commonly found in Southern Oregon and Northern California, extending south along the mountaintops almost to San Francisco. *Prunus subcordata* appears to have substantial drought tolerance, which is not surprising based on its often dry habitats. On poor sites it grows as a shrub or a thicket, but can make a small tree if given good conditions and water. Leaves of this plum have a passing resemblance to those of European plum, *P. domestica*, being broadly ovate to almost round. Fruit ranges from dark red to yellow, and

are about 1.5-3 cm in diameter. Some wild forms have hair on the fruit, although these may be hybrids with other *Prunus* such as *P. andersonii*. Luther Burbank reportedly crossed this species with Japanese plums and hybrids, but apparently none of his material survives. Oregon State University conducted trials on local selections and did some cultural research at in the 1950’s, but the crop never expanded into commercial production (Roberts and Hammers, 1951). It is still used locally in Oregon for producing jelly. It seems to be poorly adapted to low-chill, high humidity areas.

Bush Cherries

Sand Cherry is so-called because the fruit resembles a small cherry (Figure 4) and they prefer sandy sites in their native habitat. *P. besseyi* is one of the most cold-hardy *Prunus* species, and is found as far north as Manitoba, Canada, and south to Colorado. The species was known as *P. pumila* in its eastern range from Wisconsin to Massachusetts and Pennsylvania.

However they are pollen and graft compatible with plums and not cherries and have been misclassified as cherries. A few cultivars of the pure species have been named, but there are many hybrid cultivars available. These are some of the only plums that are hardy enough for the northern US and Canada. Sand cherry was used extensively by Hansen in South Dakota to develop cold-hardy plums, with more than a million seedlings grown (Hansen, 1937). 'Sapa', his most important release, was a hybrid of sand cherry Sultan (Japanese plum) and has been used as a parent of many other hybrids and for rootstock development. Sand-cherry hybrids with plums are often called "cherry plums", a term also used to refer to *P. cerasifera*. In California, 'Hiawatha' (a seedling of 'Sapa') is looking promising as a semi-dwarfing rootstock for peaches.

Prunus besseyi may have been more widely hybridized than any other *Prunus*, partly due to its wide compatibility. All the breeding work appears to have been done with western forms of *P. besseyi*, as they had better fruit quality and larger fruit, plus that region of the country was too cold to grow most other *Prunus*. Unfortunately, these western forms have high sensitivity to blossom and twig blight caused by *Monilinia sp.*, making them short-lived in humid climates. *P. besseyi* also is native to the shores of Lake Michigan as well as to the inland sandy barrens of central Michigan. The species also ranges into the Northeastern United States and south to Virginia. These eastern forms of the species may be useful in breeding plums and rootstocks better adapted to the humid regions. They are much smaller-statured plants than western accessions even in good soil, sometimes growing as a ground cover rather than an upright shrub, and plant health at Byron seems good so far. The late-blooming characteristic of *P. besseyi* is at least partly due to higher post-rest heat accumulation, enabling them to fruit well in lower-chilling zones than would be expected (Werner et al., 1988). Use of this species to develop cold-hardy plums continues in the USA only at the University of Wisconsin-River Falls in Wisconsin.

Chinese Bush Cherries A second misclassified "cherry" is *P. japonica* and relatives *P. glandulosa* and *P. humilis*, which are from China (Ingram, 1948). This group is best known in Europe and North

America as the double-flowered ornamental form of *P. glandulosa* called flowering almond. These shrubs grow as multiple stems, and are easy to propagate using rooted cuttings or root sprouts. As a result they are frequent relics around old homestead sites. The flowers are borne singly or in pairs, and come in pink or white, single or double. Fruit are red to dark red, about 1 cm diameter on a 1 cm stem, edible raw but often cooked due to their acidity. *P. japonica* accessions from China are quite prolific and have crossed readily with plum to produce a range of fruitful hybrids. This species appears to have some resistance to plum curculio, 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, as well as used as a dwarfing rootstock (actually interstem) for peach. In China there is at least one breeding program for *P. humilis*, with large-fruit selections up to 3 cm. Meador from New Hampshire also has released 'Jan', 'Joy' and 'Joel', hybrids of *P. japonica* and *P. jacquemontii*, a similar species from the Himalayas. These hybrids are providing cold-hardy tart cherries on a small bush. 'Joy' is self-fruitful but the others require cross-pollination. Hybrids of *P. japonica* *P. salicina* produced in Japan are vigorous but unfruitful (Kataoka et al., 1988), but hybrids with Japanese plum at Byron have been highly productive.

