

The Origins of the Grape Program at Foundation Plant Materials Service

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The story of the Foundation Plant Materials Service (FPMS) Grape Program at the University of California, Davis (UC Davis) is the history of the effort to provide researchers and industry with healthy, true-to-variety grapevine planting stock. The grape industry in California has benefitted from its earliest years by the introduction of better wine, table grape, and rootstock varieties from around the world. However, too often as new selections were introduced to California, new pests and diseases appeared as well. Unfortunately, many of those diseases were spread unwittingly by man, through careless propagation and viticultural techniques. Because planting virus-free stock to establish new vineyards is an efficient and effective way to control these diseases, much of FPMS' effort over its fifty year history has focused upon detection and elimination of grapevine virus diseases. UC Davis and United States Department of Agriculture (USDA) plant pathologists have been world leaders in grape virus disease detection, identification, treatment and prevention technology. UC Davis viticulturists have provided the vision and expertise to ensure that the FPMS grape collection represents the great diversity of grape plant materials needed by a vital and ever-changing industry.

KEY WORDS: clones, FPMS, grape importation, certification, clean stock, quarantine,

Vitis vinifera in California

From the end of the 18th century, when *Vitis vinifera* first made its appearance in California, until the early 19th century, the Mission grape was the most widely planted grape in the state. It was readily available, prolific, and for a period of time, it was the only variety available. Then, beginning in the early 1830s, Jean-Louis Vignes, a Frenchman living in Los Angeles, reached out to the Old World for wine grape varieties which would produce wines of a higher caliber than those of the dull, ubiquitous, acid-deficient Mission grape. By the 1860s and 1870s, the trend of importing more interesting European wine grape varieties was in full swing [1].

According to historian James T. Lapsley [21], the late 1880s saw a frenzy of planting of Bordeaux varietals in California, largely in response to the phylloxera epidemic in Europe. California growers were speculating a possible end to the wine industry in France and were planting their young vineyards with Merlot, Cabernet Sauvignon, Malbec, Cabernet Franc, and Petit Verdot in anticipation of the new opportunities which might become available to them. Napa Valley vineyard acreage increased from 3500 acres in 1880 to nearly 12 000 acres in two years [18]. By the turn of the century, when it had become clear that phylloxera was just as capable of surviving in California as it was in Europe, yet another planting boom took place, this time with plants grafted on the phylloxera-resistant *Rupes- tris* St. George rootstock.

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The transition in California's vineyards from the Mission grape to high quality European grape varieties, and the resultant explosion of California's wine industry, has not been without challenges. With the new grape varieties came new insect pests and diseases, requiring new methods of disease detection and improved viticultural techniques. Of particular interest in the FPMS history are the grapevine virus diseases: fanleaf, leafroll, rugose wood, and others. These debilitating diseases came to California on European imports, just as phylloxera had moved from the vines of the New World to those of the Old World in 1863.

University Involvement

It was probably the appearance of phylloxera in Sonoma in 1873 which prompted the University of California's pioneer Professor of Agriculture, Eugene W. Hilgard, to spearhead the campaign for State support and funding for scientific-based instruction in viticulture and enology. In 1880, the California State Legislature obligingly created the State Board of Viticultural Commissioners and mandated that the University of California would establish a program providing for instruction and research in viticulture and enology [3].

The mandate charged, among other things, "the Professor of Agriculture or his assistant to make practical examinations and reports upon the different sections of the State adapted to viticulture" and for there "to be prepared, printed, and distributed to the public, quarterly reports...the progress and treatment of the phylloxera and other diseases of the vine, and such other useful information as may be given for the better instruction of viticulturists" [4].

In 1889, Hilgard was joined in his efforts by Frederic T. Bioletti, a University of California graduate who began his career as Foreman of the University Cellar, later became the University's first Professor of Viticulture, and ultimately in 1916, head of the newly

created Department of Viticulture (now the UC Davis Department of Viticulture and Enology).

In 1908, the University Farm was established at Davis, California, providing University students and faculty with prime vineyard land for research. But by 1916, Prohibition had taken effect, if not yet in law, then in actual fact. Enological research, for all intents and purposes, effectively ceased at the University. Limited viticultural research efforts continued on table and raisin grape varieties only.

With the Repeal of Prohibition, the 1930s saw a stepped-up campaign on the part of the University to encourage the planting once again of better wine grape varieties. Growers and speculators had been waiting in anticipation of the wine boom they expected would come with Repeal. By 1935, the Department of Viticulture had moved officially from Berkeley to Davis, and Professors Albert Winkler and Maynard Amerine worked tirelessly giving lectures, short courses, and training programs designed to disseminate viticultural knowhow to the state's grape growers and to encourage the upgrading of grape varieties [21].

