

PREFACE

CITRUS CROPS IN CALIFORNIA mean primarily navel and valencia oranges, lemons, grapefruit, and tangerines, tangelos, and tangors. By the most recent figures available (1998–1999) at the time of this writing, the California Agricultural Statistics Service reports the following total values for these crops: navel oranges \$227 million; valencia oranges \$188 million; lemons \$214 million; grapefruit \$81 million; and tangerines et al. \$23 million. Altogether that's about a three-quarter-billion-dollar citrus industry, placing citrus in the top ten of California crops. Three of these—oranges, lemons, and grapefruit—are individually also among the top 30 California export crops. To sustain this productivity and competitiveness in the US by creating new varieties, maintaining the diversity of citrus crops, ensuring healthy trees in the field, and desirable fruit in the marketplace, it is imperative that breeders, researchers, and the industry have access to reliable collections of citrus genetic resources. As this report shows, this has been possible by virtue of an unofficial state 'system' for conserving and utilizing citrus genetic resources. This system is comprised of University of California, state, and federal organizations and their interrelationships are documented herein.

The reliance on *ex situ* collections of genetic diversity for crop improvement is typical for most California crops. Of the 350 agricultural commodities produced in California, less than 10 percent are either species indigenous to California or related to California indigenous species. The vast majority are introduced from outside California and usually from outside the US as well. This puts a premium on the existing *ex situ* collections maintained in California. Generating a collection from the areas of a given crop's genetic diversity is increasingly difficult, if not impossible, for most crops.

As effective as it has been, the current situation for citrus is a decentralized system that has been driven by need and opportunity, not by careful planning involving all components. While this report has focused primarily on the University of California component—the Citrus

Variety Collection (CVC) at the UC Riverside campus, the task force undertaking this analysis was comprised of representatives from all components. The role of citrus in California's economy and the history of citrus in southern California were driving forces for the establishment of the University of California Citrus Experiment Station in 1906, and ultimately the UC Riverside campus, now a major university in its own right. However, there were concerns that the current and long-term financial and facility status of the CVC was not adequate to allow it to continue as the primary collection of citrus genetic resources for California. No organization is in the position to single-handedly resolve this situation. The UC Genetic Resources Conservation Program, with its mission of facilitating genetic resources collections for species important to California, and the UC Riverside College of Natural and Agricultural Sciences together convened this task force as a first step in addressing this concern for the CVC. The major objective of this task force was to obtain a clear statement of the value of the collection, the role it plays, and the resources necessary to sustain and enhance it. With the findings of this report as motivation and its recommendations as a strategy, we hope the targeted organizations will find it imperative to contribute to the solution of this crisis in support of citrus genetic resources for the good of California citrus production and citrus research in general.

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CHARGE TO THE TASK FORCE

EVALUATE THE CURRENT STATUS of the Citrus Variety Collection (CVC) at the University of California, Riverside campus with regard to its contents, utilization, and value and its interrelationships with other California, federal, and international citrus genetic resources and research organizations and activities. Prepare a report

documenting these findings and include recommendations for organizational, fiscal, and administrative steps necessary to ensure the long-term security of the CVC as a dynamic genetic resources conservation facility serving the California citrus industry and University of California research, teaching, and extension objectives.

ABBREVIATIONS AND ACRONYMS USED IN THIS REPORT

APHIS	Animal and Plant Health Inspection Service of the US Dept. of Agriculture	IOCV	International Organization of Citrus Virologists
ARS	Agricultural Research Service of the US Dept. of Agriculture	IPGRI	International Plant Genetic Resources Institute
CCPP	Citrus Clonal Protection Program	LREC	UC Lindcove Research and Extension Center
CDFA	California Department of Food and Agriculture	NCGRCD	National Clonal Germplasm Repository for Citrus and Dates
CEB	Citrus Evaluation Block	NPGS	National Plant Germplasm System
CNAS	College of Natural and Agricultural Sciences, University of California, Riverside	PI	Plant Introduction, USDA NPGS
CRB	Citrus Research Board	RAPD	random amplified polymorphic DNA
CRC-AES	Citrus Research Center and Agricultural Experiment Station	RFLP	restriction fragment length polymorphism
CSIRO	Commonwealth Scientific and Industrial Research Organization	SCREC	UC South Coast Research and Extensions Center
CTV	citrus tristeza virus	TAMUK	Texas A&M University, Kingsville
CVARS	UCR Coachella Valley Agricultural Research Station	UC	University of California
CVC	Citrus Variety Collection	UCR	University of California, Riverside
CVIP	Citrus Variety Improvement Program	USDA	United States Department of Agriculture
ELISA	enzyme-linked immuno-sorbant assay	USHRL	United States Horticultural Research Laboratory, USDA
FAO	Food and Agriculture Organization of the United Nations	VI	Variety Introduction
GCGN	Global Citrus Germplasm Network	WFFVC	A.H. Whitmore Foundation Farm Variety Collection
GRIN	Genetic Resources Information Network, a unit of the National Genetic Resources Program		

