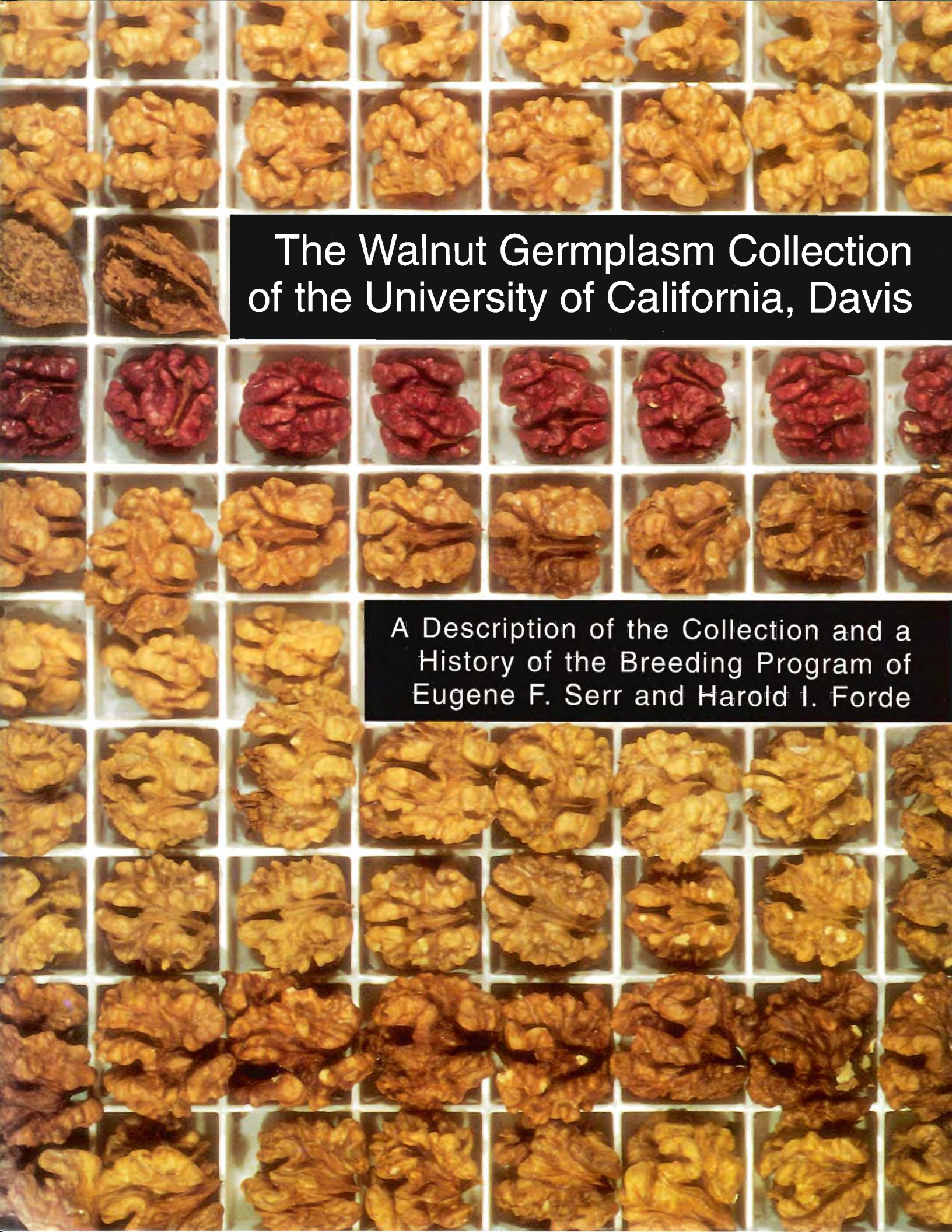

The Walnut Germplasm Collection of the University of California, Davis

A Description of the Collection and a History of the Breeding Program of Eugene F. Serr and Harold I. Forde

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A Description of the Collection and a History of the Breeding Program of Eugene F. Serr and Harold I. Forde

Walt Tulecke and **Gale McGranahan**

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Genetic Resources Conservation Program
Division of Agriculture and Natural Resources
University of California
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This report is one of a series published by the University of California Genetic Resources Conservation Program (technical editor: P.E. McGuire) as part of the public information function of the Program. The Program sponsors projects in the collection, inventory, maintenance, preservation, and utilization of genetic resources important for the State of California as well as research and education in conservation biology. These activities take place on the several campuses of the University of California with funds provided by the State of California to the University.

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PHOTOGRAPHY CREDIT

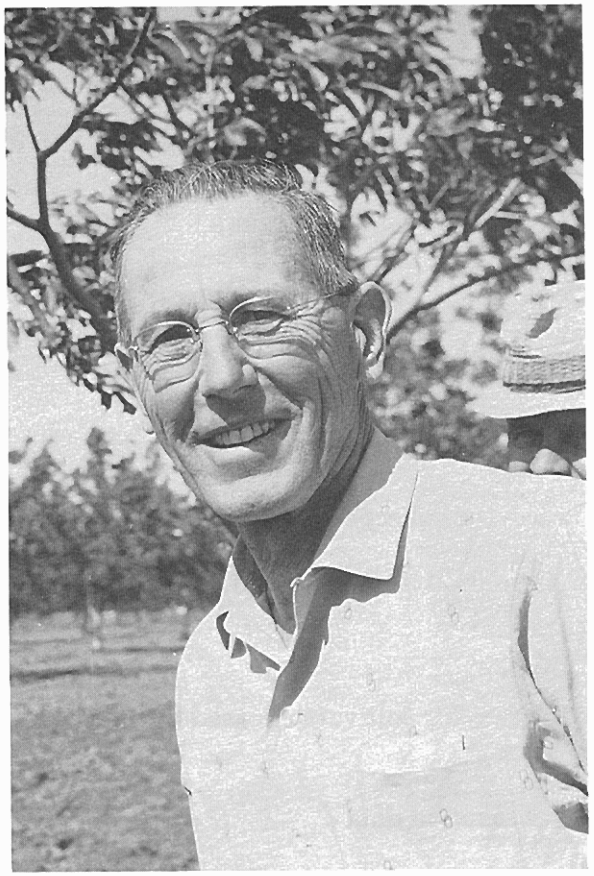
Front cover, pages 4, 5, and 17–22: **Don Edwards**, Dept. of Pomology, University of California, Davis, California

Contents

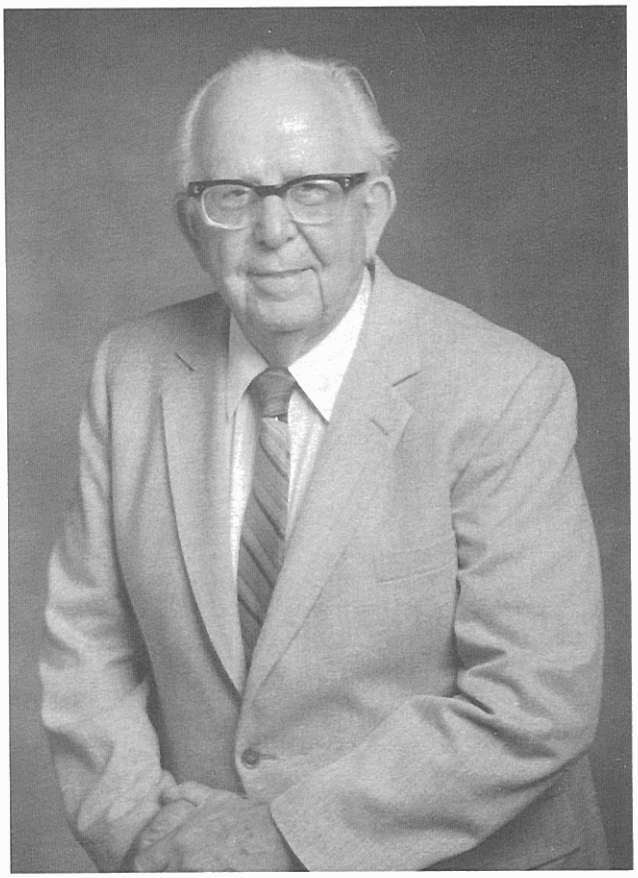
Dedication

This publication is dedicated to **Eugene F. Serr** and **Harold I. Forde** who conducted the walnut breeding program at the University of California, Davis from 1948 to 1978. Serr and Forde's collaboration was collegial and productive. This brief history of some of their work and the description of their walnut germplasm collection is a tribute to them and to their success.

Eugene F. Serr



Harold I. Forde



Preface

This document has been prepared with support of the University of California Genetic Resources Conservation Program (UC GRCP) as part of its continuing effort to assess the value, status, and needs for access and conservation of crop genetic resources important for California. The California walnut industry has been remarkably successful, accounting for 99% of the US walnut production with a $267 million contribution to the state's economy (California Dept. of Food and Agriculture 1993). Components of this success, of course, include cultivars accepted by the producers and consumers, skillful horticultural practices, astute marketing, fortuitous climate, and available water. These were detailed and discussed in a report recently produced by a Walnut Industry Study Group convened by the University of California Agricultural Issues Center (Coppock 1994). This document emphasizes the genetic contributions to the success of walnuts in California. Genetic diversity is key to the sustained productivity of crops. Without it, there can be no new cultivars to meet society's future needs, which are unpredictable.

It is apparent that the transition from walnut cultivars that were derived from variants that occurred by chance to cultivars produced by plant breeding, that is, selection of progeny from controlled crosses, had a major impact on the cultural practices that could be applied. Central to this effort has been access to the genetic diversity for the crop. That is the story of this report and since the effort was largely the work of two men over long careers, the report is also their story. The report presents an oral history and documentation of the Walnut Germplasm Collection in the UC Davis Dept. of Pomology, revealing the logic of plant breeding and providing historical insight into the system and personalities that developed the germplasm.

The amassing and maintenance of a large germplasm collection takes combined and sustained efforts and support of several individuals and organizations. In the case of walnut, there has been continued support from the California industry, the US National Plant Germplasm System, and, to

a small extent, the UC GRCP, as well as individuals involved in the extension and research efforts of the University of California. We feel this document will aid in sustaining that effort and support. We congratulate Drs. Tulecke and McGranahan for their efforts in bringing this story to us.

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Acknowledgements

For this brief history of the walnut breeding program at the University of California, Davis, 1948 to 1978, a number of individuals were contacted for information and assistance. Special thanks go to them for their helpfulness. Each had a special relationship to Eugene F. Serr and Harold I. Forde.

Robert Livermore, President of Zendex Corporation, and a former student of Serr, helped initiate this project with his interest and with financial support and the University of California Genetic Resources Conservation Program matched his support to get the project going. **Bill Stuke**, nurseryman in Gridley, California, worked closely with Serr for 43 years and was a close friend. Two sons of Serr, **Eugene Serr, Jr.** of Red Bluff and **John J. Serr** of Orinda shared recollections of their father. Professors emeriti **Harold Olmo, Omund Lilleland,** and **Dillon Brown** and extension specialist **Dave Ramos,** all of UC Davis, were helpful with information. Dillon Brown's book on the history of the Pomology Department was particularly useful (Brown 1990). We thank farm advisors **Wilbur Reil** and **Bill Coates** for reviewing the germplasm section of the manuscript and **Herb Phillips** for data compilation. We are grateful to the California Walnut Marketing Board for its support of the Walnut Breeding Program and ongoing germplasm evaluation and to Diamond Walnut Growers, Inc. for its contribution to this project.

The one person who was most helpful is **Harold I. Forde,** who gave many hours of his time to provide information on walnut cultivars. He also read the manuscript at different stages of preparation. At 79 years, Forde's memory brought forth a clear and steady stream of information with many stories of the good old days. Special thanks to Harold I. Forde.

Introduction

This account of the early history of walnut breeding and a description of the walnut germplasm collection at the University of California, Davis is intended to be useful to plant breeders, walnut growers, farm advisors, and the general public. It contains information about some of the important breeding stock collected and used in controlled crosses made by Serr and Forde from 1948 to 1978. Descriptions and illustrations of cultivars and selections from different crosses as well as five-year averages for leafing date, harvest, shell, and kernel characters are given. Also included are some recollections of Harold I. Forde about interesting and important aspects of their work. This information comes from interviews which were recorded and transcribed as part of an oral history of walnut breeding at UC Davis.

The Walnut Germplasm Collection is contained in a reserve block of walnut trees known as the Stuke Block located in the Wolfskill Experimental Farm, Winters, California. The Stuke Block is named after William E. Stuke, a nurseryman in Gridley, California, who was a friend and cooperator with Eugene F. Serr for more than 43 years, beginning in 1924 when Stuke was starting his nursery and Serr was farm advisor in Sutter County. Much of the material in the Stuke Block comes from the old Variety Block of Serr and Forde which has since been taken out. The Stuke Block consists of genetic lines of special interest to California, including old and new cultivars, selected parental stock, and representative rootstock species. This collection is the only source of old California walnut cultivars and stock of potential value for future walnut breeding at Davis. The collection is intended to serve as a source of material which is already adapted to California and for studying and solving future problems in walnut culture. It also serves as a resource for student research, for growers and farm advisors, and for teaching. Complementing the UC Davis collection, the USDA National Germplasm Repository at Davis maintains a collection of some 400 accessions of several *Juglans* species, with an emphasis on representing the diversity of the genus rather than on maintaining walnut cultivars.

There are some 20 species of the genus *Juglans*, all of which produce edible nuts. The most horticulturally developed and widely cultivated species is *J. regia* L., the English or Persian walnut. A recent review of the distribution and utilization of *Juglans* species as genetic resources for the cultivated walnut was presented by McGranahan and Leslie (1990). Several *Juglans* species are important as rootstocks for *J. regia* production (see McGranahan and Catlin 1987 for review). Specimens of the *Juglans* species, cultivars, and numbered selections discussed here are located in either the Stuke Block or in the National Germplasm Repository–Davis section of the Wolfskill Experimental Farm.

California leads the nation accounting for 99% of US walnut production and five Central Valley counties (Butte, San Joaquin, Stanislaus, Sutter, and Tulare) account for the bulk of California's output (California Department of Food and Agriculture 1993). The leading cultivar in California, Chandler, was released from the UC Davis breeding program initiated by Serr and Forde (McGranahan and Leslie 1990).

History of the breeding program

The walnut breeding program of Serr and Forde began in 1948 when Serr was appointed Lecturer and Associate Pomologist in the Pomology Division of the College of Agriculture, University of California. Serr was 50 years old at the time and was Extension Specialist for deciduous fruits and nuts for the state of California.

Somewhat earlier, in the spring of 1947, Warren P. Tufts, Chair of the Pomology Division, called in Harold I. Forde and a botanist, Richard King, and said that a walnut breeding program was to be initiated. Forde was 34 years old at the time; King was only temporarily involved. Forde and King made some preliminary crosses and worked on pollen preservation and bagging methods during the 1947 season. Earlier still (1944), Eugene F. Serr and Assistant Professor Arthur Davey in the Pomology Division had collected and evaluated 12 selections of the cultivar Franquette to see which was superior. Unfortunately, Davey passed away in February, 1947. Tufts then encouraged Serr and Forde to take up the walnut work together. Tufts had a reputation for being a well-liked and efficient chair of the Division and he was very supportive of Serr and Forde.

Historical accounts of walnuts in California (Smith et al. 1912; Webber and Goodspeed 1919; Batchelor 1924; Batchelor et al. 1945) mention the hard-shelled walnuts brought in from South America by the Mission fathers in the 1770s. A hundred years later (1869), Joseph Sexton purchased a large sack of walnuts at the dock in San Francisco and planted a thousand trees at his ranch in Goleta, California. The origin of these nuts is uncertain, perhaps Chile or China. The selections from these trees gave rise to the Santa Barbara soft shells, such as Placentia. About the same time (1870), Felix Gillet, a nurseryman in Nevada City, California, was importing scion wood and nursery stock from France. He is credited with introducing the French cultivars Franquette, Mayette, and others to California. As a result of these introductions by Sexton and Gillet, walnut growers found superior open-

pollinated seedlings that led to the cultivars Eureka, Placentia, Concord, Payne, Hartley, and others.