Nanking Cherry *Prunus tomentosa* is a common trade ornamental/fruiting shrub which is native to North and West China from the Himalayas to Korea. It is extremely cold-hardy but suffers from dieback in warmer climates. In northern China and Korea the fruit was the first to ripen, and so it was made into a compote to celebrate the "5th day of the 5th moon", the longest day of the year. The species name describes the most distinctive feature, the heavily pubescent leaves and young stems. Leaves are irregularly toothed, thick and about 5-7 cm long. Flowers are white, 1.5-2 cm in diameter and in 1-2 per bud. Fruit is 1 cm across, sometimes slightly hairy, and with a flavor that ranges from mild to tart. Fruit is usually bright red, but rarely dark red or white. It has been crossed to some extent to other bush cherries such as *P. besseyi* but little to true cherries. Some nurseries sell "black Nanking cherry," which may be hybrids with sand-cherry,

also known as "sandkings." Some have suggested Nanking cherry may be closer in affinity to the wild shrubby almonds. It is usually propagated by seed, sometimes fruiting in the second year from seed and so has been spread widely particularly in northern regions. *Prunus tomentosa* has been hybridized with *P. besseyi*, *P. cerasifera* and *P. japonica*.

Desert Species

Six *Prunus* species native to desert regions from Texas to California have pubescent fruit and unclear taxonomic affinities. Most are not well-adapted to eastern conditions. The most utilized may be *Prunus texana*, which is endemic to the Rio Grande Plains and Edwards Plateau of Texas, preferring poor or disturbed soil. It is a bushy shrub with grayish, very irregular branches. Young branches are covered with short, stiff hairs. Peach bush has white or rarely pink blossoms that develop into small pubescent fruit with fair fruit quality. As a seedling it can be highly precocious, fruiting in Florida in 12 months from seed. It hybridizes readily with other plums, and natural hybrids have been reported and grown for fruit. It is sometimes used to make jellies and preserves. Two other species have useful characters. Not surprisingly, *P. andersonii*, native to the desert areas of California, has high levels of drought tolerance (Rieger and Duemmel, 1992), but it does not grow well in our climate. *Prunus minutiflora*, is one of the few dioecious (male and female flowers on different plants) *Prunus* species. As its name indicates, it has extremely small flowers. F₁ 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.

Plumcots

Natural plumcots have been grown for generations in regions of the world where both cots and myrobalan plums were grown such as in Southwest Asia. These were common enough to merit their own species name, *P. dasycarpa*. Several local varieties have made it to the US, including 'Irani Olju', 'Tlor Csiran', and 'Mirocais'. These plumcots are mostly red or purple skinned with some light fuzz. Typical of the plum parent they tend to be acidic and small.

Hybrids between *P. salicina* or *P. cerasifera* and apricot have also been successful, but many are not very productive. Burbank introduced several plumcots long ago, but mostly as novelties. In recent times many varieties have come out of California from private breeders, such as 'Red Velvet,' 'Royal Velvet,' 'Flavor Supreme,' 'Flavor Delight,' 'Flavor Queen,' 'Plum Parfait,' 'Dapple Dandy' and others. Most of the initial wave were not very productive, which reduced their commercial value. Some, though, had excellent eating quality. After backcrossing and intercrossing these plumcots, it became difficult to distinguish hybrids from plums. Zaiger Genetics trademarked the terms "pluot" and "aprium" for hybrids that resembled the plum parent or the cot parent, respectively. The California industry has recently begun using the term "interspecific" to describe these plumcot derivatives although the term overlooks the fact that most Japanese plums are already just that. Confusion over what is legally a plum affects marketing orders, grade standards, monetary box assessments, and pesticide usage. A recent molecular study compared DNA of pluots 'Black Kat', 'Dapple Dandy', 'Flavor Fall', 'Flavor Grenade', 'Flavorich', and 'Flavorosa' to that of 14 plum varieties, 7 apricots, and 'Flavorella' plumcot (Ahmad, et al. 2004). They found no evidence of apricot DNA in any of these pluots, whereas the plumcot had genetic material from both apricot and plum. In any case the marketing of these pluots as distinct from plums has allowed a wider range of fruit to be marketed, in terms of appearance and quality.

My predecessor Jim Thompson released a plumcot selection, BY69-1637P in 1984. It was notable for large size, but was unproductive and very acidic in flavor. In 2002 we released 'Spring Satin' plumcot for use in the Southeast.

Conclusion

Much of the interspecific 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 interested in 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. Tremendous strides have been made in plum breeding in the last century, particularly in terms of size and firmness. Given the wealth of plum germplasm available, there is potential for similar progress in areas of fruit quality, disease resistance and climatic adaptability if breeding efforts are continued and expanded.

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