EXECUTIVE SUMMARY

FINDINGS

The California citrus genetic resources conservation and utilization system

CITRUS CROPS (especially oranges, lemons, and grapefruit) are a significant component of California's agricultural production. To maintain or increase their value, commercial citrus varieties must be available to meet the needs of the diverse citrus producing regions in California and consumer preferences. Ensuring continued variety development, healthy trees in the field, and desirable fruit in the marketplace means continued research, breeding, and product development. All of this requires reliable availability in California of citrus genetic resources.

California maintains one of the largest and most diverse assemblages of citrus genetic resources in the world with a functional conservation and utilization system comprising three primary units: the Citrus Variety Collection (CVC) and the Citrus Clonal Protection Program (CCPP) at the University of California, Riverside and the USDA National Clonal Germplasm Repository for Citrus and Dates (NCGRCD). Closely collaborating with these three units are the UC Riverside Citrus Breeding Program and the California Citrus Research Board.

This California citrus genetic resources system is unique among organized collections throughout the world and serves as a model for conservation, utilization, and teaching. The system maintains a broad cross-section of genetic diversity along with complementary programs that provide virus-free budwood for commercial use, programs for distributing genetic resources for research uses, and research programs for crop improvement, physiology, biochemistry, phylogeny, genetics, and molecular biology. Executive summary figure 1 illustrates the flow of genetic resources into and out of the system and among these units, the Citrus Evaluation Blocks (CEBs), and the UC Riverside Citrus Breeding Program.

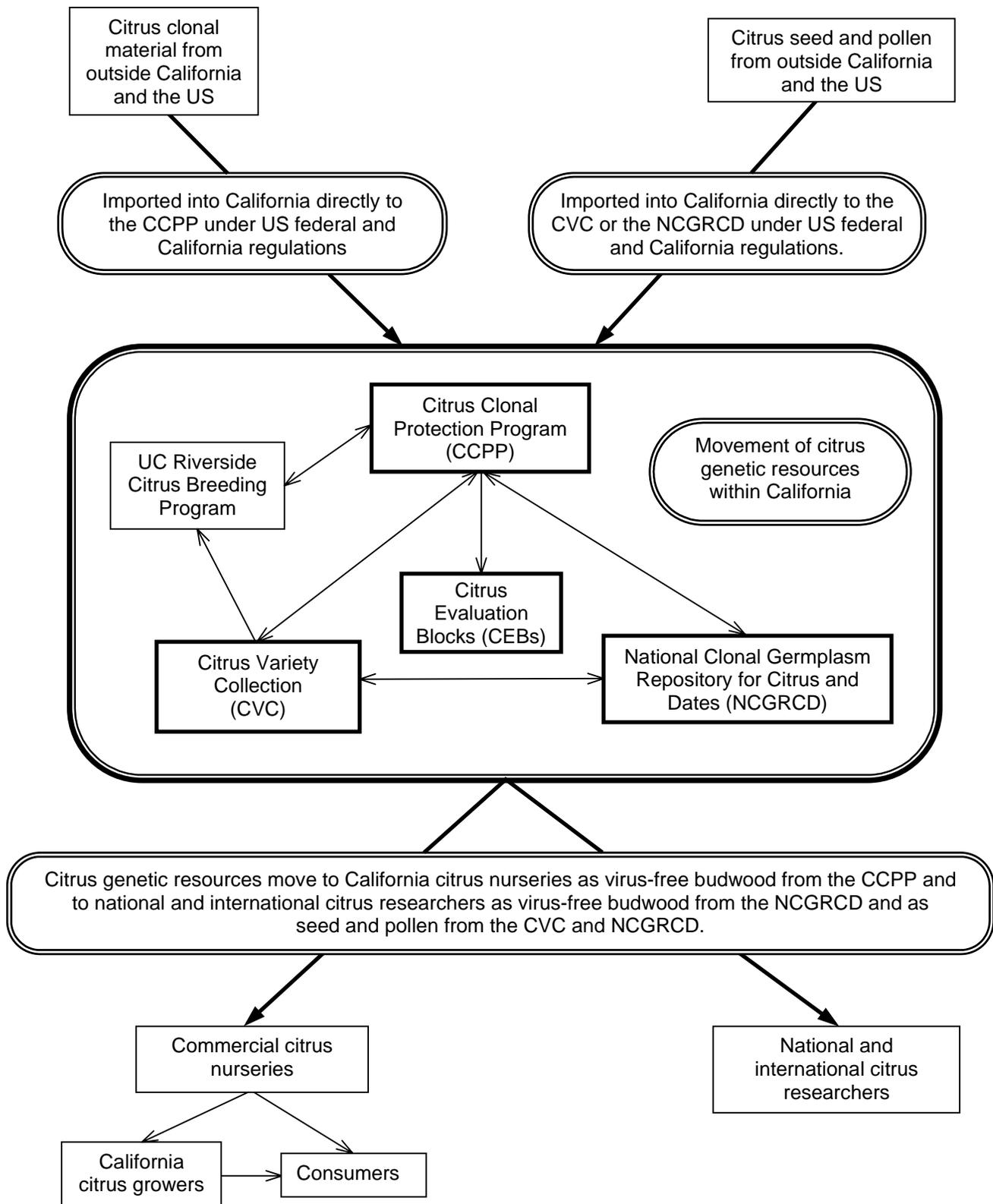
Because of the integration of the CVC with the CCPP and NCGRCD, there are no major impediments to importation of citrus genetic resources into California.