All of the early walnut cultivars were obtained by selecting seedlings that occurred by chance, rather than from controlled crosses, which was the method of Serr and Forde. However, some walnut breeding work was done by Luther Burbank between 1879 and 1885 (Whitson et al. 1914) which gave rise to Paradox, the hybrid from northern California black walnut (*J. hindsii* (Jeps.) Rehder) and *J. regia*. He also crossed *J. hindsii* and the eastern black walnut (*J. nigra* L.) to get the Royal walnut. It was Paradox that was especially useful for rootstocks since it provided root vigor and some disease resistance.

The walnut breeding program initiated by Serr and Forde emphasized yield as one of the most important characters for economic reasons and yield was related to a great extent to the number of pistillate flowers produced. Hence, those cultivars which produced pistillate flowers on lateral buds, known as lateral fruitfulness or fruitful laterals, would have the potential for bearing more nuts than those that only flowered on the terminals. The time and abundance of pollen shedding was important to assure adequate pollination when the pistillate flowers were receptive. Later leafing to avoid frost and minimize blight was also desirable. Shell qualities of thickness, smoothness (Fig. 1), color, and seal, the size of the nut, the proportion of the nut weight contributed by the kernel (spoken of as 'percent kernel'), and kernel color, flavor, and plumpness (Fig. 2) were other traits systematically evaluated for the materials in the breeding program. Early maturity of the nuts was needed to allow adequate time for the harvest, processing, and shipment of nuts to market in the fall. Tree vigor and strength suitable to orchard practices as well as some disease resistance were also recognized as important considerations in evaluating progeny. Constant attention to all these criteria through field observation, record keeping, and the collection and crackout of nuts resulted in a detailed evaluation of a tree's performance over many years.

By 1956 Serr and Forde were able to state clearly the objectives of the walnut breeding program which had begun in 1948. The characters they were selecting were now very specific. They were making crosses to get at least two flowers per inflorescence, with lateral fruitfulness of 50% or better. Nut size of 38 to 42 mm length with kernels of 8 to 10 g dry weight was desirable. Pollen shedding needed to be coordinated with pistil receptivity or another pollenizer had to be available. A leafing date of 14 to 21 days after Payne for interior valleys and some upland orchards was desirable. Other important traits were nut maturity in late September to early October and a kernel that was 50 to 60% of the nut weight, with light color and good flavor. A fairly smooth shell with a strong seal and light color was also needed. Tree vigor included strength in both the scaffold and branches.

In their summary of results after the first seven years of walnut breeding with selected lines, Serr and Forde came to the conclusion that certain characters were inherited in a more predictable manner and other characters were less reliable. Leafing dates of 14 to 21 days after Payne, a character of Franquette, and pistillate flowering on lateral buds, a character of Payne, could be obtained in a few selected progeny by crossing Franquette with Payne. If Payne was selfed then some progeny were dwarfed, giving short internodes, small nuts, and russeted hulls, indicating a recessive gene(s) for this character. Overall, by 1956 Serr and Forde had made 39 different crosses, pollinated 15,691 pistillate flowers in controlled pollinations, and derived a population of 833 seedling progeny to be evaluated and selected for desirable characters.

Their general procedure after deciding on the crosses to be made in a given season was to collect pollen, storing it when necessary, and enclose unopened flowers in small (4" × 6") gabardine bags to exclude pollen. When the flowers were receptive they would inject with a hypodermic needle a small amount of pollen from the selected male parent into the bag. The nuts

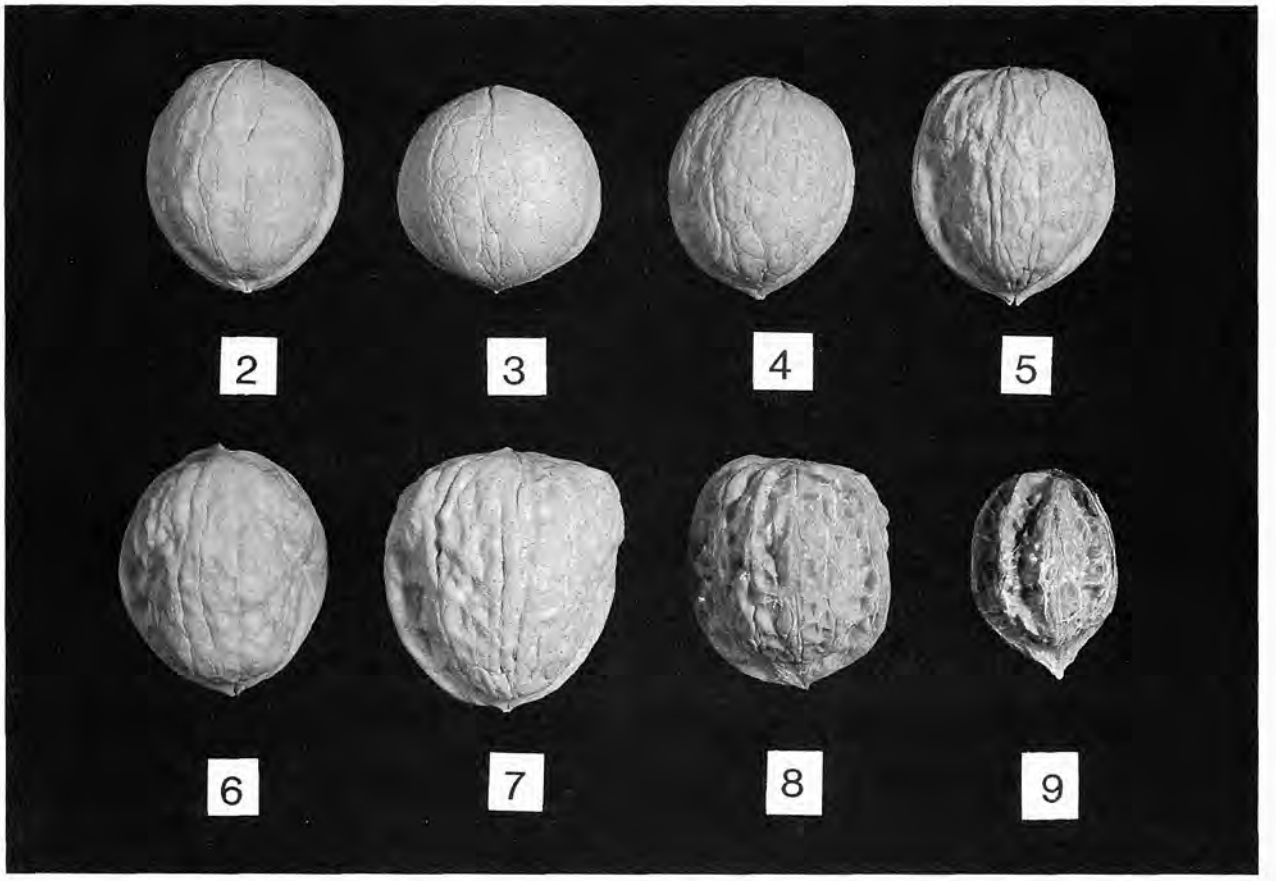


Figure 1. Illustrated are eight of the nine degrees of shell smoothness used in scoring this character in the breeding program.

were collected in the fall, dried, and stratified for about two months and then germinated in deep flats (8") in the greenhouse. A typical flat contained a 4" layer of potting soil, a layer of sand on which were placed about 24 seeds covered by another layer of sand. The seeds were allowed to germinate and after the seedlings' first flush of growth, the flat was transferred to the lath house where it remained until the dormant seedlings were transplanted to a nursery bed the following winter. In the nursery a seedling would be assigned a permanent number which consisted of the year of germination, followed by a number indicating its position in the row, e.g., seedling 49–46 germinated in a flat in 1949 and was the 46th seedling in the nursery row. Once they were big enough, usually the following year, wood was collected and trees were grafted to northern California black walnut (*J. hindsii*) in a "seedling block" orchard for evaluation. (In later years seedlings were transplanted rather than grafted.) A minimum of 20 seedlings per cross was desired and the cross was repeated if it showed particular promise.

Figure 2. Plumpness is one component of kernel quality, along with color and flavor. Degrees 3, 5, and 7 (from top to bottom) in a nine-point plumpness scale are shown here.

If a grafted seedling exhibited some superior traits it was "selected" and budded or grafted to two Paradox and two *J. hindsii* in a selection block orchard to confirm and extend observations on progeny performance. Field trials of selected lines were made through arrangements with nurserymen and walnut growers usually working with the farm advisors.

During the 1948–1955 period, the cultivars used for crosses included Early Ehrhardt, Hodges, Payne, Concord, Eureka, Hartley, Waterloo, Conway Mayette, Franquette, and others with less familiar names like Myrtleford and Harriette. Payne was used in many of the crosses because it was the only source of lateral fruitfulness until Marchetti became available. Hartley was also used extensively but did not prove to be a good parent.

From the early records (1948–1955), it is apparent that Serr and Forde assembled at the campus orchards and the Wolfskill Experimental Orchard a wide variety of

the available genetic resources of walnut. Their initial baseline was very broad. Besides the standard cultivars at that time, such as Payne, Hartley, Franquette, and others, they acquired more such as King, Khagazi, Schlapp, Doc Lock, Mammoth, Sorrentina, Belliciti, Don Juan, Simonet, and Harriette. From Dr. H.P. Olmo of the Viticulture Department of UC Davis they obtained about 35 numbered collections of nuts gathered from such locations as the Tabriz area of Iran. Serr and Forde also brought in scion wood from the United States Department of Agriculture Plant Introduction Station in Chico, California. This included 22 walnut lines introduced from various parts of the world. Eventually, the constraints of time and space forced Serr and Forde to eliminate many of these genetic lines as being of no value for their work, since these lines did not contain the desirable traits which they were seeking.

In 1956, Serr and Forde began using the best seedlings from their controlled crosses as parents, thus beginning a breeding program of recurrent mass selection. By 1972 almost all the crosses made were between selections. This resulted in a narrowing of the germplasm base and an increasing frequency of deleterious traits such as the short internode/russeted hull phenotype which had been first observed when Payne was selfed.

Also in 1956 they began getting requests for their selections. One of the first selections out for field trials was 49–49, later released as Vina. In 1957, they had requests from 67 growers and farm advisors for scion wood from their collection. The number of requests per year increased until 1967 when 100 requests were received, each for one or more selections or cultivars. The popularity of their germplasm and selections for field trials was in part due to the fact that Serr and Forde reported annually on their evaluation of walnut cultivars in the trade journal, *Diamond Walnut News*, comparing the performance of old and new cultivars and promising selections.

After his retirement in 1965, Serr continued to work with Forde in evaluating their most promising selections. He recommended that 10 cultivars be named and released by the University. Serr named all of these cultivars except one (59–129), which was named after Serr by the Pomology Department after Serr's death in 1968. The other nine cultivars were Lompoc (52–48), Gustine (52–61), Vina (49–49), Amigo (56–226), Pioneer (51–170), Tehama (58–11), Pedro (53–113), Midland (49–47), and Chico (56–206). These cultivars were the culmination of 20 years of work with controlled crosses and represented the selection and evaluation of 1,734 walnut seedlings.

From 1965 to 1978 Forde continued the walnut breeding program and in 1978 released three new cultivars from crosses made in 1963 and 1965: Chandler (64–172), Howard (64–182), and Sunland (66–4). Chandler is now the most popular cultivar in California, making up about 70% of nursery sales. Another two cultivars, Cisco (66–178) and Tulare (67–11) from the

Serr/Forde breeding program have been released recently. Pedigrees of many of the Serr/Forde cultivars are diagrammatically illustrated in Appendix 1 (page 35).

Until his retirement Forde continued making between five and 10 crosses per year, thus increasing the total number of crosses in the program to almost 200, and the number of progeny evaluated to 5,916. He also found time to publish in two excellent chapters some of the information he had gathered over the years (Forde 1975, 1979). These cover subjects in flowering and pollination, breeding, and cultural practices and have been an essential resource for the current breeders. The success of the Serr/Forde walnut breeding program is widely recognized and similar programs have been set up in Europe.

Important to the success of the program were the keen observations made in the field by Serr and Forde. They developed the habit of accurate record keeping of the data from many crosses, measuring many traits from many cultivars and selections over a long period of time. This covered observations of thousands of trees over these three decades. The data they collected were essential for studies on heritability (Hansche et al. 1972) and phenological changes associated with aging (McGranahan and Forde 1985). Further, they cultivated mutually resourceful relationships with nurserymen, growers, USDA, and the University. This provided the basis for field tests in orchard plots of the progeny coming from their breeding program. Altogether, these elements of cooperation and keen observation made for a successful long-term breeding program for walnuts.

The walnut breeding program has not stopped although there was a brief hiatus after Forde retired. In 1982, G. McGranahan was hired by the US Department of Agriculture to breed for solutions to the blackline problem. In 1989, she joined the Dept. of Pomology and continued her activities of breeding walnuts and curating the Walnut Germplasm Collection. The early years of her program were directed towards examining the inheritance of the hypersensitive response to the virus that causes the disease and beginning a backcross breeding program to develop hypersensitive cultivars, as well as introduction of germplasm so that the traditional cultivar improvement program could be continued. The new germplasm is now being used in the breeding program and over 1,000 seedlings from controlled crosses are ready to be evaluated.

Personal histories

Eugene Frank Serr was born in Hubbard, Texas on March 1, 1898. At an early age his family, including his brother, Edward, and his sister, Anna Marie, moved to southern California. Here, Gene Serr attended San Bernardino High School and graduated in 1915. Gene worked for two to three years as an assistant baggage clerk for the Southern Pacific Railroad, a good job, which he left in 1918 to attend the University of California, Berkeley. Gene's father, an upholsterer by trade, was against this decision and provided him no support. However, his sister, Anna Marie sent him money from time to time. Gene graduated with a degree in plant physiology on May 17, 1922, with "Honors in Agriculture" on his diploma. His first job after graduation was as an "itinerant" farm advisor, as they called them in those days; he was located in Yuba City, Sutter County from 1924 to 1930. It was on July 12, 1924 that Anna Grace Raub, age 23, married Eugene Frank Serr, age 26, according to the marriage certificate. They had two sons: Eugene Frank Serr, Jr., born May 14, 1925 and John Serr, born January 5, 1927. John recalls that his father was a good singer around a campfire. He liked to go to the mountains or the seashore and he liked weekend picnics with the family.

In 1930 Gene Serr and his family moved to Linden, California, near Stockton, where they lived on a small ranch of 40 acres and Serr became farm advisor in San Joaquin County. According to his son John, Serr was "never happy without a ranch." On the Linden ranch Serr raised 20 acres "of the best Elberta peaches you ever tasted," according to John. Serr remained at this position of farm advisor until 1938. Finally, in 1939 the family moved to Davis, California where Serr became the Extension Specialist for deciduous fruits and nuts, traveling extensively over the whole state, but headquartered at the University. During all this time Serr was learning and teaching, two things he did very well. He believed in applied research, experimentation, and demonstration as the keys to move agricultural practices forward and he believed in working closely with the growers.

A review of the Annual Reports which Serr submitted to the University during his eight years as Extension Specialist (1939–1947) gives an indication of Serr's total involvement with the fruit and nut crops of California and the people who raise them. During one typical year he made 383 farm visits and was in the field 165 days, covering more than 35,000 miles. In 1943 he arranged 27 Grower Conferences with 2,189 attendees. His own special interest was in mineral deficiency diseases, but he also was knowledgeable and helpful in areas such as propagation, pruning, cover crops, soils, plant diseases, and irrigation. Serr was constantly encouraging "active cooperation," as he described it, between the University, USDA, Farm Bureau, Cooperative Marketing Associations, growers, and nurserymen. Serr was often described as a gentle, quiet, and shy person, but it did not seem to stop him from getting people together to help one another.