Virus Diseases

In the 1930s and 1940s, very little was known about plant viruses; information on the virus diseases as related to plant life was just beginning to appear in the scientific literature [22]. Prior to that time, many virus-related problems in grapevines had been attributed to sloppy viticultural techniques and poor growing conditions. In a 1931 unpublished book proposal, Frederic T. Bioletti wrote a chapter entitled "Vine Trouble Attributed to Climatic, Soil and Cultural Conditions" which listed "California vine disease" (later known as Pierce's disease and proven to be of bacterial origin), "red leaf" (later identified as leafroll virus), and "shot berries" and "coulure" (symptomatic of fanleaf virus as well as other conditions) [6].

During the 1940s, as the state's wine industry developed and plantings expanded, new knowledge and methods of disease detection gradually made clear to scientists just how widespread virus disease problems were in the state's vineyards.

The classic case of virus disease in California was that of the problem growers experienced with Emperor, a table grape variety from Iran. In 1941, it was the third most important table grape in California. However, growers often had problems with color development and sugar levels in this variety, leading to the idea that there were two varieties, normal red Emperor and so-called "White Emperor". Harold Olmo, a UC Davis viticulturist and geneticist then at the beginning of what was to be a long and productive career, determined that this problem was perpetuated by vegetative propagation and proposed that a virus might be implicated [27]. In 1946, USDA plant breeders Elmer Snyder and F. N. Harmon, working at Fresno, published reports of their work clearly demonstrating that the "White Emperor" condition was graft transmis-

sible, a probable indication of virus disease [17]. Further work determined the symptoms of the disease [13], its distribution and indicator varieties for detection [14], and synonymy with the disease known as leafroll found in Germany [31]. This was a landmark case in the history of grapevine virology because it clearly established a virus disease as the cause of poor vineyard performance in the production of an important table grape variety. The importance of propagation from healthy stock also became clear to researchers and industry.

Yet more virus problems plagued California's viticultural scientists in addition to the "White Emperor" problem. In 1948, Harold Olmo introduced his new variety, Ruby Cabernet (a cross between Carignane and Cabernet Sauvignon), which performed well in University vineyards but very poorly when grafted onto vines in the Napa Valley. According to Olmo, "The growth and fruit of the vines had markedly deteriorated and virus contamination was evident...it seemed unreasonable to spend 15 years in breeding and testing a new variety and then see it contaminated unwittingly after commercial introduction. Some control in the propagation and distribution of new varieties had to be devised" [29].

University plant pathologist William B. Hewitt voiced his concern over the disease conditions in California's vineyards when he wrote "There are, in California vineyards, increasing occurrences of vine diseases, either caused by viruses or suspected of being caused by viruses. These diseases present the vineyardists of that state with some serious problems; and it is certain that unless some action is taken to prevent the spread of these and other vine diseases, great harm will be done the grape and wine industry" [19].

Hired initially by the University in 1937 to work on Pierce's disease, which was believed at the time to be viral in origin, Hewitt would play a pivotal role in early identification [20] and elimination of virus diseases in California's vineyards. A member of the UC Davis Plant Pathology Department, Hewitt devoted his life to the study of grapevine diseases and ultimately became known as the father of modern grapevine virology.

In 1954, fanleaf virus was identified by Hewitt as being the cause of vineyard problems in Calmeria, a USDA-bred table grape variety [Luigi Chiarappa, personal communication]. A state-wide survey by Nursery Services, California Department of Agriculture (CDA), later to become the California Department of Food and Agriculture (CDFA), revealed the widespread dissemination of fanleaf disease. The USDA's Agricultural Research Service (ARS) responded to the resulting crisis by sending a young USDA plant pathologist, Austin C. Goheen, to its Fresno facility in an attempt to help the industry control fanleaf, which was being spread to new plantings Fresno area, and to work on other viruses.

In 1956, Austin Goheen was transferred from

Fresno to Davis [10]. At this time, the USDA entered into cooperative research with the California Agricultural Experiment Station at Davis in 1956 to study virus diseases of grapes in order to assure clean grape propagating materials [10,11]. Goheen's transfer was intended to relieve pressure on Eastern quarantine facilities (see Grape Importation later in this article) as well as to contribute to the pathology research effort. Goheen would become a key advisor and guiding force behind FPMS until his retirement thirty years later in 1987, taking a large part of the responsibility for virus testing and grape importation in the years to come.