Citrus genetic resources are not native to California, meaning that *ex situ* conservation in California of acquired accessions is the only way to ensure their availability for continued use. In addition, access to citrus genetic resources from native habitats is increasingly undependable, putting a premium on conservation of what has already been collected.

Expanded use of molecular techniques such as marker-assisted selection and transformation in breeding programs will increase the value of genetic resources for crop improvement and allow the use of more distantly related species as gene sources for cultivated species. This means that increasingly the concept of genetic resources will expand to include cDNA and genomic DNA libraries, and the probes, clones, and sequences derived from them.

The Citrus Variety Collection

- ◆ The CVC, with 865 accessions, is the key component of the California system for maintaining citrus genetic resources.
- ◆ The CVC is the oldest component, initiated in 1910 with a focus on establishing a broad representation of accessions from all citrus-growing regions of the world.
- ◆ The collection presents a long-standing investment of human resource efforts and considerable investment of public funds through the University of California, State of California, US Dept. of Agriculture as well as funds and donations of plant materials from private and commercial resources. Clearly, this genetic resources collection could not be developed if it were to be initiated today.



Executive summary figure 1. Movement of citrus genetic resources into, within, and out of the California system for conservation and utilization of citrus genetic resources.

- ◆ The security of CVC accessions and the extent of its activities to enhance the scope and value of the accessions are impaired by the piece-meal, transient, and undependable nature of its current funding. Only partial support for the curator position is secure on a reasonably long-term basis.
- ◆ The full range of tasks necessary for curating and administering the CVC require at a minimum a full-time curator, a full-time technical assistant, and seasonal part-time employees. These tasks cannot be met with the current levels of support without impairing the integrity of the collection for current and future uses.
- ◆ Increasing requests for educational outreach programs from the CVC is a sign of public interest in genetic resources, especially citrus. Meeting these requests limits the time that can be devoted to critical aspects of maintenance and evaluation of the accessions in the CVC. There is no funding dedicated to these activities.
- ◆ Immediate facility and equipment needs appear to be met through availability of space through the UCR Dept. of Botany and Plant Sciences and loans of some specialized equipment. However, there is no long-term commitment to these space arrangements and no plans to accommodate CVC growth.
- ◆ Normal care of a citrus genetic resources collection is considerably more complex and expensive than the maintenance of plants in a commercial grove. CVC currently receives horticultural management services from the UC Riverside Agricultural Operations department. However, the trend is for reduction of services that can be provided and this impacts the long-term security of the CVC. It may be necessary for the CVC budget to accommodate these management costs.
- ◆ Few granting agencies will fund baseline genetic resources conservation activities. Some successful proposals by the curator have furnished indirect support for the CVC. However, short-term (annual) grants cannot be a successful long-term strategy for conservation activities.
- ◆ The value of the CVC to the US National Plant Germplasm System, operated by the US Dept. of Agriculture, is reflected by several points: (1) seed and pollen requests to the NCGRCD are filled from material maintained by the CVC, (2) the CVC provides field evaluation opportunities and vegetative material for the NCGRCD, and (3) about 70% of the citrus accessions listed publicly as available in the NPGS are available only at the CVC. Some temporary USDA financial support to the operations of the CVC has been provided in the past two years through a short-term cooperative agreement.
- ◆ Integrated pest management techniques are not optimally employed in the management of CVC plantings.
- ◆ The current rootstock status of the CVC collection appears to be adequate with respect to resistance to known disease threats.
- ◆ Information on the accessions of the CVC has been maintained on a computer database since 1996, replacing a handwritten index card system initiated at the inception of the CVC.
- ◆ Electronic access to some information about the CVC is at the CVC website (<http://cnas.ucr.edu/~citrus/index.htm>). In addition, some information about the CVC collection is available from the USDA GRIN database (<http://www.ars-grin.gov/>).
- ◆ Greenhouse facilities are inadequate for the CVC to carry out propagation and maintenance of accessions.