In 1948 Serr was appointed Lecturer and Associate Pomologist in the Division of Pomology of the University of California, Davis and later (1952) as full Pomologist, a position which he held until he retired in 1965. He was Pomologist emeritus until his death from a heart attack on January 26, 1968 while working in an orchard at the Kearney Field Station (Brown et al. 1969). Earlier, in 1956, Serr was seriously ill with heart trouble and he had to curtail some of his activities, including his forays into the mountains at higher altitudes.

Serr was responsible for both almond and walnut crops from 1948 to 1951, but from 1951 to 1965 he specialized in walnuts and the walnut breeding program. His early interest in the mineral nutrition of tree crops continued and led to the recognition of phosphorus deficiency in walnuts in Lake County and to methods to remedy it. He was also interested in the selection of improved rootstocks of the Paradox type and worked with others to locate black walnut trees which produced high percentages of hybrids which were particularly useful. Serr also was involved in improving pruning practices and mechanical harvesting.

At the University, Serr taught orchard operations from 1948 to 1956 and a course in subtropical pomology from 1958 to 1965. In 1963–1964 he was on leave and went to Turkey on a Fulbright grant at the request of the Turkish Government. At Ege University, Ismir, Turkey, Serr lectured in pomology, participated in research, and traveled widely in the country.

Dr. Omund Lilleland, 92 years of age when interviewed in 1991 and a long-time professor emeritus of the Pomology Department, knew Gene Serr as a "persistent tenacious person who would not give up." Dr. Harold P. Olmo, also a senior retired professor emeritus in Viticulture at Davis, described Serr as an "exceedingly gentle person." He knew Serr as a very practical man who was always in the field. Olmo described Serr's and Forde's relationship over the twenty years of their collaboration in this way: "They were like brothers."

In May 1956 the Board of Directors of Diamond Walnut Growers, Inc. conferred The Order of the Golden Walnut for Distinguished Service to the Walnut Industry on Eugene Frank Serr, Pomologist, University of California, Davis.

Figure 3. Eugene F. Serr, Farm Advisor, 1924

Harold I. Forde was born in Fullerton, California on August 6, 1914. Two years later his family moved to Marysville, California, where his father went into farming on his own 80 and later 160 acres. Forde worked on the farm through the Depression helping with the peach, prune, and almond orchards. Forde lived there with his parents and three sisters until he graduated from Marysville High School and attended Yuba College. He took a year off to work and then went to the University of California, Davis where he completed his degree in Pomology in 1938; he was a member of Alpha Zeta and Sigma Xi and graduated with "highest honors." On September 10, 1938, Christina Arrild and Harold I. Forde were married and later raised a family of one son, Richard, and two daughters, Ruth and Roberta. Forde was a part-time student when he worked as an analyst in Pomology from 1938 to 1942. For a couple of years Forde taught hydraulics as a civilian instructor for the Army Air Corps in Lincoln, Nebraska. He was later drafted and entered the service. Forde served in the 3rd Infantry Division in Europe and, near the Battle of the Bulge, he was wounded, suffering permanent

damage to his right hand and lower arm. He had to convert to being left-handed when he returned to work at the University.

While Forde was away he was promoted to Senior Laboratory Technician. Dr. Lilleland, of the Pomology Department, observed, when Forde returned from the war, "that changed him. He lost some of his drive." And Forde agrees that the war did take its toll. Dr. Walter Howard, former chair of the Pomology Department, with an office opposite Forde's place of work, urged Forde to "drop the shovel and take up the pen," when he returned from the service, meaning that Forde go for a Ph.D. Dr. Lilleland also remarked, "Too bad he did not get a Ph.D.; he had the knowledge and the respect of people in the department."

Without the degree, Forde advanced from Principal Laboratory Technician in 1948 to Senior or Staff Research Associate in 1971. Forde worked as a partner and colleague with Gene Serr from 1948 to 1966. In the beginning, Serr, with his 16 years of field experience as farm advisor and extension specialist, was the teacher. As Forde recalls, "I learned everything I knew about walnuts in the beginning from Gene Serr." After Serr's retirement, Forde continued the walnut breeding program by continuing to make crosses and selections and evaluate the progeny, cooperating with other faculty in Pomology until his own retirement in 1978. Among those faculty were Aldo Rizzi, Paul Hansche, George Martin, Bill Griggs, and Julian Crane. From 1966 to 1978 Forde was relied upon as the most experienced and knowledgeable person associated with the walnut breeding program. He also continued his work as an advisor and consultant in walnut breeding for more than fifteen years after his retirement in 1978, and continues to participate in decisions about new cultivars. In 1979 Forde was a consultant at the Agriculture College of the University of Chile. He worked with Monica Ortiz de Bustos on walnut propagation and with Carlos Rojas in the evaluation of seedling walnuts.

In 1994, Forde received recognition from the California walnut industry with a Distinguished Service Award:

"*Whereas, Harold I. Forde has pioneered the successful Breeding Program for walnuts at the University of California during his many years of outstanding service to the walnut industry.*

"*Whereas, the fruit of these labors included the development of the Chandler variety which is becoming the mainstay of the California walnut industry and presently accounts for than half of all nursery sales.*

"*Whereas, he devoted his career to an amalgamation of efforts by the University of California and the California walnut industry in developing close and positive working relationships which continue to this day.*

"*Now therefore be it resolved, that in honor of his many years of meritorious service to the California walnut industry, the California Walnut Commission and the Walnut Marketing Board do hereby name Harold I. Forde as a recipient of the Distinguished Service Award, an award originally established by Commission and Board action on September 15, 1989.*"

Serr and Forde worked closely and effectively from 1948 until 1968, when Serr died. Their relationship was friendly and cooperative. According to Forde, they were in the field together on different trips and in the orchards making their selections and evaluating the trees and nuts for desirable traits. They also took time to go deer hunting on a couple of occasions and do some fishing at Dillon Beach. They were successful in those activities, as well as in their walnut work.

Description of germplasm

The term germplasm can be used to describe the plant material used for the genetic improvement of a crop. It can include trees from the wild as well as cultivars and advanced selections. It includes everything the breeder has to work with. The description of germplasm here is taken from a variety of sources. This includes published accounts, five-year averages of data collected on the performance of trees at the University of California, Davis, as well as comments by Harold I. Forde, William Stuke, and others having experience with walnut cultivars. The purpose of listing these descriptions is to provide information on the genetic resources which were available to Serr and Forde and additional material that is now available to other breeders. These descriptions will help the grower, farm advisor, and plant breeder to know the origin of the material and the useful characters which are represented in the Walnut Germplasm Collection in the Stuke Block in the Wolfskill Experimental Orchard, Winters, California.

In the following lists of descriptions, a star symbol (*) by the name of a cultivar or accession indicates that it is also represented by a color photograph of nut characteristics on pages 17 through 20. Additional evaluation data are tabulated in Appendix 2 (page 37).

Additional walnut germplasm and cultivars are slowly being added to the collection. New introductions and breeding material are usually evaluated for several years before being considered for inclusion in the collection. Recommendation for inclusion is based on importance to California and need for permanent preservation. Recent additions include several genotypes with unique attributes such as red kernels ('Rouge de la Donan' and 'Purpurea'), cut leaves (*J. regia* laciniata and *J. nigra* laciniata), and weeping habit ('Weeper'), as well as representative genotypes from other countries (e.g., China, Hungary, Pakistan, Spain) that do well in California.

Old cultivars and introductions

Adams refers to several numbered cultivars which originated from open-pollinated seedlings of PI 18256, and were selected by Moses Adams in Salem, Oregon in 1940. They are frost hardy, maturing at midseason, but are not laterally fruitful. The nuts have a strong shell, but the kernels are somewhat dark. Adams was used in only a few crosses by Serr and Forde. The Adams in the Stuke Block is Adams 10. It was evaluated by E. Germain in France. It leafs out slightly later than other Adams and shows some resistance to blight.

Ashley (*) is a seedling or budsport that was first noticed by Pallas Neal Ashley about 1945 in the orchard of Wendall Payne (not related to George Payne) located in southern Colusa County. The Ashley cultivar was patented and assigned to Stuke Nursery. This cultivar is very similar to Payne in phenology and is 90% fruitful on lateral buds. It yields well, somewhat better than Payne, but is more susceptible to blight. The shell seal is adequate and kernel weight is about 52% of the nut weight. The kernel color is light; flavor is good, and quality is high. The tree is small and early bearing, requiring regular pruning. Forde says that some crosses were made but they did not give exceptional progeny. Ashley has been widely planted on the west side of the San Joaquin Valley and in the Sacramento Valley, but is no longer popular.

Carmello comes from an open-pollinated seedling of Payne which was discovered by C.E. Sullivan near Yuba City, California about 1948. Carmello was patented and assigned to Sierra Gold Nursery. Carmello leafs out with Payne but is harvested later. It is protogynous but not laterally fruitful. The nut is a large bijou type with low percent kernel and the shell seal is poor. It is important only as a novelty nut.

Cascade (*) is a selection made by William Schildgen from the Okanagan Valley, Loomis, Washington, being one progeny of a series of crosses of a Russian, perhaps Carpathian, walnut with a Manchurian type, probably Manregian, which he obtained from Oregon. The Russian nuts were brought to Canada by the Dukobor people who settled north of the Okanagan Valley. Cascade is presumably a seedling from a backcross to Manregian. It leafs out with Hartley and is late harvesting. The nuts are large, dark-shelled with a large kernel. Yield is moderate. Cascade won "Grand Champion" in the Northern Nut Growers nut evaluation in 1983.

Concha (*), an introduction from Chile, was selected from the orchard of Alfredo Concha as "better than average" by Forde in 1979. Many of the orchards in Chile are propagated from seed instead of by grafting, thus each tree is genetically different. Forde wandered the orchards there in search of superior trees. Carlos Rojas and Monica Ortiz de Bustos directed him to the best trees in Concha's orchard. Concha leafs out with Payne, is laterally fruitful, and is harvested with Hartley. Nut seal is good, kernel weight is 47% of nut weight, and kernel color is variable. Concha was a late arrival in the collection and was not used in the breeding program.

Early Ehrhardt (*) is a chance seedling, or possibly a budsport, of Ehrhardt found by George Rutherford in Refugio Canyon near Goleta, California about 1940. It is a soft-shelled Santa Barbara type with low winter chill requirement and leafs out almost two weeks earlier than Payne. It is protogynous and bears only on the terminals. Nuts are of lower quality than Ehrhardt. Kernel weight is 55% of the nut weight, but the kernel color is poor. Early Ehrhardt is subject to sunburn in California's Central Valley. Forde considers it of no practical value, but walnut researchers often use it to signal the beginning of the breeding season.

Eureka (*) originated about 1903 as a seedling tree on the Stone Ranch near Fullerton, California from nuts obtained from the Meek estate in Hayward, California. The parent tree was thought to be a Persian or Kaghazi type from Iran. In 1912, R.E. Smith wrote: "The Eureka comes very close to satisfying the requirement of an ideal walnut for California." Five-year averages indicate leafing one week and harvest one to two

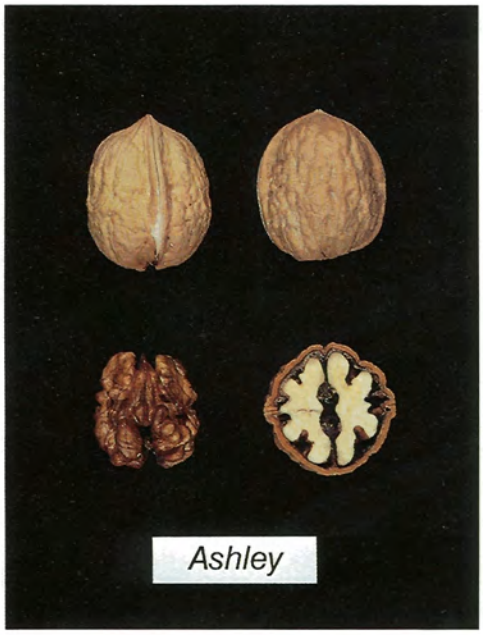
weeks after Payne, with little fruitfulness on lateral buds. Yield is only moderate. The nut is elongated and rounded at both ends, shell quality is excellent, seal good, but kernel color is poor. Eureka is not highly susceptible to sunburn, but it is late maturing and susceptible to frost. If selfed, Eureka gives one quarter albinos, hence possesses a recessive gene for this character. Other Eureka types include Blackmer, Waterloo, Marchetti, and Trinta.

Franquette was brought to California from France in the 1870s by Felix Gillet. It is still widely planted in France and is one of the high quality *"noix de Grenoble"*. The name Franquette has been applied to a number of selections made over the years by different growers, but they all have certain traits in common. Franquette is a large terminal bearing cultivar which is not fruitful on lateral buds. It is the standard for late leafing in California and often escapes blight and codling moth. It comes into production late and requires little pruning. The nut quality is usually good but yields are only fair. Forde has suggested that Franquette has a lower yield than Hartley, both terminal bearers, because Hartley branches more and therefore has more terminals. Franquette also produces one or two nuts per terminal while Hartley produces two or three.

Arthur Davey and Gene Serr brought about 12 selections of Franquette to the Wolfskill Experimental Orchard beginning in 1944 and evaluated them. They concluded that the original Franquette was superior. William Stuke and Gene Serr gathered about 17 selections of Franquette at the Stuke Nursery in Gridley about ten years later, including Lattin, Treat, Scharsch, and others. **Scharsch Franquette** (✱) originated from a single tree of Joseph Scharsch near Ord Bend, Glenn County, California. It is also a good pollenizer for Hartley and bears catkins at a younger age than regular Franquette. As with other Franquettes it leafs out three to four weeks later than Payne, and the harvest is late. The nuts have a medium-thin shell, good seal, light colored kernels, and good fill. **Moyer Franquette** was brought to California from Oregon by William Stuke. Its distinctive character is that it extends the duration of pollen shedding for eight to nine days beyond other Franquettes. **Graves Franquette** (✱) is a chance seedling selected by a grower in Merced County. It has a phenology similar to Scharsch Franquette, but the nuts produce a higher percentage of light-colored kernels.

Hartley (✱) originated in the orchard of John Hartley in Napa Valley, California; it may be a seedling of a Franquette × Mayette cross. This was one of the selections made by William Hunter, a nurseryman, who planted seeds in Hartley's orchard in 1892, selected the best in 1909, and later introduced the Hartley as a cultivar in 1925. It was exhibited as the Hartley nut at the World's Fair in 1915 and won a blue ribbon. According to Forde, John Fisk, the farm advisor in Napa County, called Gene Serr's attention to the Hartley. Serr brought scions of it to San Joaquin County in 1932. From there it spread up and down the Central Valley. In 1940 it was commercialized, because it was particularly well suited to the in-shell market. Hartley is the standard for midseason phenology which is about two weeks after Payne and a week or more before Franquette. The Hartley nut is fairly large, broad based with a pointed tip. The shell is light in color and thin, with a good seal; the kernel is light colored but percent kernel is low. Hartley is susceptible to deep bark canker when stressed by a lack of water or poor soil. The problem with codling moth is minimal. Hartley is less susceptible to blight than Payne, since it leafs out two weeks later. Hartley is a consistent producer, even though it is only slightly fruitful on lateral buds. There are more Hartleys than any other cultivar in California, but in recent years the number of new Hartley plantings has declined.