Identification of Varieties

In addition to disease problems in California's vineyards, there were many questions of varietal identity that needed to be resolved. The job of varietal identification at UC Davis fell upon Harold Olmo's shoulders early in his career as the successor to Bioletti in ampelographic expertise. According to Olmo, planting was often done in the first half of the 1900s with little knowledge of or concern for varietal identity. Part of the problem stemmed from the fact that the same varietal might, in different regions of its native land, be called by completely different names. Also, some growers and winemakers were indifferent to issues of correct identity in a day when varietal wines were virtually unknown. Confused nurserymen would sometimes dispense with attempts to identify a variety correctly and simply tack a pet name onto saleable vines. This meant that European selections coming to California were often mislabeled when they arrived, and that frequently the original names were lost once the vines went into vineyards (Harold Olmo, personal communication).

The Need For a Clean Stock Program

In December of 1950, after a day-long meeting at Davis in which key University researchers outlined their respective investigations before an audience of wine industry representatives, the Wine Institute's Viticultural Research Committee made the following recommendations to its Board of Directors: a) develop a concrete program for importation of selected "strains" of desirable European grapes; b) request the University to re-establish identification of grape varieties planted in California; and c) request the University to engage in an expanded program of collection, isolation and propagation of choice varieties of grapes which would be made available to industry. These proposals were fleshed out in detail by Harold Olmo in a landmark article which proposed the establishment of a post-entry quarantine on the Davis campus, the establishment of a Foundation vineyard to provide clean, true-to-type stock to the industry, a program to re-import true-to-type stock, and the establishment of an advisory committee to oversee the program [28]. His recommendation was that responsibility for the administration and policy of the grape certification program

should rest with a committee of six members, representing the following groups: the California Grape and Tree Fruit League, the Bureau of Entomology and Plant Quarantine at CDFA, UC's Division* of Viticulture, UC's Division* of Plant Pathology, the California Nurserymen's Association, and the Wine Institute. (*These divisions later became the departments which exist today at UC Davis.)

Olmo's article was followed just one month later by a companion article by William Hewitt [19]. In "Virus and Virus-Like Grape Diseases", growers were alerted to the serious disease problems that were occurring in California vineyards. Hewitt outlined the major grape vine virus diseases known or suspected at that time: "White Emperor disease" (leafroll), yellow mosaic (fan-leaf), fanleaf, leafroll and rough bark (later called corky bark). Hewitt also mentioned Pierce's disease in the article, which at the time he believed to have been caused by a virus, but limited his discussion of same because it was spread in nature by sharpshooters. It was clear that his article was written to support the proposed program and give a pressing scientific basis for its creation. In concluding his article, Hewitt remarked "... the job is to produce certified healthy vines as a source of cuttings for the grower. This calls for a definite program on an industry-wide basis. Such programs have been proposed to the industry, and I am happy to note that efforts to implement controlled methods of introducing only healthy vines and cuttings in California vineyards have already been started."

Industry response was summed up in another article which appeared in the same August, 1951, *Wines & Vines* issue in which Hewitt's had appeared. "Because of the increased threat to California vineyards from virus and virus-like diseases, proposals by Dr. H. P. Olmo and Dr. William B. Hewitt to control the introduction of new cuttings (both imported and California-bred varieties) into California vineyards are receiving serious consideration by that state's vintners" [5].

From the 1950s on, Goheen, Hewitt, and Olmo worked together with industry to create the state's grapevine clean stock program and offer sound guidelines for its future. Over the years, Hewitt conducted basic research on the grapevine viruses while holding the importation permit, Goheen and his staff performed the disease testing and therapy for the FPMS program, and Olmo was the plant explorer, sending innumerable new clones, varieties, and species home to Davis. This cooperation of plant pathologists and viticulturists working with industry characterizes the FPMS grape program to this day.

California Grape Certification Association Formed

In July 1952, the California Grape Certification Association (CGCA) was formed to develop, maintain and distribute virus-free grape stock that was true to the variety name. This was a corporation developed as a cooperative effort of the industry and the University. By 1953, CGCA had begun adding selections to the

existing UC Davis grape collections and started an indexing program. Olmo's former genetics student Curtis J. Alley (no relation to the senior author) was hired as manager of the newly developed grape certification and registration program [29].

In 1956, the California Department of Agriculture, later to become the California Department of Food and Agriculture (CDFA), issued "Regulations for Registration of Grapevines Inspected and Tested for Virus Diseases", thereby creating the California Grapevine Registration and Certification (CGR&C) Program which would be administered by the California Grape Certification Association, effective September 1956. From this time forward, CDFA would provide the regulatory oversight and direction for the grape Registration and Certification Program. The CGR&C program is administered by CDFA Nursery Services. It is a voluntary regulatory program that targets the elimination of specific grapevine virus diseases such as leafroll, fanleaf, corky bark, stem pitting and fleck that are spread from vine to vine by grafting and/or vegetative propagation. FPMS provides the Foundation stock from its grape collection to grapevine nursery participants. These nurseries participate in the CGR&C program under CDFA inspections and standards, providing their grower customers with assurance that their vines meet program standards. This cooperation between CDFA, the University, and industry continues to this day.

Foundation Plant Materials Service Formed

On 1 July 1958, two programs, the California Grape Certification Association and the virus-free cherry stock program, were officially combined and given the title "Foundation Plant Materials Service" (FPMS). The University announced that FPMS was established in July 1958 to maintain virus-tested stock of cherry and grape in a foundation block and distribute this stock as part of the state "Grapevine and Tree Certification Program" [2]. Industry voice *Wines & Vines* announced that the "University of California creates Foundation Plant Materials Service to maintain virus-tested propagative sources of new materials from breeding programs and selections from foreign and domestic sources for distribution to the public." In the years to come, other crops were added to the responsibilities of the unit. By 1995, FPMS crops came to include grapes, many fruit and nut trees (including cherry, peach, plum, pistachio, and almond), strawberries, sweet potatoes, and roses. Throughout all these years, the grape program has remained the largest and the most complex of the FPMS commodity programs.

In 1959, certified grape stock became available to those growers who had actively participated in the CDFA Grape Registration and Certification Program. According to FPMS manager Alley, the new clean stock had "passed a test procedure designed to determine infection with any one of three known viruses. The new organization operating the program is the Foundation Plant Materials Service. It maintains foundation stock

in isolation and distributes the materials first to growers and organizations participating in the Registration and Certification Program of CDFA" [2].

Pioneers in Virus Disease Detection and Elimination

Since its inception, scientists working with FPMS have pioneered techniques in grapevine virus disease detection and elimination. These are the two cornerstones of the grape clean stock program: the ability to determine if virus is present and the ability to eliminate virus from diseased stock. Techniques which were first applied or adapted to the field or at FPMS are now being used in grapevine clean stock programs around the world. FPMS staff members are often called upon to consult on problems related to clean stock programs and virus control around the globe.

During the first 30 years of the program's existence, all disease detection was essentially done either through frequent visual inspections on the part of staff and University advisors, or through tests with biological indicators, in greenhouses or by field-budding onto appropriate indicators. At the outset, the use of indicator varieties for field budding for the detection of virus disease in grapevines was virtually unknown, and during those thirty years, USDA plant pathologist Austin Goheen pioneered the use of these indicators, using trial-and-error to find the ideal indicator varieties for each type of virus known at the time [12]. Goheen and his technician, Carl Luhn, worked with then FPMS manager Curtis J. Alley, to monitor disease problems in all stock submitted to FPMS for testing services. Luhn started working with Goheen in 1960 and today in 2000, years after his retirement from USDA still works part-time at FPMS grafting grapevines and propagating roses. Austin Goheen once commented that Carl Luhn could graft two pencils together and they would grow [Andrew Walker, personal communication]!

Field and greenhouse indexing was used almost exclusively as the method of disease detection at FPMS until 1988, when Adib Rowhani, a University plant pathologist, was assigned to assist with developing new disease detection and elimination methodologies at FPMS. Rowhani brought the use of ELISA (enzyme linked immunosorbent assay) testing, a serological test that can be used to detect specific diseases and viruses, to the FPMS clean stock programs as a more rapid, cost-effective procedure than field indexing. With the old indicator techniques, two years were required for testing but an ELISA test could be performed in a matter of days. With the use of these tests, frequent retesting of the collections became practical, allowing important improvements in quality control for disease detection [30]. Most recently, Rowhani implemented powerful PCR (polymerase chain reaction) testing as a more sensitive alternative to ELISA testing based on DNA technology, which can be used to detect the presence of virus organisms even during seasons of low titer. [See Giovanni Martelli's article, these proceed-

ings, for a review of grapevine virus detection techniques over the last 50 years.]