Howe is a chance seedling discovered by Cecil B. Howe of Brownsville, Oregon and brought to California by Serr for evaluation. It resembles Franquette but leafs out earlier; the shell seal is poor and weaker than Franquette. The growth habit is upright with a central leader. It is reportedly tolerant to blight. The nut is oval and the shell and kernel qualities, other than seal, are satisfactory. It is only available at the US National Germplasm Repository–Davis.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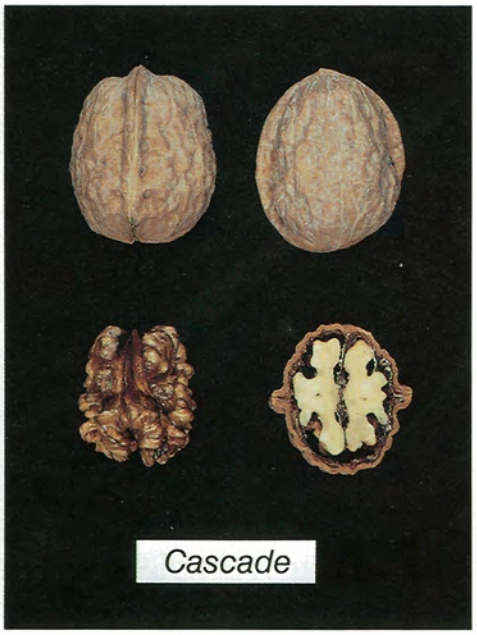
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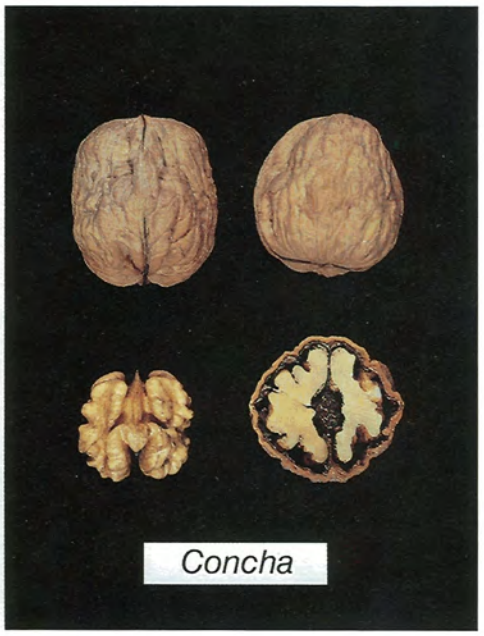
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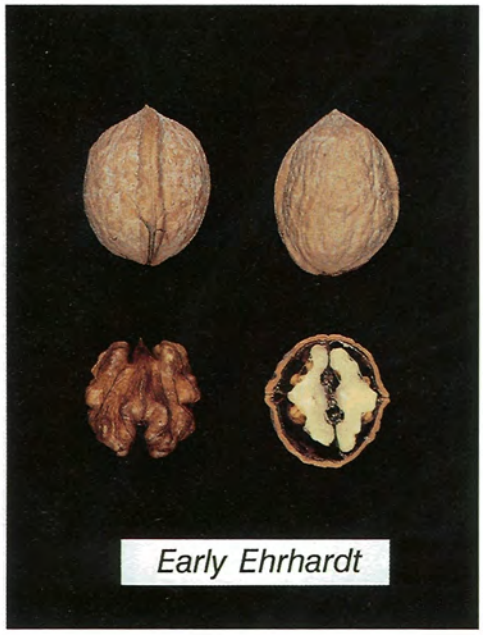
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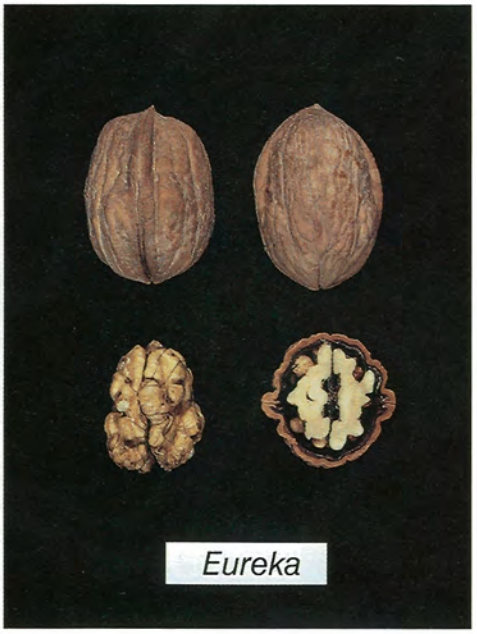
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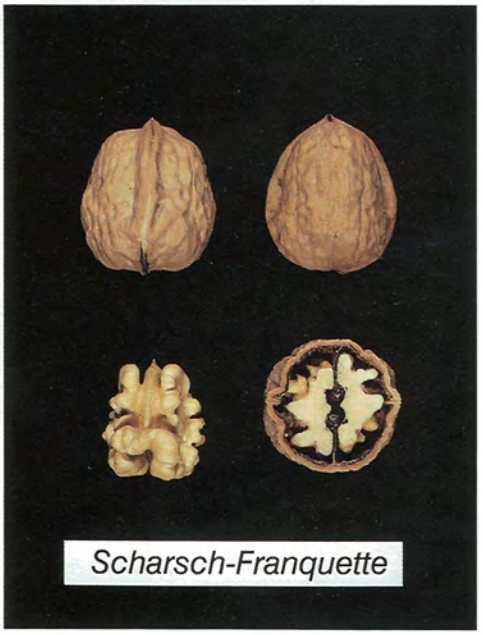
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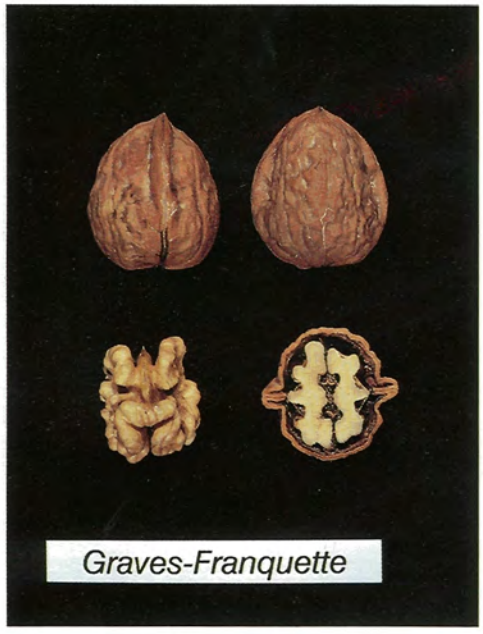
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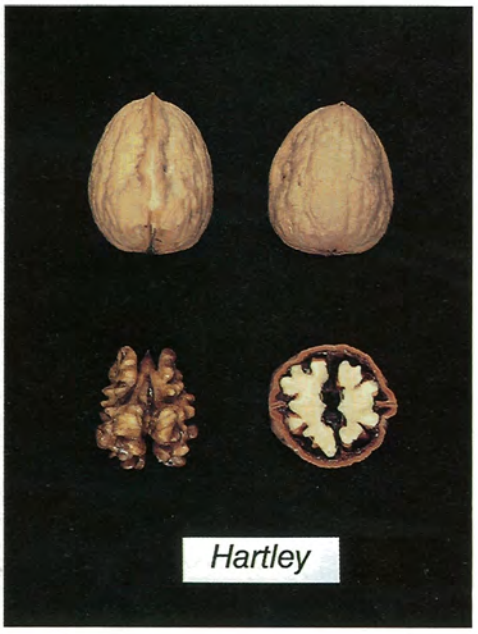
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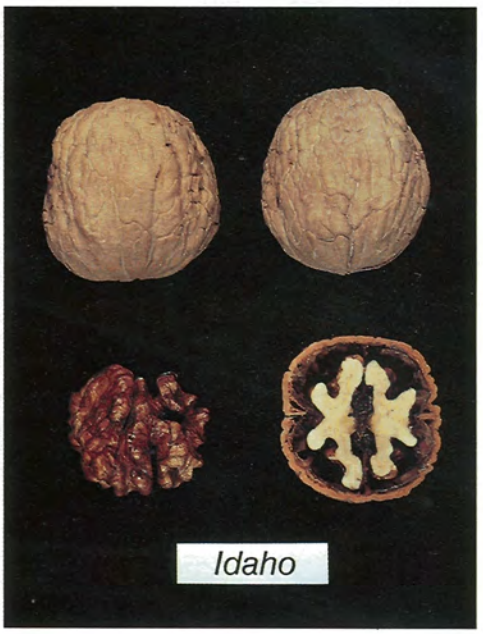
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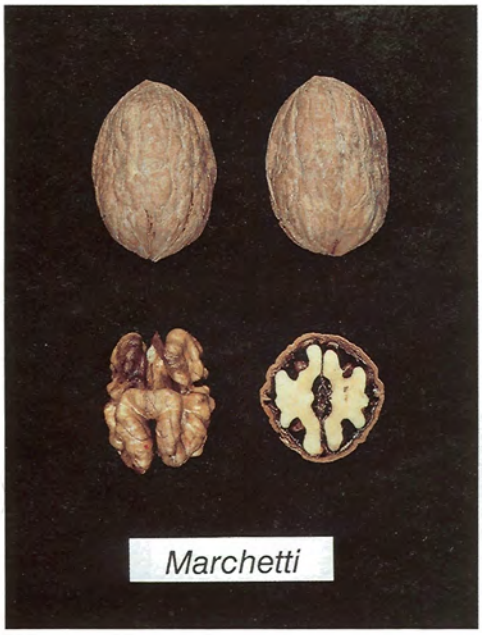
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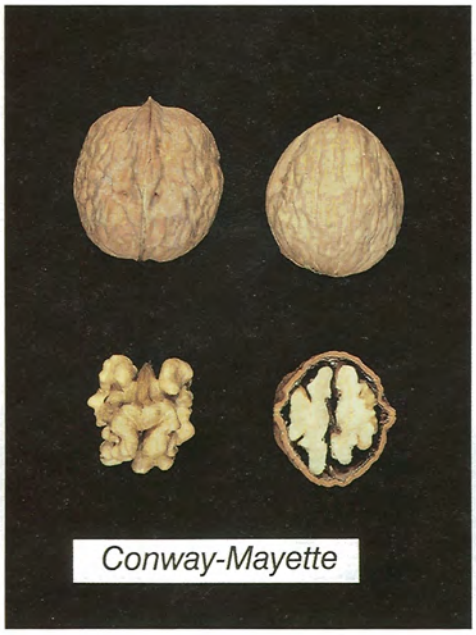
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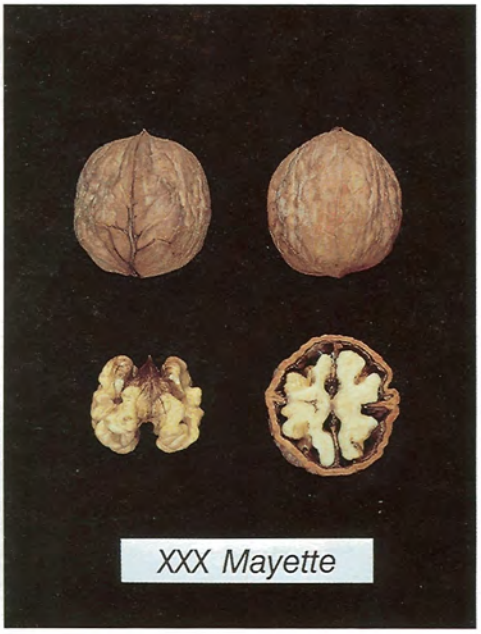
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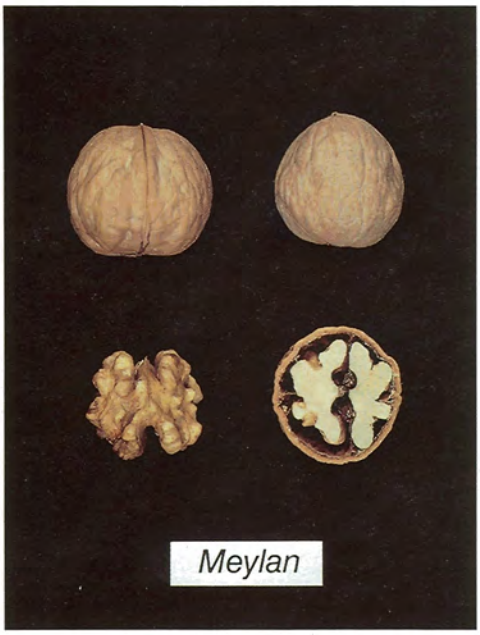
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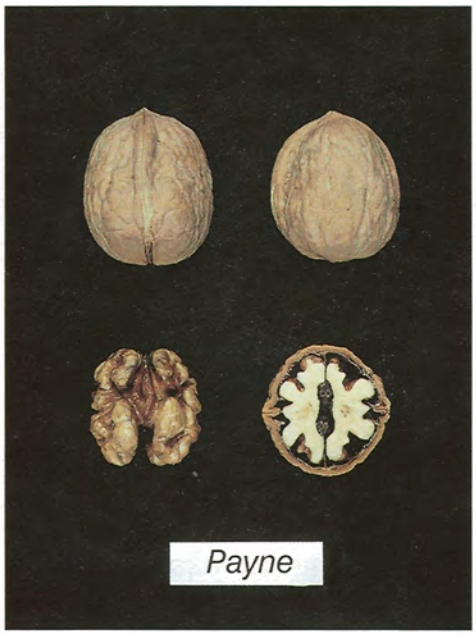
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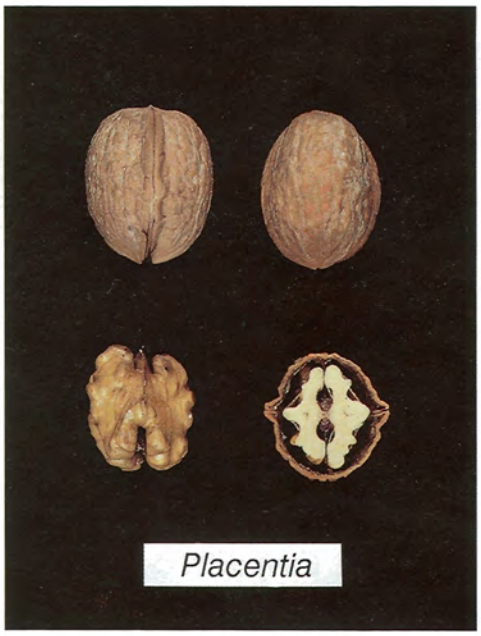