Heat therapy to eliminate virus disease in plants was being successfully used during the 1950s on an experimental basis with stone fruits, potatoes, strawberries, and other crops [26]. Hewitt and Goheen felt it would offer promise in the elimination of grapevine virus diseases and in 1959 began experimenting with the technique using a hot air treatment of plants in a closed growth chamber in 1959 [9,15,]. Unfortunately, the only climate control chambers available to them between 1959 and 1969 had been designed to meet the specific requirements of plants other than grapevines and although they offered opportunities for experimentation, were not of great use in grapevine disease therapy. Only in 1969, when a chamber with capacity adequate to meet the needs of the grapevines became available to Goheen, did he really begin to make headway in pioneering the use of heat therapy to eliminate grapevine virus disease. In brief, Goheen experimented with taking cuttings to the very edge of their heat tolerance, exposing the cuttings to high temperatures for extended periods of time to retard or kill viruses without also killing the plants. When new, ostensibly virus-free, buds began to appear on the cuttings, they would be removed and utilized to propagate new, clean stock. Goheen ultimately settled on an optimum treatment temperature of 100° Fahrenheit for a period of approximately 60 days. [Carl Luhn, personal communication].

The micro shoot-tip culture is more recently became the method of choice at FPMS for eliminating virus. The process involves cutting a shoot tip that is half a millimeter in size, including the meristem and a few leaf primordia, putting it in a sterile culture, and then regenerating a new grape plant in a climatically controlled growth chamber from that small tip [23]. Susan Nelson-Kluk, FPMS manager from 1981 to 1994, first began experimenting with this technique for grapes at FPMS in 1988 with support from an industry grant [24]. Further work at FPMS over the 1990s has resulted in improvements in survival and the rate of virus elimination to the extent that this process is now routine and reliable.

There have been ongoing discussions about the relative merits of heat treatment therapy *vs.* tissue culture therapy for the elimination of virus from infected grapevines. A commonly held belief is that heat treatment produces high yielding clones that are excessively vigorous. Little scientific evidence exists for this theory. At the time that the “heat treatment clones” were obtained for inclusion in the FPMS collection, high yield, cluster size, and vigor were important characteristics which were consciously sought [See M.A. Walker, this proceedings]. For example, Zinfandel Selection 1A in the FPMS collection never received heat treatment, but it is as reported to be vigorous and productive as is the heat treated selection Zinfandel Selection 6 [32].

When Goheen performed heat treatment, he normally maintained the original selection preheat treatment as well as sequentially numbered selections which represented varying treatment durations. In the FPMS collection, there are multiple selections with varying heat treatment time but which have been produced from the same original source vine. These selections can be expected to be genetically identical in most cases and are not likely to be the source of significant clonal diversity [7]. However, because there is some statistical possibility of change and/or different disease profile, individual sources propagated from the same original accession with varying heat treatment history (number of days) are maintained under separate selection numbers at FPMS. In more recent years, the same cautious approach has resulted in each tissue culture explant from the meristem shoot tip therapy program receiving a unique selection number when it is made available.

Grapevine Importation at Davis

Austin Goheen pointed out that “During the early development of perennial crop plants, the spread of diseases and pests was not considered to result from germplasm movement. Taking grapes as a model, we note that germplasm was moved in an indiscriminate fashion from its center of origin or its center of collection to new areas of the world without regard to diseases or pests that might be present in the materials. This often resulted in disasters, such as the introduction of grape phylloxera from North America to France and the later introduction of grapevine fanleaf virus from Europe to the United States. Originally phylloxera occurred only in North America and fanleaf virus only in the eastern Mediterranean area. Grape germplasm growing within its center of origin tolerated the presence of indigenous diseases and pests” [10].

In order to help protect domestic plant materials from contamination by foreign disease and pests, the USDA Plant Quarantine Law was enacted on 17 September 1912. It restricted the importation of foreign plant materials, and required a permit for anyone wishing to import them.

During the ensuing years, import permits could be obtained fairly easily by anyone with legitimate reasons for wishing to import plant materials.

In 1948, the Foreign Quarantine Notices encoded as Part 319.37 of the USDA Plant Quarantine regulations “ended uncontrolled importation of clonal plant materials” and prohibited “importation or entry into the United States of any *Vitis* spp., excepting under special conditions or with a Departmental Permit issued by USDA”. “Quarantine 37”, as it came to be known, not only specifically mentioned *Vitis* spp, but also mandated a post-entry quarantine period, conducted under the direction of a permit-holding plant pathologist, for grapevines.