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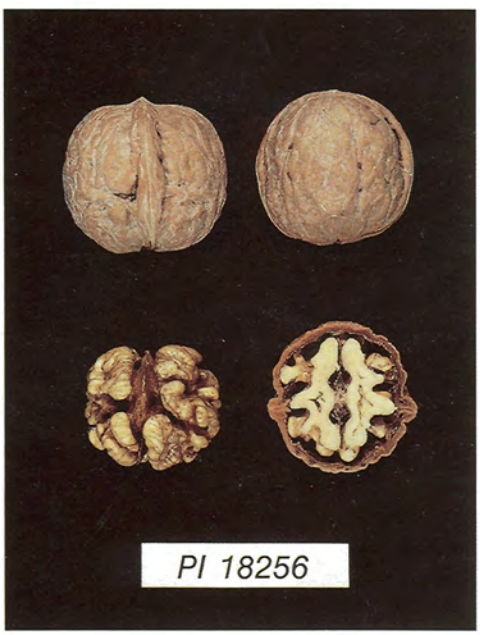
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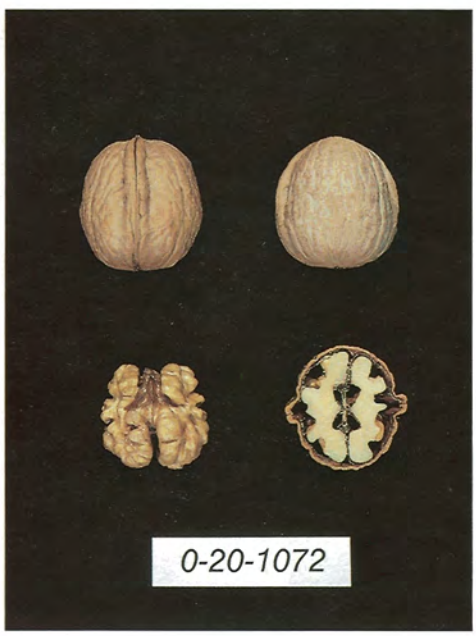
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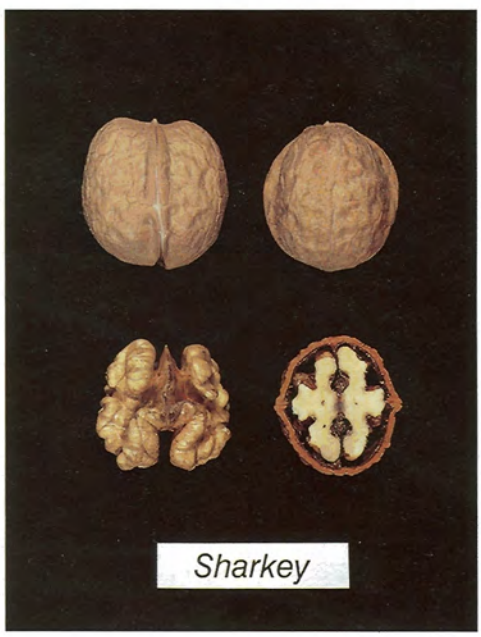
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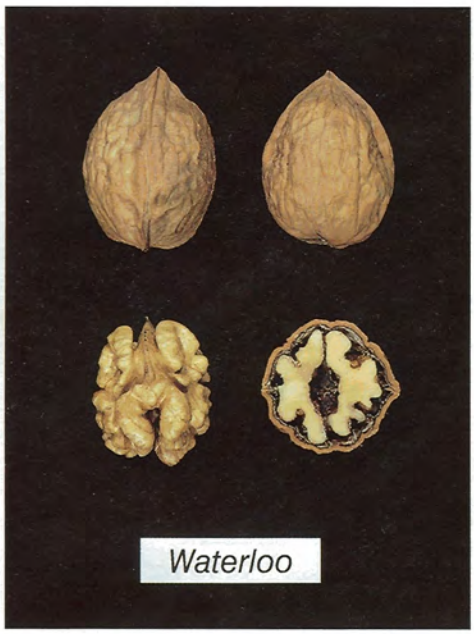
Sinensis #5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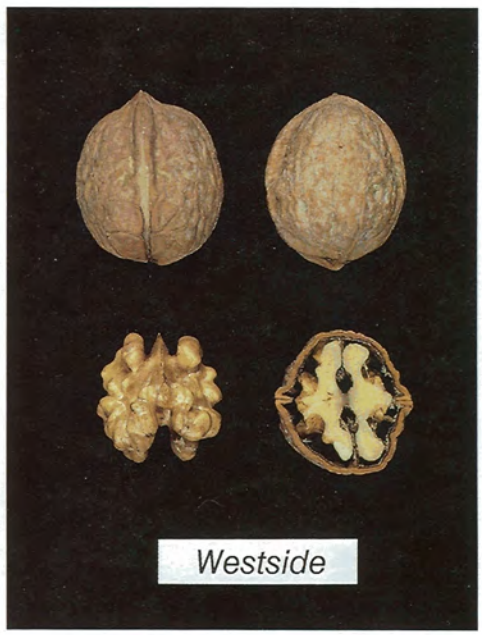
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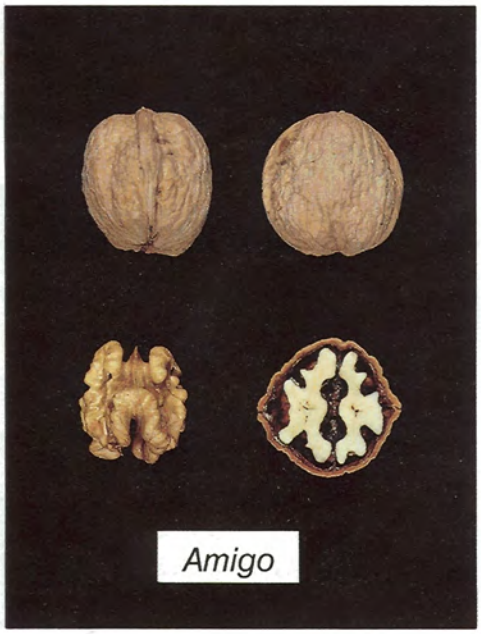
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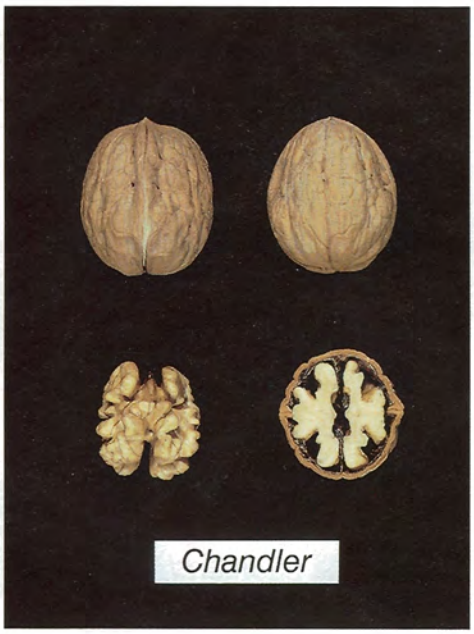
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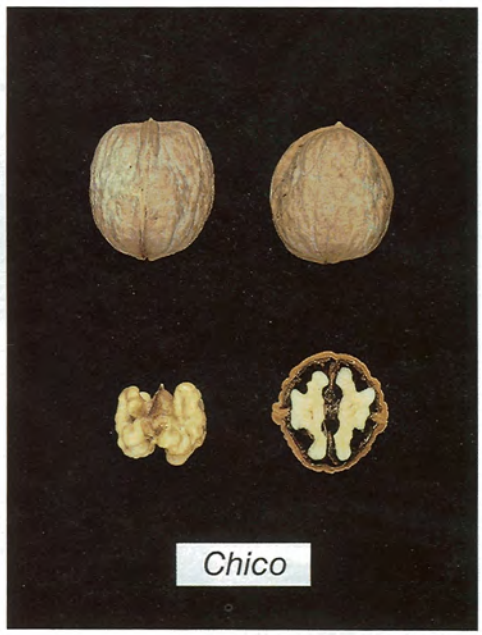
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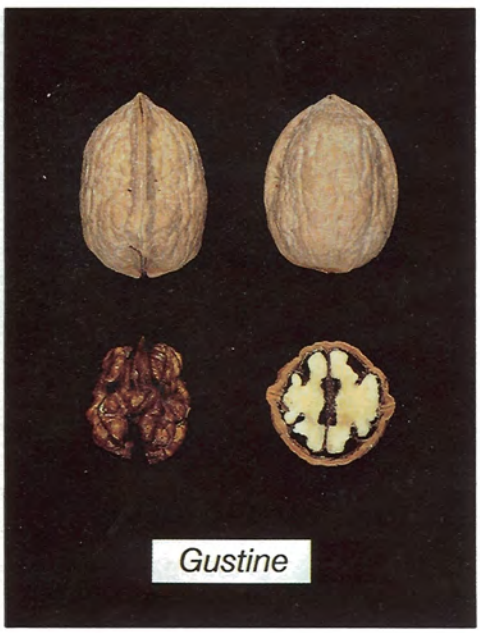
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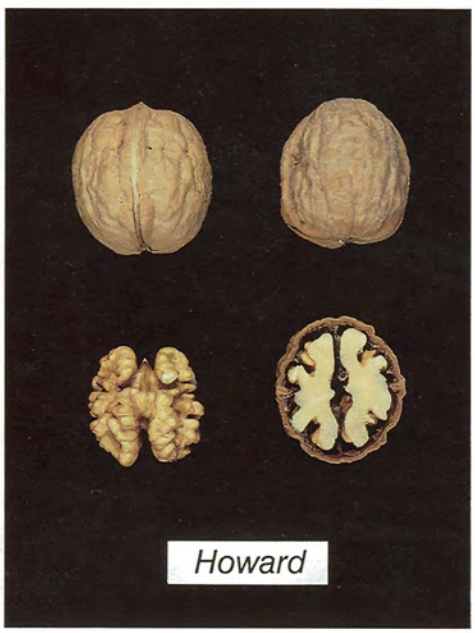
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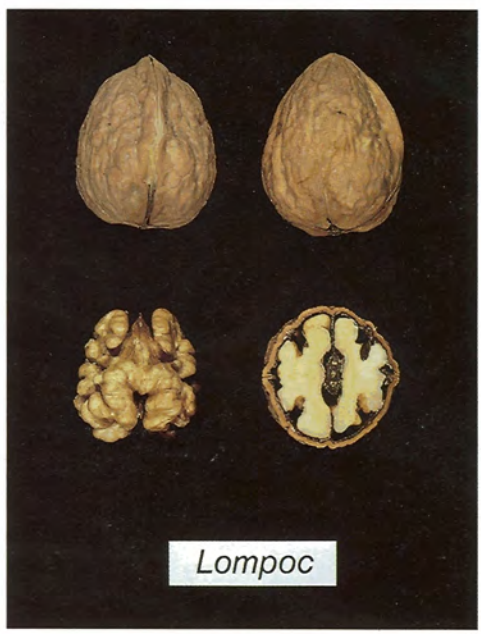
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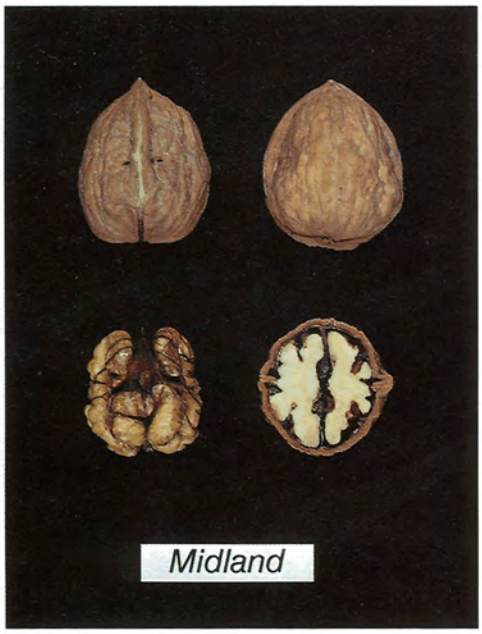
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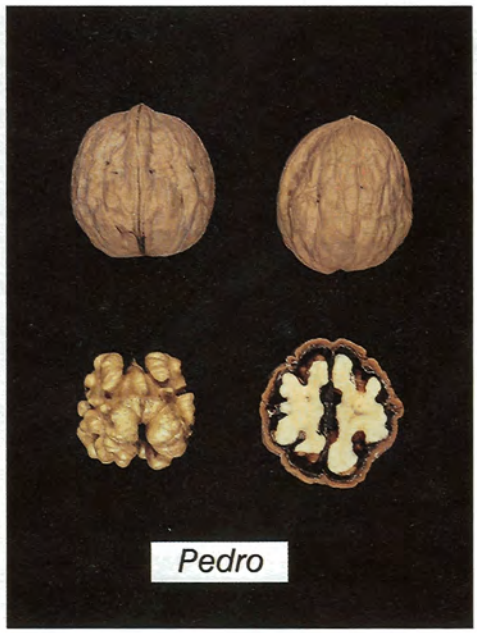
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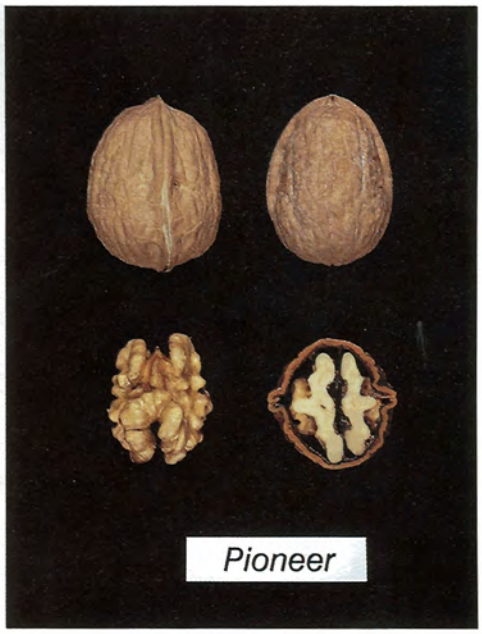
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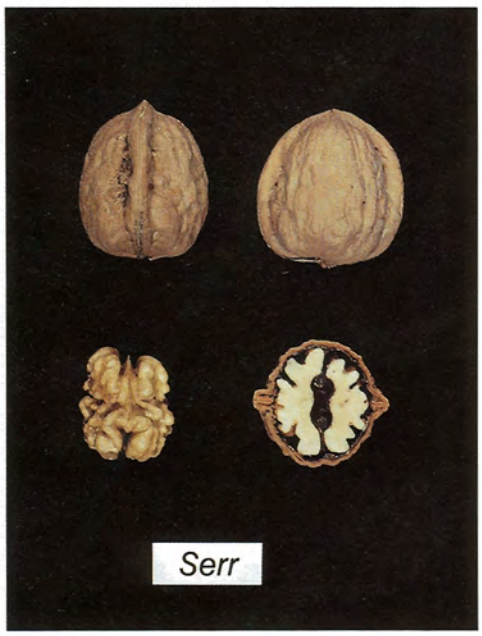
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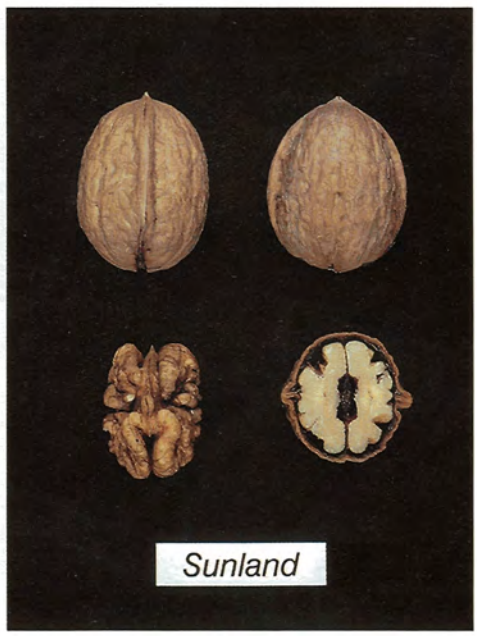
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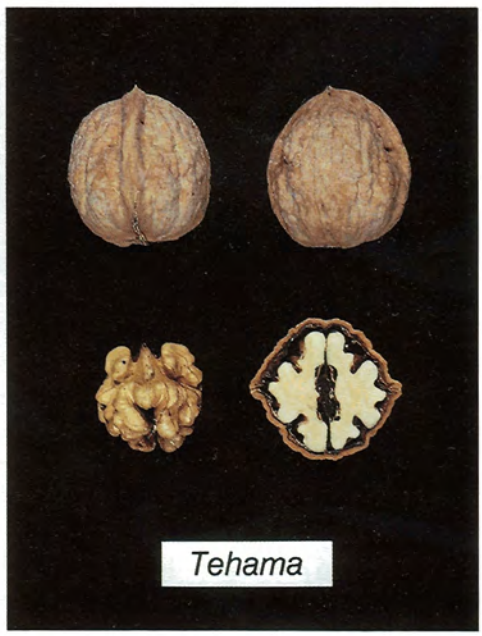
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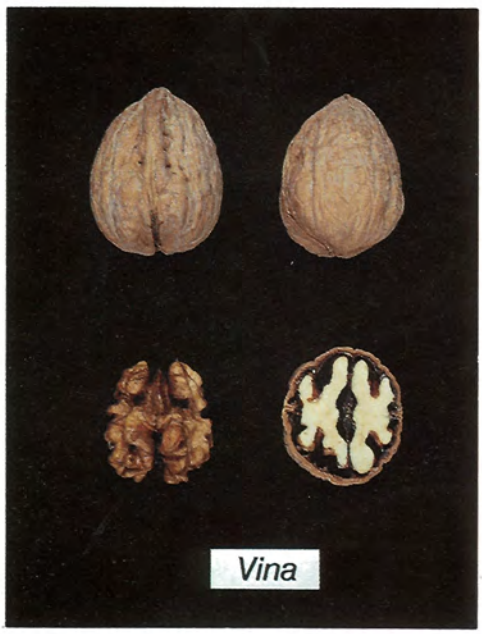
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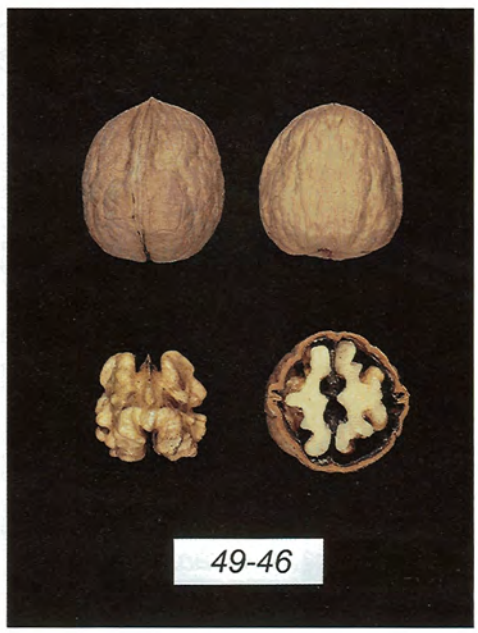
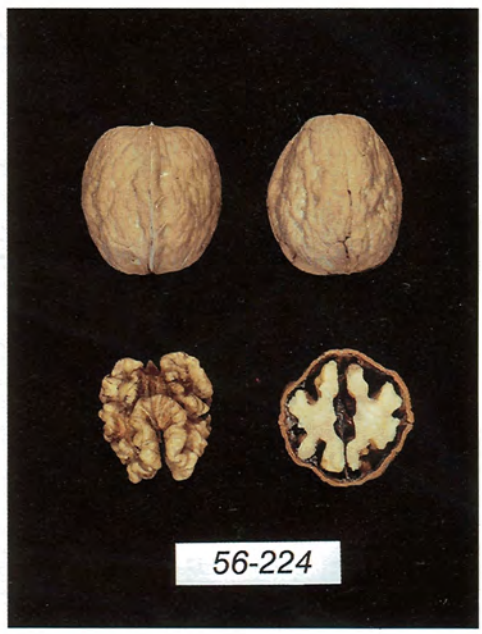