Under these quarantine regulations, prohibited materials including grapes could enter the United States for experimental or scientific purposes, but they

could not be released until they were tested for viruses. In 1950, tests for grape viruses had not been developed and, as a result, the USDA-Animal and Plant Health Inspection Service (APHIS) quarantine greenhouses in Glenn Dale, Maryland, were filled to overflowing with rooted grape cuttings [11]. During those years, many precious vines died while at the USDA facility due to the inadequate funds and staff available for this critical work [28]. Further, grapes are not easy to maintain in greenhouses and the Eastern climate was not favorable for growing *Vinifera*. These difficulties meant that a virtual embargo existed on the introduction of new grape selections.

As a result, both Olmo and Hewitt had a strong interest in establishing a post-entry grapevine quarantine facility on the Davis campus. Olmo's master plan called for "an isolation greenhouse near or on the Davis campus. All foreign and out-of-state introductions would be sent directly here for propagation and indexing for viruses" [28].

Eventually, a USDA "Departmental" import permit (one of the classifications of permits which can be issued by USDA) was issued to Hewitt, as the supervising plant pathologist in charge of disease testing. The University's first grapevine quarantine greenhouse, built by Hewitt to USDA specifications, was established on the Davis campus in the early 1950s. Unfortunately, the primitive metal screen was so fine-meshed as to be opaque, and many of the valuable import vines perished in the first Davis quarantine greenhouse. Needless to say, technology in implementing post-entry quarantine procedures would have to evolve over the years following "Quarantine 37" on the Davis campus [Harold Olmo, personal communication].

When Hewitt left Davis and moved to the University's Kearney Agricultural Center at Reedley, California, in 1969 to serve as the Station Superintendent, the USDA-APHIS permit was transferred to Austin Goheen, who continued to oversee FPMS indexing procedures until his retirement in 1986.

In June, 1988, due to the loss of equipment and facilities that came with Goheen's retirement, FPMS stopped making commitments to import additional grape materials. From 1988 to 1993, no importation occurred at FPMS, which was forced to refer its potential clients to the two remaining North American quarantine facilities at Geneva, New York, and Saanichton, British Columbia. As a result of the quarantine hiatus in California, illegal clonal importation activity hit an all-time high; much-needed screening and indexing processes were often bypassed in favor of quick, potentially dangerous illegal entry. Vine importation and quarantine was only resumed in 1993 when a new FPMS facility with appropriate equipment was constructed (See New Facilities section of this paper).

The Search for Clones

When the California Certified Grape Association was initially set up in 1952, its founders might have expected to fulfill its mission of cleaning up California's

vineyards within 25 years. What they hadn't anticipated was the renewed enthusiasm for importing top-quality materials from regions of the world in which they were traditionally grown, an interest in emerging varieties, and, especially, the interest in European clonal selections which would blossom in the late 1970s and early 1980s among California's vintners and growers.

In 1951, Olmo had prophetically emphasized that "the better selections... must again be re-imported from areas where these varieties have given the most outstanding results in Europe" [28]. Both Olmo and his protegee Curtis Alley believed that it was possible to improve grape varieties by clonal selection. Over the years, they collected clones of important grape selections and conducted studies of their performance [2]. Many of the clonal selections they developed enriched the FPMS collection and are industry standards today, such as FPMS Chardonnay Selection 4 and Cabernet Sauvignon Selection 8.

Although research was underway at UC Davis to study the importance of clonal variation, in the first decades of the grape clean stock program, FPMS clones were requested by growers by variety name, not clone or selection number. Although selection numbers were recorded when cuttings were sold, few nurseries or growers maintained records beyond the varietal level [Amand Kasimatis, personal communication]. It was not until the 1980s that an appreciation of the importance of clones (and/or selections) began to be reflected in the orders and requests which reached FPMS (Mike Cunningham, personal communication).

Goheen himself did not believe clonal variation was an important quality factor within varieties [A. C. Goheen, personal communication]. He firmly believed that most (or all) clonal variation was the result of virus infection. As a result, during the 1970s and 1980s when he guided the FPMS grape program, acquisition and propagation decisions were not made to increase clonal diversity. In fact, when the selections were initially propagated in 1984 for a new Foundation collection in Brooks South Vineyard, Goheen instructed the FPMS staff to plant only one clone of each variety - the one with the most heat-treatment days and, therefore, the highest chance of being free of virus. Later, as the importance of clonal diversity became more generally appreciated and particular FPMS selections recognized, more materials were moved into Brooks [M. Cunningham, personal communication].

During the 1980s, the success of European clonal research programs began to attract the interest of both researchers and industry in California. FPMS began to get requests for specific clones of the major international varieties.