49-46


56-224

Idaho (✱) is a protogynous selection from among the large bijou-type nuts. Idaho is said to have originated in Parma, Idaho and was introduced to California by E.T. Rice about 1947. It leafs out with Payne and bears mostly on terminals. The nut is large, but the kernel is of poor quality and its weight is only 35% of the nut weight. Yield is poor. Idaho is a cold-hardy Carpathian type now kept only as a curiosity.

Marchetti (✱) is a chance seedling which occurred in the orchard of Guilio Marchetti near Stockton, California about 1948. Guilio Marchetti was the foreman of a Dr. Fitzgerald who willed him some land when he died. According to Forde, the nut is very much like Eureka and several other characters resemble Payne. To quote Forde, "It is quite possible that Marchetti is a natural cross of Eureka and Payne." Marchetti leafs out almost a week after Payne, is more than 80% fruitful on lateral buds, bears heavily, and requires a vigorous rootstock. The nut seal is very good, the kernel is of variable color but of satisfactory quality. Yields are excellent and harvest is a week after Payne. The trees tend to overbear, so they must be pruned every year. It adapts well to hot summers. Marchetti is more susceptible to blight than Payne but some growers, like Walt Deardorf, still like it better. Marchetti was used by Serr and Forde for many crosses in their walnut breeding program.

Mayette was brought from France by Felix Gillet. Mayettes are characterized by their late leafing date and their nut shape, which is flat on the stem end like Hartley. They tend to have defective seals. Several selections have been made. **Conway Mayette** (✱) is a slightly later-leafing selection made by a Mr. Conway in Los Molinos, California about 1915. The trees are large and difficult to shake for harvest. **XXX-Mayette** (✱) is protogynous and sheds pollen late enough to cover the pistillate bloom of Franquette, unlike other Mayettes. Nut seal is excellent and the shell is strong. The kernels are small, percent kernel is low, but kernel color is good. It is somewhat difficult to use in breeding because the flowers tend to be receptive while still very much hidden by the leaves.

Meylan (✱) is a French type originally from Meylan (Isère), France. It is terminal bearing, protogynous, late leafing, and late in shedding pollen. The nut seal is poor, yield is fair, kernel quality is good, but the percent kernel is low. Meylan has been used as a pollenizer for Franquette in Lake County. Some say that the kernel lacks astringency and is therefore a good nut for people sensitive to walnuts.

Payne (✱), a chance seedling with fruitful lateral buds, was found by George Payne, a farmer from Santa Clara County, who sold scions of it as a business. It soon became an outstanding cultivar in the coastal valleys and the San Joaquin Valley. It has been speculated that Payne is derived from a cross of a French cultivar introduced by Felix Gillet in the 1870s and a Chinese seedling introduced by immigrants because the character of lateral fruitfulness is found in certain Chinese types and in Payne and its relatives. Recent DNA analysis by Robert Fjellstrom, Pomology Department, UC Davis, however, suggests that Payne is not related to typical Chinese germplasm. Payne is an early leafing, precocious, and high yielding cultivar that has become the standard for phenology descriptors in California. The nut seal is good and kernel quality is satisfactory. Payne is susceptible to frost, blight, codling moth, and sunburn, and its growth slows with heavy production. In 1948 when Serr and Forde were beginning the walnut breeding program there were only two old, low-vigor Payne trees in the campus orchards for experimental work. They needed Payne for its lateral fruitful character and other traits. Serr and Forde obtained wood from the Anderson Barngrover orchard near Linden, California. They chose this source because Pearly Payne, the brother of George Payne, had grafted part of the Anderson Barngrover orchard over to Payne. This assured Serr and Forde that their Payne material was authentic. Payne was the only cultivar with fruitful lateral buds until they obtained Marchetti. Payne was one of the most important parents in the walnut breeding program and almost all the University of California walnut releases have Payne in their background. If Payne is selfed it always gives some seedlings with a compressed growth habit, russeted hulls, and small nuts.

Placentia (*) is one of the Santa Barbara soft-shells derived from the nuts bought at the wharf in San Francisco by Joseph Sexton about 1869. The origin of this sack of nuts is not clear, both Chile and China have been suggested. The Placentia was the standard in-shell walnut until the Hartley came along. Placentia is earlier leafing than Payne and therefore also susceptible to blight and frost damage. Placentia is protogynous and terminal bearing. The shell is thin but strong, with a good seal. Kernel color is poor. For many years Placentia was considered the best cultivar for southern California. Placentia was not used for any crosses by Serr and Forde, but it may be a source of genes for low chilling requirement.

PI 125249 is a seedling of PI 65870 which came from Fa Hua Ssu Temple near Beijing, China in October, 1925. It was obtained by Serr and Forde from the USDA Plant Introduction Station in Chico, California. PI 125249 is earlier in leafing and harvesting than Payne and is protogynous. The nut is large with a high percent kernel. Although in one year it is listed as being 75% fruitful on lateral buds, in other years the percentage is so low that it must be considered a terminal bearing cultivar. This introduction is only available at the US National Germplasm Repository–Davis.

PI 159568 represents a seedling selection made from PI 127460 which was collected in Pagham, Afghanistan (10 miles west of Kabul) in 1937 by a USDA plant explorer and brought to the USDA Plant Introduction Station at Chico, California. Serr and Forde obtained their breeding material from this source. The tree has a phenology similar to Payne but is not fruitful on lateral buds. It bears an elongated nut with a good quality kernel. PI 159568 was used by Serr and Forde in a number of crosses, and it gave rise to Sunland and Serr. To quote from a letter of Forde to the Chico Station, dated October 31, 1968: "P.I. 159568 was used as a parent because of a number of good characteristics. The nut is well filled, the kernel is plump, kernel color is fairly good, the percent kernel is good — about 54%. The shell is smooth and light colored. Perhaps most important, our P.I. 159568 trees have had very little if any walnut blight. 159568 nuts also seem to be resistant to sunburn."

PI 18256 (*) Walnuts collected by Frank Meyer of the USDA in 1906 in the mountains 40 miles north of Beijing, China were brought to the USDA Plant Introduction Station at Chico, California. One seedling (PI 18256) was selected out of several hundred by Lloyd Joley at the Chico Station. Scions were taken to Salem, Oregon by Moses Adams in 1927 where it was named Manregian. The name comes from a contraction of Manchuria and *Juglans regia*. It is now referred to commonly as Manregian. Seedlings from Manregian are sometimes used as rootstock and bear the same name. In phenology it is similar to Payne, but it is not laterally fruitful. The nut is large and round, the shell thin but strong. Kernel quality is good, but the kernel is somewhat dark. It is known for its hardiness to frost and some resistance to blight. Since the 1950s its seedlings have been recommended as a rootstock for walnut cultivars in Oregon to avoid blackline disease. Trees grafted on Manregian are reported to grow more rapidly than on black walnut rootstocks. However, their tolerance of salt accumulation is low. Forde comments, "It may be a good rootstock in Oregon. It is not good here."

Olmo 13-1048, 20-1072 (*), 38-1207, 70-1307 Dr. Harold P. Olmo, Department of Viticulture, UC Davis, collected walnuts from the Tabriz area of northern Iran; scions from these seeds were evaluated as part of the walnut breeding program. O-13-1048 and O-20-1072 have a phenology similar to Payne and are unique in that their nuts are "paper shelled". Kernel weight is about 70% of nut weight. O-20-1072 has surprisingly light-colored kernels. O-38-1207 and O-70-1307 are both midseason cultivars with only fair kernel quality. Forde's comment: "Gene thought we should forget it; I did some crosses on my own because I was curious. Nothing very good happened." O-20-1072 is in the Walnut Germplasm Collection in the Stuke Block; the others are retained by the US National Germplasm Repository–Davis.

Poe is a midseason to late leafing cultivar from Lake County, California. Poe was selected by

Oscar Poe near Lakeport around 1900. It is terminal bearing, protogynous, and low yielding. The nut is thick shelled, and the kernel is small. One gourmet food writer described Poe as less astringent than other walnuts and tasting slightly like butterscotch.

Sharkey (✱) parentage is unknown, but Forde suggests that it may be derived from seed from China. The Tribble Brothers Nursery in Elk Grove, California discovered it about 1925 and named it after Millard Sharpe of Vacaville, California, whose nick-name was "Sharkey." Sharpe also worked as a nurseryman for the University. The Sharkey cultivar is early bearing and somewhat fruitful on lateral buds. It leafs out at the same time as Payne, is protogynous with pistillate bloom two weeks earlier than Payne, and sheds pollen 10 days later than Payne. The nut is round and well filled, with a fair seal. Forde considers it the best nut for eating that we have. Many crosses were made using Sharkey, one of which led directly to Amigo and Chico and indirectly to Chandler and Howard.

Sinensis (✱) Gene Serr requested seed of *J. sinensis* Dode from Japan but received seed of what appeared to be *J. regia*. Fifteen seedlings were obtained from these seeds and numbers 5 and 7 were selected for some crosses. Both are protogynous and bear nuts primarily on terminals. Sinensis 5 leafs out five days after Payne and pistillate bloom is nine days earlier than Payne. The nut seal is good. Kernel weight is 50% of nut weight, but kernel quality is poor. Sinensis 7 leafs out seven days after Payne and its pistillate bloom is four days earlier than Payne. The nut seal is good. Kernel weight is 55% of nut weight and kernel quality is fair. Sinensis 7 is only available at the US National Germplasm Repository–Davis.

Trinta may be a budsport or chance seedling of Waterloo since it occurred on two trees in the Waterloo orchard of Manuel Trinta near Patterson, California. Forde believes that whoever grafted the trees got the scion from a seedling by mistake. Trinta was patented and assigned to Sierra Gold Nursery. Trinta is fruitful on lateral buds and leafs out four days after Payne and it is harvested two weeks after Payne. The shell is moderately strong, seal is satisfactory, but the kernel quality is poor. The trees are vigorous, fast growing, dense, and heavy bearing.

Waterloo (✱) was first described by Gene Serr (while still a farm advisor), who discovered it about 1934 in a planting of Eureka seedlings near Stockton, California. It is named after Waterloo Road in Linden (near Stockton), where Serr owned a 40-acre ranch. Waterloo is not laterally fruitful, but it is a good producer. It leafs out with Hartley, but it is harvested after Hartley and before Franquette. The nut is strong with a good seal, but kernel color is poor. Waterloo is a parent of Gustine, Lompoc, and Tehama. Forde comments, "Waterloo is a fairly decent cultivar; it came out about the same time as Hartley, but Hartley is better."

Westside (✱) is a chance seedling from the San Joaquin Valley that was patented and assigned to Stewart Nursery. It is protogynous and highly fruitful on lateral buds. Westside requires an early pollenizer. The nut of Westside is small and thick-shelled with low percent kernel. The cultivar Chico came along and proved better than Westside.

Cultivars released by the University of California, Davis

Amigo (56–226) (✱) is from a Sharkey × Marchetti cross made by Serr and Forde in 1955, selected in 1963, and introduced in 1968; it is a sibling of Chico and 56–224. The tree is productive with many clusters of four nuts, 80% fruitful on lateral buds, and leafs out about two weeks after Payne. It is protogynous and was originally selected as a pollenizer for Midland, Pioneer, Tehama, and Pedro. The nut is of satisfactory quality but the shell seal is poor in some years. The kernel weight is 56% of nut weight. The kernel is light colored and has good quality. Forde remarked, "One thing we did not know was that the new seedlings shed pollen and leaf out earlier as they got older." This lesson was learned from evaluating Amigo and other selections. Some farm advisors have noted that the hulls of Amigo nuts sunburn easily but the kernel is not severely affected. It is also quite susceptible to codling moth and walnut husk fly.

Chandler (64–172) (✱) is from a cross made by Serr and Forde in 1963 between Pedro and 56–224. Chandler was patented and released by the University of California in 1979. Chandler is highly fruitful on laterals and quite vigorous, thus it needs pruning, particularly to avoid shoots with a narrow crotch angle. Growth starts midseason, about the same time as Hartley. The nuts are oval, smooth, with some weakness in the shell so they may not be suitable for the in-shell market. However, Forde suggests that the shell may firm up as the trees get older and put less energy into wood. Nut seal is good and the kernel is particularly light colored, almost pearly. The nuts easily crack out in halves and some say that it stores better than other cultivars. Occasionally one finds some shrivel on the lobes of the kernel but this has not been an economically important flaw. Chandler yields well if pollenizers are present. It is now the most frequently planted walnut cultivar and Forde regards it as the most important cultivar coming from their breeding program.

Chico (56–206) (✱) is from a cross between Sharkey and Marchetti made by Serr and Forde in 1955 and released by the University in 1968. Chico is a small, upright tree that leafs out at about the same time as Payne and is very fruitful on laterals with the potential for heavy yields. Chico is protogynous like its sibling Amigo. The nut is small, round, with a good seal and good quality kernel, but the kernel is sometimes difficult to extract from the shell. The trees grow vigorously when young and need frequent pruning to prevent overbearing. If overbearing occurs the nuts may be numerous but smaller. Chico stands up well to the heat and was used in some of the original hedgerow orchard trials.

Cisco (66–178) is from a cross between Meylan and Pedro made by Serr and Forde in 1965. Cisco was named and released in 1990 as a pollenizer for midseason cultivars, especially for orchards that require a pollenizer tree that is smaller and more precocious than Franquette. Cisco is a late-leafing, late-maturing cultivar which is fruitful on laterals. It sheds pollen in moderate amounts and covers the peak pistillate bloom of Chandler and Howard. The nut has a medium light color with a good seal. Kernel weight is 47% of nut weight. Kernel color is variable.

Gustine (52–61) (✱) originated from a cross between Waterloo and Payne made by Serr and Forde in 1951 and released by the University in 1968. Gustine is highly fruitful on lateral buds, leafs out with Payne, and is very productive. It matures at midseason. The nut is a Eureka type, pointed, with a good shell seal and good fill, but the kernel color is sometimes poor. It is more vigorous than most other laterally fruitful cultivars and requires heading back when young to prevent the breakage of limbs. Two defects are brittle wood and greater susceptibility to bark canker than other cultivars. Gustine is no longer planted.

Howard (64–182) (✱) is a sibling of Chandler from the cross Pedro × 56–224. Howard was patented and released by the University of California in 1979. It is a laterally fruitful, midseason cultivar with heavy bearing potential. It is not as vigorous as Chandler and must be pruned heav-

ily. Some farm advisors recommend removing nuts for the first two bearing years to encourage growth. The nuts are not as light colored as Chandler, but they are larger and have a stronger shell.

Lompoc (52–46) (✱) is from a Waterloo × Payne cross made by Serr and Forde in 1951 and released by the University of California in 1968. Lompoc is moderately fruitful on lateral buds, leafing date is close to Payne, but harvest is late. The nut is large and pointed with a good seal; the kernel weight is 54% of the nut weight. It is a productive cultivar, but does not do well in a hot interior valley. Lompoc is named after a city in the Santa Ynez Valley, California. It is a parent of Sunland.

Midland (49–47) (✱) is from a Franquette × Payne cross made by Serr and Forde in 1948, selected in 1955, and released by the University of California in 1968. It is moderately fruitful on lateral buds and leafs out 11 days after Payne. The shell seal is good, the kernel weight is 48% of the nut weight, and under the right conditions the kernel can be of high quality. Midland matures at midseason and does not tolerate very high heat. Its adaptability to the mid-Central Valley suggested the name. Midland is more vigorous than Vina, a sibling, and does not require heavy pruning as Vina does, but it never has had a strong following.

Pedro (53–113) (✱) is from a Conway Mayette × Payne cross made by Serr and Forde in 1952, selected in 1958, and released by the University of California in 1968. Pedro leafs out about two weeks after Payne and sheds abundant pollen over a long period of time, covering such cultivars as Ashley, Lompoc, Marchetti, Serr, Gustine, and Vina. It is laterally fruitful and highly productive and matures at midseason or later. The nut is large with a good shell and fair seal. The kernel weight is 50% of nut weight and kernels are of fair quality. Pedro does not withstand the heat well and has been found to do well in the cooler parts of Europe, especially Hungary. Pedro was used in the crosses that produced Howard and Chandler and is still being used in the breeding program.

Pioneer (51–170) (✱) is from a cross between Franquette and Payne made in 1950 by Serr and Forde, selected in 1957, and released by the University of California in 1968. The cross that produced Pioneer, was made two years later than the cross that gave its siblings, Vina (49–49) and Midland (49–47). The leafing date is one to two weeks after Payne. It is moderately fruitful on lateral buds and shell seal is fair to good. The nut is more suitable for in-shell than cracking; kernel weight is 45% of nut weight, and only 62% of the kernels are light colored. The overall nut quality is not very good. It requires little pruning and is harvested at midseason. Forde says that he would like to forget this cultivar. It was only released because some growers were going to grow it anyway.

Serr (59–129) (✱) was selected by Serr and Forde from a Payne × PI 159568 cross made in 1958. It was released by the University of California in 1968. The trees are vigorous, leaf out close to Payne, and are moderately fruitful on lateral buds. The nut is thin shelled with a good seal and well filled. The light-colored kernel is of excellent quality. Serr is well adapted to the hot climate of the San Joaquin and Sacramento Valleys and is somewhat resistant to sunburn. As Forde puts it, Serr seems to "thrive on adversity" and is used in replant situations because of its vigor. However, the Serr cultivar does have a problem with pistillate flower abscission which appears to be related to excess pollen. The Serr cultivar was named to honor Gene Serr after his death in 1968. Forde recalls that the faculty discussed naming the best of the ten new cultivars released in 1968 after Serr. Forde said, "We thought it was the best one. Too bad we did not give Vina his name; it was the best of the ten."

Sunland (66–4) (✱) is from a cross between Lompoc and PI 159568 made by Serr and Forde in 1965. It was patented and released by the University of California in 1979. Sunland is a vigorous, early-leafing cultivar, with good bearing potential on lateral buds. The nuts are large, oval, with a good shell and seal and have high percent kernel. While the kernel is of good quality, large, and plump, its color has been a problem in recent years. Although Sunland is a

half-sib of Serr it does not appear to have the pistillate flower abscission problem. Sunland is susceptible to blight (like other early leafers) and also to shallow bark canker and stress from rapid growth. The large leaves increase water use and the long season, 173 days, makes for a late harvest. The pollen is somewhat difficult to use in breeding because it clumps and sticks together.

Tehama (58–11) (✱) is from a cross between Waterloo and Payne made by Serr and Forde in 1957, selected in 1963, and released by the University of California in 1968. This cultivar which can be very productive is 80% fruitful on lateral buds, leafs out two weeks after Payne, and is harvested at midseason. The nut is suited for cracking; the seal is good but the shell tends to be weak. Kernel weight is 54% of nut weight. The kernel has good quality and 70% are light colored. The tree requires pruning to prevent overbearing. Its name is derived from its apparent suitability to the Tehama County area.

Tulare (67–11) came from a Tehama × Serr cross in 1966 by Forde. Tulare was patented and released by the University of California in 1993 (US Plant Patent Number 8,268). Tulare leafs out at midseason, is laterally fruitful, and sheds pollen during most of its pistillate bloom period. Growth habit is upright, with moderate vigor. It is precocious, with heavy nut production. The nut shell is of medium texture and color, the kernel weight is 54% of nut weight, and kernels are mostly light colored. Tulare is considered suitable for hedgerow and other high-density planting systems.

Vina (49–49) (✱) is from a cross between Franquette and Payne made by Serr and Forde in 1948, selected in 1955, and released by the University of California in 1968. Vina is a productive and consistent bearer, being 80% fruitful on lateral buds and leafing out about a week after Payne. Shell seal is good. Kernel weight is 48% of nut weight. The kernel is of good quality, but color is sometimes a problem. The nuts mature early to midseason. Serr and Forde reported that the trees are tolerant of summer heat and show some resistance to blight. Growth is vigorous in young trees; regular pruning is required to prevent overbearing and lower quality nuts. Forde mentions that they came close to discarding Vina because of the overbearing. Vina is now considered the best of the 1968 releases.

University of California numbered selections

49–46 (✱) is from one of the early crosses between Hartley and Payne. It is a fairly good catkin producer, but as it ages it produces fewer and fewer catkins. It leafs out a week later than Payne but is harvested about the same time as Payne and is highly fruitful on lateral buds. The nut resembles Hartley in being flat on the bottom but the seal, kernel weight, and color are only fair. Forde notes that 49–46 is the only potentially useful derivative from crosses with Hartley. Progeny of certain crosses with 49–46 have an unusual compressed growth habit and russeted nuts, similar to the traits found in selfed Payne seedlings.

53–128 is a seedling selected from a Payne × Early Ehrhardt cross made by Serr and Forde in 1953. It leafs out early and is protogynous, flowering seven days earlier than Payne. It is highly fruitful on lateral buds. The shell seal is good, kernel weight is 58% of nut weight, but the kernel color is poor. With a low chilling requirement, 53–128 is suitable for southern California. It is not in the Walnut Germplasm Collection but is retained in the US National Germplasm Repository–Davis.

56–224 (✱) is a seedling from a Sharkey × Marchetti cross made by Serr and Forde in 1955. It leafs out shortly after Payne, is fruitful on lateral buds, protogynous, and is harvested a week later than Payne. The nut is large but has a weak shell. One serious defect is the occurrence of holes in the shell. Gene Serr planted about one acre with 56–224 in his orchard near Auburn, California and the nuts did not perforate at this elevation of 2,500 feet above sea level. However, the selection was not suited to the frost conditions there. Serr and Forde made quite a few crosses with 56–224, including the cross with Pedro which resulted in 35 progeny, two of which became the cultivars Chandler and Howard.

59–124 is a seedling selected by Serr and Forde in 1958 from a cross between Payne and PI 159568. This is a sibling of Serr and some growers think that it is much better. It is early leafing and laterally fruitful. The nut shell and seal are good, the kernel weight is 54% of nut weight, and the kernel has good quality. Forde considers 59–124 better than Serr since there is apparently no problem with pistillate flower abscission. Forde said that it was one of the better seedlings, but they did not make crosses or release it. The Driver family, Modesto, California, considers it a potential replacement for Serr.

59–165 was selected by Serr and Forde from seedlings of a 1958 Waterloo × Ehrhorn cross. (Ehrhorn is a chance seedling possibly from a Payne × Concord cross; it occurred in Mountainview, California and was selected by Adolph Ehrhorn from the orchard of Peter Lusich about 1938.) 59–165 leafs at midseason, is fruitful on lateral buds, and is harvested at the same time as Hartley. The nut has a fair seal, good percent kernel, and a moderate percentage of light colored kernels. It is a parent of a group of super-late seedlings. In 1967 Gene Serr commented on the vigor of a six-year-old tree, "I think it has a very good bearing potential."

61–25 was selected by Serr and Forde from a cross between 49–46 and 53–57 (Conway Mayette × PI 18256). It is a midseason cultivar, laterally fruitful, and it resembles the new French cultivar Lara. The kernel weight is 53% of nut weight and nuts have a high percentage of light-colored kernels.

63–378 was selected from a cross between Vina and Scharsch Franquette made by Serr and Forde in 1962. (Because 63–378 is protogynous, it has been suggested that it may have been from a Marchetti × Sharkey cross made that same year.) 63–378 is early to midseason leafing, protogynous, and laterally fruitful. Yield is good, but the nuts are poorly sealed with a moderate percentage of light colored kernels. The kernel weight is about 55% of nut weight.

64–57 was selected from a Serr and Forde cross made in 1951 between 52–48 (Payne × Waterloo) and 56–224. It is early to midseason leafing, laterally fruitful, and protogynous. The kernel weight is 55% of nut weight, nuts are variable in

color, and seal is poor. 64–57 has been planted in San Benito County, and is especially popular there with grower Al Bonturi. Farm advisor Bill Coates noted 64–57 suffered less winter freeze damage than other cultivars in the 1990 freeze.

67–13 was selected from a Tehama × Serr cross and is a sibling of Tulare. This selection is early leafing, high yielding, and laterally fruitful and is harvested early. It is nearly homogamous in flowering and produces large numbers of catkins. Kernel quality is generally excellent, but varies from poor to outstanding. Kernel percent of nut is consistently high. 67–13 does well in hedgerow plantings and as a pollenizer for Chico. It was going to be released as "Yolo" until P.B. Catlin determined that it has the problem of pistillate flower abscission like Serr.

68–104 is a seedling selected by Serr and Forde from a 1967 cross between Vina and Serr. 68–104 is a midseason leafing, laterally fruitful selection with high yield. The kernel is light colored and weighs 55% of the nut weight. It is retained because it shows some tendency to bear nuts in shaded parts of the tree. This selection was never released because the nuts are too small, even though that is not obvious from the evaluation data.

73–16 is a seedling from the cross 59–165 × Pedro made by Forde in 1972. 73–16 is a superlate, leafing out two months after Payne with a peak pistillate bloom at the end of May to early June. It is harvested only a month after Payne and is laterally fruitful. The percent kernel is low, but kernel color is light.

74–245, 74–256, 74–258, 74–259, 74–266 All of these selections are from the cross 61–12 (49–46 × Scharsch-Franquette) × 59–165 made by Forde in 1973. This is a family of plants saved in the collection for their super-late phenology. Their peak pistillate flowering is in late May to early June. 74–259 is the most fruitful on laterals; 74–258 has the biggest nuts. Percent kernel varies from 37% (74–256) to 49% (74–259). The kernel weight is low, from 4.8 g (74–256) to 6.9 g (74–258). Kernel color is suprisingly good.

76–80 is from a cross between Chandler and 61–25 made by Forde in 1975. 76–80 is midseason leafing, precocious, and somewhat fruitful on lateral buds. The kernel weight is 53% of the nut weight. Its nuts have a very high percentage of light-colored kernels, similar to its parent Chandler. The nut may have a seal problem and the shell is weak. Yields are average to good.

76–98 and **76–112** These two seedling selections are from the cross Howard × 61–25 made by Forde in 1975. Both selections are retained for their late leafing (23 to 26 days after Payne) and dichogamy traits (protandrous with no overlap of staminate and pistillate flowers). They are both laterally fruitful and have average to good yields and a high percentage of light kernels, however, 76–112 has small nuts with low percent kernel.

77–12 is from a cross between Howard and 64–57 made by Forde in 1976. It is a protogynous, short-season selection which leafs out 18 days after Payne and is harvested earlier than Payne. The kernel weight is a very low percentage of the nut weight. Nuts have poor seal. It is retained for the short-season trait. The kernels have variable color and may have an unusual oil composition with a high percentage of unsaturated fatty acids.

78–10 resulted from a cross between 53–153 (Hartley × PI 18256) and Chandler made by Forde in 1977. It is similar to Cisco in phenology and is laterally fruitful, with excellent kernel quality and average to good yield. It is being retained as a potential pollenizer of Chandler, Howard, and Hartley.

78–189 is from a cross between Chandler and 64–436 (Marchetti × Sharkey) made by Forde in 1977. It is protogynous, nearly homogamous, and laterally fruitful with average yield. Nut size is small but kernel quality is good. It is a potential pollenizer for Chandler, Howard, and Hartley. It leafs out with Hartley or up to a week later. Forde described 78–189 as "one of my last children," i.e., one of the last crosses made in the Serr/Forde walnut breeding program.

Paradox and black walnuts in the collection

Paradox 'Burbank' is a hybrid between a California black walnut (either *J. hindsii* or *J. californica* S. Wats.) and the English or Persian walnut (*J. regia*). Paradox types are noted for their vigorous growth and are widely used as rootstock. In the 1890s, Luther Burbank reported that he made this cross and named the resulting hybrid, Paradox (Whitson et al. 1914). He mentions the "enormously enhanced capacity for growth" beyond that of either parent, with "leaves of extraordinary length" and foliage that has "a delicious apple-like fragrance." Burbank recognized the characteristics of hybrid vigor from wide crosses, noting, "The tendency to surpass their parents in size is a characteristic that is very commonly manifested when plants of different species are hybridized." The Paradox 'Burbank' in the Walnut Germplasm Collection was obtained by Serr and Forde from the Burbank garden at his home in Santa Rosa, California.

Paradox 'Bowman Kuhn' is a selection of Paradox which is rootable from cuttings and shows some resistance to nematodes (Lownsbery et al. 1974). Forde recalls getting suckers from Paradox trees in the orchard of Bowman Kuhn, a grower who had a high incidence of lesion nematode in his orchard. The Paradox 'Bowman Kuhn' obtained by Forde was the better, more resistant Paradox in that orchard.

Paradox 'O'Farrell' is a tree on the property of Eileen O'Farrell in Davis, California. It was used in several studies aimed at selecting vigorous Paradox × *J. regia* seedlings and was found to yield superior seedlings. Several of its offspring have been selected as clonal rootstock.