Vineyard consultant Phil Freese, formerly Vice President of Winegrowing at Robert Mondavi Winery, remembers clearly when the importance of clonal variations dawned upon him.

"My personal interest in clonal variations stemmed

from a trip to France with André Tchelistcheff in 1977. Tchelistcheff and I had visited Raymond Bernard in his experimental vineyard of 125 different Pinot noir clones in Dijon. My statement to Bernard was ‘Gee, I’ve learned that there are no difference in clones’, because that was what I believed at the time. Bernard then proceeded to talk with me about clones and show me some of their differences....a sort of ‘we don’t really know, but here are some ideas about clonal differences’-type approach. This was a great ‘aha’ for me, and I began to think about the issue of clonal variation.” [P. Freese, personal communication].

As a result of his interest in improving the availability of clonal selections and other new grape varieties for US industry, Freese went on to become actively involved in the FPMS grape program, serving as Chair of the Industry Grape Advisory Committee from 1985 until 1993, and spearheading fund raising efforts for the Grapevine Importation and Clean Stock Facility (see New Facilities section in this article).

In 1984, Oregon vintner David Adelsheim addressed an FPMS meeting regarding clonal work with Pinot noir in Oregon and France. His address stimulated much industry interest in new clonal importation, not only of Pinot noir, but of other varieties as well.

Although Goheen was not a believer in the importance of clonal variation, he was willing to facilitate the treatment and testing of private domestic and foreign clones submitted by researchers and private industry members. He responded to their interest in European clones by increasing importation in the mid- to late 1980s, facilitating the importation of many important clones obtained by industry contacts in Europe which came to FPMS in the late 1980s. In addition, a large number of wine grape clones in quarantine at Oregon State University (OSU) (imported during the years OSU plant pathologist Ron Cameron had an import permit) were transferred to FPMS under Goheen’s import permit.

New Facilities in Modern Times

When FPMS came to a serious impasse in its ability to provide access to the new clones and varieties industry needed in the wake of Austin Goheen’s retirement in 1986, there was a serious void left in the Davis grape programs. For a year or two, Goheen retained his USDA-APHIS grapevine importation permit and donated time to supervise a scaled-down quarantine program at FPMS to index, maintain and distribute existing selections, but it soon became clear to industry that someone was needed to replace Goheen; new, adequate, and expanded facilities were also needed to get the job done properly.

In the wake of Goheen’s retirement, USDA-ARS (Agricultural Research Service) plant pathologist Deborah Golino (second author of this article) was transferred in 1987 from Riverside to UC Davis to fill

the grape virology post. Golino’s primary charge was to conduct research, as many of the service-oriented activities Goheen had performed were outside the realm of current USDA-ARS responsibilities. Therefore, even with the replacement of the “Goheen position”, there was still an urgent need for dedicated importation services [16].

Industry, the University, and the USDA proposed that quarantine service work could best be provided by FPMS with an internally held importation permit. With the instigation and insistence of industry representatives, a proposal for the desired new facility was completed in 1990, to be jointly funded by USDA, the University, and private industry. The new facility was constructed in phases over the ensuing four years. In 1990, a quarantine screen house and clean stock greenhouse: in 1991, a primary quarantine greenhouse, indexing greenhouse, soil storage area and head house; in 1992, a lab/office and second screen house; and in 1993, a second indexing greenhouse, landscape irrigation, and all fixed equipment [25]. All importation and quarantine work at this facility would be self-supporting, paid for by fees charged to FPMS clients contracting for these services.

The official groundbreaking ceremony for the new facility was held on 1 June 1992 and the facility was occupied in September 1994. An open house and dedication of the new facility was held on 21 April 1995.

The Role of FPMS Within University of California, Davis

Foundation Plant Materials Service began its life in 1951 as the California Grapevine Certification Association (CGCA). In 1953, when Alley was hired as the first manager, the funding came from Viticulture and Enology (VEN) Department funds, and his assignment was divided 50/50 between his duties at the California Grapevine Certification Association and those in the VEN Department. He was responsible for the day-to-day operation of the CGCA, and was advised by a committee of experts. When the grape program finally began to offer certified stock for sale in 1958, some of the financial burden on the University was relieved by revenue from the sale of plant materials. Alley remained with FPMS until 1970, when he resigned as its manager to take a full-time position as an Extension Specialist with the Department of Viticulture and Enology. Leon Corey replaced Alley and remained manager of FPMS until 1980. He had been trained on the job as a plant pathologist while working as Hewitt’s research assistant.