***J. hindsii* 'Rawlins'** is a selection of northern California black walnut which yields well and gives 20 to 40% Paradox seedlings if *J. regia* pollen is available. Other selections of California black walnuts give up to 90% Paradox seeds, but produce comparatively fewer nuts. In a letter to Mr. Cliff Gonyo, Kelseyville, California in 1964, Forde mentions, "In the case of Rawlins seed, we found when they germinate, that part of the sprout shows some pink color on the base of the young root. The ones with the pink color produced nearly all Paradox while the pure white ones turned out to be all black." The original source of 'Rawlins' was from Hubert T. Rawlins in Glen County, California.

***J. nigra* 'Student Orchard'** was obtained from the Pomology Orchard where students practiced grafting. Students had grafted some early-leafing black walnuts which Dr. Davey obtained from the Tennessee Valley Authority and two of these grafts took. One of them is the source of this germplasm. These 'Student Orchard' Eastern black walnuts cross readily with California black walnuts. The hybrids, known as Royals, can be picked out easily. The hybrids are large seedlings like the Northern California black walnut instead of small seedlings like those of the Eastern black walnuts. Forde commented that it was "too bad that somebody did not try the compatible 'Student Orchard' × *J. hindsii* hybrids as rootstocks."

***J. nigra* 'Thomas'** is a well-known cultivar from Pennsylvania which was discovered in 1881 (Jaynes 1979). 'Thomas' bears early, cracks easily, and has a large kernel. 'Thomas' does not perform consistently from year to year and the nuts do not fill well. It is in the collection because it has been the standard grafted Eastern black walnut for over a century. It also has light colored kernels with a rich black walnut flavor.

Publications of Eugene F. Serr and Harold I. Forde

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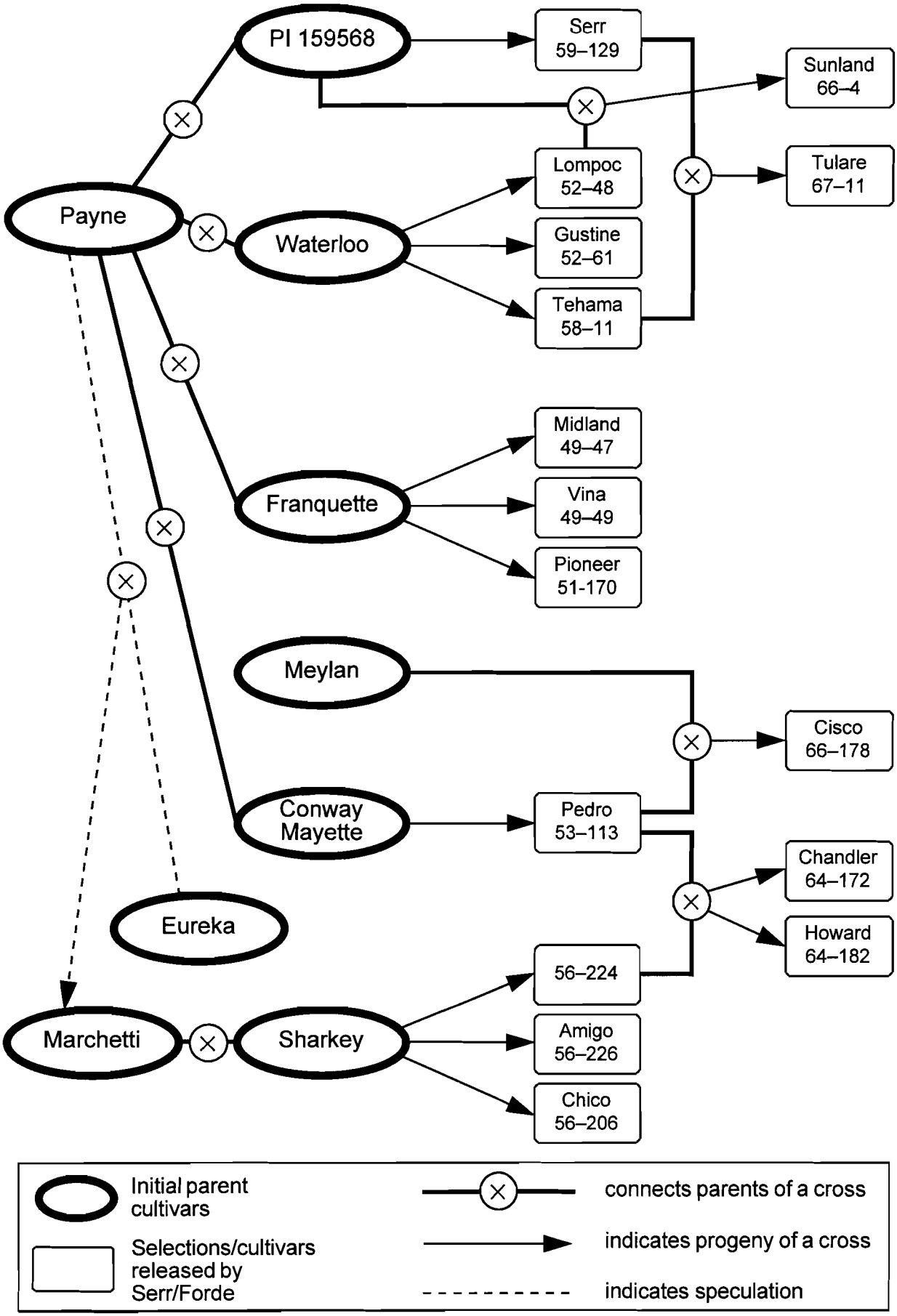

Appendix 1. Pedigree diagram for cultivars released from the Serr/Forde Walnut Breeding Program

Appendix 2. Germplasm evaluation data

Although this table represents actual data collected, it should be considered only as an approximation of a cultivar's performance because many of the traits vary with tree age and environment. In California, Payne is considered the standard by which other cultivars can be judged, therefore, the leafing, pollen-shed, and bloom data are expressed in date form as well as in days after Payne's leafing date (DAPL); harvest data are expressed as date and days after Payne's harvest date (DAPH).

	Leafing		First pollen shed		Last pollen shed		Peak female bloom		Harvest		Fruitful laterals	Kernel		
Cultivar [ID number]	Date	DAPL	Date	DAPL	Date	DAPL	Date	DAPL	Date	DAPH	%	Weight g	% of nut weight	Color % lights
Old cultivars and introductions														
Adams [28]	3/28	12	4/3	18	4/17	32	4/18	33	10/1	13	8	8.1	50	60
Ashley [4]	3/20	1	3/31	13	4/13	26	4/16	29	9/21	6	88	6.7	52	82
Carmello [29]	3/22	4	4/13	26	4/26	39	4/15	28	10/8	23	0	9.1	41	70
Cascade [87–18]	4/4	17	—	—	—	—	4/21	34	—	—	30	—	—	—
Concha [5]	3/15	1	3/27	14	4/8	27	4/9	26	9/22	13	72	7.9	47	70
Early Ehrhardt [6]	3/9	-13	4/1	9	4/13	21	3/27	4	9/25	0	0	5.6	55	45
Eureka [7]	3/26	7	4/2	14	4/19	32	4/18	31	9/26	10	0	7.1	50	52
Scharsch Franquette [3]	4/14	27	4/14	28	5/17	61	5/5	49	10/12	22	0	5.1	47	76
Graves Franquette [32]	4/17	27	4/21	33	4/24	36	5/9	49	10/12	17	0	5.0	48	86
Hartley [2]	4/3	16	4/14	26	4/28	40	4/29	42	10/1	15	6	5.8	47	76
Howe [34]	4/1	14	4/9	23	4/15	29	4/22	35	10/6	20	0	7.4	59	68
Idaho [35]	3/17	0	4/2	17	4/15	30	3/31	14	9/17	7	18	8.2	35	30
Marchetti [41]	3/25	6	4/1	14	4/15	27	4/18	30	9/23	8	82	6.3	51	68
ConwayMayette [31]	4/17	30	4/20	33	5/4	46	5/6	49	10/7	22	0	5.3	44	66
XXX Mayette [58]	4/16	25	5/2	41	5/12	51	5/6	45	10/9	10	0	5.3	44	90
Meylan [42]	4/11	28	4/27	45	5/8	56	4/25	40	—	—	0	—	—	—
Payne [1]	3/19	0	3/29	10	4/15	27	4/15	27	9/20	0	80	5.5	50	70
Placentia [51]	3/16	-4	4/6	16	4/17	27	3/31	10	—	—	2	6.1	48	24
PI 125249 [47]	3/18	-4	4/9	17	4/19	27	4/10	18	9/16	-10	11	8.7	58	62
PI 159568 [48]	3/18	0	3/26	8	4/11	24	4/19	32	9/20	3	0	7.8	54	76
PI 18256 [49]	3/19	-1	4/1	11	4/10	20	4/11	21	9/28	4	14	10.3	58	22
Olmo 13-1048 [24]	3/16	0	3/28	11	4/11	24	4/9	23	9/15	0	0	7.3	72	50
Olmo 20-1072 [25]	3/17	0	3/30	13	4/11	24	4/15	28	9/14	-1	0	7.1	70	84
Olmo 38-1207 [26]	3/30	13	3/31	14	4/14	27	4/18	31	9/29	14	0	5.7	46	66
Olmo 70-1307 [27]	3/28	10	4/17	31	4/25	39	4/14	28	9/21	6	0	8.1	51	20

Appendix 2. Germplasm evaluation data (cont.)

Cultivar	Leafing		First pollen shed		Last pollen shed		Peak female bloom		Harvest		Fruitful laterals	Kernel		
	Date	DAPL	Date	DAPL	Date	DAPL	Date	DAPL	Date	DAPH	%	Weight g	% of nut weight	Color % lights
Old cultivars and introductions (cont.)														
Poe [52]	4/7	16	4/21	29	5/1	40	4/22	31	10/1	2	0	5.0	42	65
Sharkey [53]	3/18	0	4/10	22	4/22	35	4/1	14	9/15	0	26	6.5	54	64
Sinensis [54]	3/22	5	4/7	21	4/13	27	4/4	17	9/17	2	3	7.5	50	44
Trinta [55]	3/23	4	4/3	14	4/17	28	4/18	29	9/27	12	80	7.9	47	48
Waterloo [56]	4/3	16	4/12	25	4/23	35	4/25	38	10/6	21	0	6.3	48	36
Westside [57]	3/20	0	4/9	21	4/22	34	4/4	16	9/29	8	90	5.4	45	60
Cultivars released by the University of California														
Amigo [56–226]	3/31	12	4/18	30	5/3	45	4/14	26	9/20	5	80	6.8	56	84
Chandler [64–172]	4/4	17	4/7	20	4/25	37	4/26	39	9/30	12	86	6.4	51	96
Chico [56–206]	3/22	3	4/14	26	4/22	34	4/6	19	9/18	3	84	4.9	50	86
Cisco [66–178]	4/17	30	4/20	33	5/11	54	5/5	48	10/12	25	70	6.5	47	64
Gustine [52–61]	3/19	0	3/27	8	4/18	30	4/15	27	9/29	9	85	6.6	51	42
Howard [64–182]	4/4	16	4/9	20	4/23	35	4/27	39	9/30	10	80	7.8	53	74
Lompoc [52–46]	3/19	0	4/1	12	4/21	33	4/17	29	10/8	18	50	7.5	54	60
Midland [49–47]	3/30	11	4/5	17	4/25	37	4/23	35	10/1	11	47	6.5	48	64
Pedro [53–113]	4/2	15	4/7	19	4/24	36	4/26	39	10/2	17	84	7.3	51	56
Pioneer [51–170]	3/28	9	4/4	16	4/26	38	4/23	35	10/1	10	55	5.3	46	62
Serr [59–129]	3/20	1	3/28	9	4/12	24	4/14	26	9/18	4	51	8.2	60	92
Sunland [66–4]	3/20	1	3/27	8	4/21	33	4/17	29	10/1	14	90	9.8	58	62
Tehama [58–11]	4/1	13	4/11	23	4/24	36	4/23	34	10/2	18	80	6.7	54	72
Tulare [67–11]	4/4	17	4/10	23	4/28	41	4/23	36	9/28	11	82	7.3	54	78
Vina [49–49]	3/26	8	4/6	19	4/16	29	4/22	35	9/23	7	82	5.0	48	50
University of California numbered selections														
Selection [49–46]	3/26	7	4/6	20	4/13	27	4/21	34	—	—	86	4.9	50	24
Selection [53-128]	3/13	-3	3/26	9	4/5	19	4/5	19	9/20	5	88	7.3	58	56
Selection [56-224]	3/23	4	4/16	29	4/25	38	4/11	23	9/24	8	80	8.2	65	82
Selection [59-124]	3/16	-2	3/26	7	4/13	25	4/12	25	9/20	0	74	8.7	54	64
Selection [59-165]	4/3	16	4/11	23	4/27	39	4/27	39	10/7	17	74	7.0	53	72

Appendix 2. Germplasm evaluation data (cont.)

Cultivar	Leafing		First pollen shed		Last pollen shed		Peak female bloom		Harvest		Fruitful laterals	Kernel		
	Date	DAPL	Date	DAPL	Date	DAPL	Date	DAPL	Date	DAPH	%	Weight g	% of nut weight	Color % lights
University of California numbered selections (cont.)														
Selection [61-25]	4/3	15	4/8	21	4/24	37	4/24	37	9/27	9	77	7.2	53	82
Selection [63-378]	3/29	10	4/16	28	4/29	41	4/12	24	9/25	4	80	7.2	55	70
Selection [64-57]	3/25	6	4/14	26	4/27	38	4/11	23	9/26	6	80	8.7	55	68
Selection [67-13]	3/24	6	4/1	14	4/24	36	4/15	28	9/23	5	68	8.4	56	70
Selection [68-104]	3/30	12	4/6	19	4/25	38	4/22	35	9/25	8	76	6.6	55	84
Selection [73-16]	5/14	57	5/16	58	5/30	72	6/1	75	10/17	31	50	5.8	43	86
Selection [74-245]	5/17	60	5/21	64	5/27	70	6/1	75	10/15	26	17	5.5	44	66
Selection [74-256]	5/15	58	5/10	57	5/21	68	6/3	77	10/23	29	26	4.8	37	90
Selection [74-258]	5/13	56	—	—	—	—	5/31	77	10/19	24	0	6.9	46	90
Selection [74-259]	5/11	54	5/12	56	5/28	72	5/28	71	10/17	27	53	5.5	49	—
Selection [74-266]	5/15	59	—	—	—	—	5/28	71	10/18	26	6	5.5	46	90
Selection [76-80]	3/29	13	4/4	20	4/18	34	4/23	38	9/25	8	44	6.7	53	98
Selection [76-98]	4/9	26	4/10	27	4/23	40	5/4	50	10/2	18	59	7.2	48	92
Selection [76-112]	4/7	23	4/14	31	4/21	37	4/27	44	9/26	12	66	5.4	41	92
Selection [77-12]	4/1	18	4/11	28	4/24	41	4/13	30	9/5	-4	86	6.4	46	68
Selection [78-10]	4/7	25	4/9	27	4/27	45	5/3	51	10/5	24	87	6.1	48	88
Selection [78-189]	3/30	16	4/9	26	4/27	44	4/13	30	9/15	5	63	6.1	48	80
Paradox and black walnuts														
Paradox `Burbank' [45]	3/19	11	—	—	—	—	4/3	26	—	—	20	—	—	—
Paradox 'Bowman Kuhn' [44]	3/20	12	—	—	—	—	4/2	25	—	—	0	—	—	—
Paradox`O'Farrell' [46]	—	—	—	—	—	—	—	—	—	—	—	—	—	—
J. hindsii `Rawlins' [36]	3/24	4	4/30	41	5/10	52	4/18	30	—	—	74	—	—	—
J. nigra `Student Orchard' [37]	4/2	17	5/3	48	5/10	55	4/21	36	—	—	56	—	—	—
J. nigra `Thomas' [38]	4/17	28	5/12	53	5/22	64	5/4	46	—	—	38	—	—	—