In 1976, FPMS was merged with Foundation Seed Service, to form one larger administrative unit known as Foundation Seed and Plant Materials Service or FSPMS. Functionally, both units continued with business as usual although the direct authority for FPMS now rested in the Agronomy Department which had oversight authority for FSPMS. Until this time, despite the inclusion of the cherry program in 1958 when FPMS was first named, the unit had been part of VEN.

Also in 1976, Susan Nelson-Kluk, a Davis-trained plant scientist was hired in anticipation of Corey's retirement to train as his replacement. She spent two years in Professor George Nyland's lab in the Plant Pathology department, working with Austin Goheen and Nyland, and learning about clean stock programs and disease testing procedures. George Nyland was responsible for the creation of several of FPMS's other commodity programs: fruit trees, roses and sweet potatoes. In 1981, Corey retired and Nelson-Kluk assumed the role of manager. Nelson-Kluk, working closely with industry representatives, was instrumental in obtaining funding for FPMS' new facility. She also took a dedicated interest in promoting the search for new clonal materials for the program, obtaining industry funding for the importation of new materials after Goheen retired and his resources were no longer available.

It was clear during the late 1980s and early 1990s that FPMS was going through a period of growth and transition. Many of the faculty that had contributed to the creation of FPMS programs were retiring. New faculty had different assignments and heavy work loads which made it more difficult to donate their time to FPMS programs. However, the importance of the clean stock programs managed by FPMS was growing, new programs were being added to FPMS responsibilities (like the high profile UC strawberry clean stock program which began transfer from UC Berkeley to FPMS in 1986), and the technical complexity of the programs was increasing rapidly. Disease detection, virus elimination and varietal identification were changing rapidly. In addition, the seed and plant programs of FSPMS were more difficult to administer as one unit as both programs grew.

A task force which included representatives of the University, state and federal agencies and industry was established in the early 1990s by the Dean of the College of Agricultural and Environmental Sciences to review FSPMS. This task force was chaired by Calvin Qualset, then acting Director of FSPMS; Phil Freese, chair of the FPMS grape industry advisory committee; and Robert Woolley, chair of the FPMS tree industry advisory committee. Specific recommendations included increased commitment of the University's financial support in order to create a more stable base for a business dealing in commodities which may fluctuate from year to year; formation of joint industry and technical advisory committees; the formation of a business advisory committee to advise directors in preparing financial plans and marketing strategies; the separation of the Foundation Seed Project and Foundation Plant Materials Service; supplying adequate lab and greenhouse facilities to FPMS; strengthening UC Departmental associations with FPMS; and an acceleration of communications and public relations activities. The task force also recommended elevating both the plant and seed groups to full-fledge departments within the College of Agricultural and Environmental Sciences, each to be managed by a faculty level director [8].

As a result of this review and the subsequent search for directors for the two units, in September 1994, Deborah Golino was hired for the new position of FPMS director. She now manages the crop programs at FPMS, holding the USDA permit for grapevine importation and quarantine. Perhaps it is fitting that the scientist first brought to Davis by USDA to replace Austin Goheen did eventually come to work on the grapevine importation and clean stock programs to which he had dedicated his career.

FPMS Today

FPMS is a self-supporting service department in the College of Agricultural and Environmental Sciences at the University of California, Davis with a mission of producing, testing, maintaining and distributing disease-tested propagating material for use by California nurseries. At this time, FPMS is responsible for programs for grapes, strawberries, fruit trees, nut trees, roses, and sweet potatoes. Propagating material can be purchased by anyone, but the programs are primarily geared toward the sale of small quantities of commercially-important propagating stock to nurseries and others who increase the stock for sale to commercial growers. FPMS is also the home of the only dedicated grape importation facility in the United States, built by the cooperative efforts of the University, USDA, and the wine and grape industry.

New technology is a major factor that continually reshapes the FPMS grape program, the California Grapevine Registration and Certification Program, and the grape nursery industry around the world. Refinements and improvements in technology are expected to occur with even greater frequency in years to come due to the tremendous power of developing molecular biology applications.

As this history documents, the FPMS grape program has never been static. However, an ever increasing pace seems necessary today to keep up with the fast moving scientific community and global economy (See Golino's "Trade in Grapevine Plant Materials", this proceedings). The program must be state-of-the-art in order to serve the large sophisticated US grape industry. Therefore, efforts are always underway to improve the grape program by the addition of new plant materials, new technology, better procedures and new innovative services.

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