RECOMMENDATIONS

The California citrus genetic resources conservation and utilization system

1. No changes in the management structure of the CVC, the CCPP, or the NCGRCD are advocated. The continued close collaboration among the three units is essential to the functioning of a citrus genetic resources conservation and utilization system for California.
2. The establishment of a **California Citrus Genetic Resources Advisory Committee (CACGRAC)** is recommended. This committee, composed of research and extension workers, agency and University administrators, growers, processors, marketers, consumers, and others, will provide guidance to the staffs of the units that comprise the California citrus genetic resources conservation and utilization system to assure the acquisition of critical genetic resources and their long-term conservation and efficient distribution.
3. The dependence of the NCGRCD on the CVC for seed and field evaluation facilities should be officially recognized by the parent organization of each unit and enhanced by a long-term commitment of support for the CVC by the USDA NPGS.
4. Citrus genetic resource management for California should expand to include resources such as DNA librar-

ies, probes, and clones. The appropriate unit and adequate funding for the effort should be topics for consideration by the proposed California Citrus Genetic Resources Advisory Committee. (Rec. 2 above).

The Citrus Variety Collection

Activities: Acquisition

5. There should be continued and enhanced linkages with other national and international citrus genetic resources collections.

6. Acquisition of new accessions, both from within and outside California and of wild or naturally occurring citrus relatives from their native habitats, is an important function for the CVC. Acquisitions should be guided by a plan developed with assistance of the recommended advisory committee. Every effort should be made to acquire accessions for the CVC that are not currently available in California, taking full advantage of the California system that allows importation of citrus genetic resources.

Activities: Documentation and database management

7. The CVC database should be enhanced to include digital representations of important accession characteristics such as photographs of flower, leaf, and fruit morphology, gels of biochemical and molecular genetic analyses, and disease susceptibility or resistance symptoms.

8. There should be continued exchange of information between the CVC and the USDA NPGS GRIN databases.

Activities: Maintenance

9. Full implementation of integrated pest management techniques should be deployed in the CVC plantings which, along with the full installation of the low-volume irrigation system, would not only increase the efficiency of tree cultivation in the CVC, but would also enhance the unit as a showcase for California citrus.

10. The CVC needs to monitor information about citrus pathogens and keep in contact with citrus specialists to anticipate disease threats to the collection.

Activities: Evaluation, characterization, and research

11. Users of the CVC should be encouraged to contribute to the maintenance of its collections.

Activities: Dissemination of information.

12. The CVC website is a potentially valuable distribution point for CVC collection characterization and evaluation data. It may need relocation from its current status on the UCR College of Natural and Agricultural Sciences server. The website should include contact information for the staff.

Personnel

13. Positions and staffing levels needed are a full-time curator, full-time technical assistant/assistant curator, part-time seasonal assistants, and a part-time database/website specialist.

Facilities and equipment

14. The CVC should have at least two up-to-date, networked computers and at least one laser-quality printer, devoted to such activities as accessioning, data analysis and exchange, equipment and budget monitoring, and preparation of outreach materials.

15. Facilities and equipment needs include research equipment, a vehicle, and a greenhouse/headhouse structure on or near the orchard site to facilitate propagation of new or replacement accessions and field evaluation activities, house equipment and tools, and offer a reception point for CVC visitors and tours.

Financial resources

16. The CVC needs an annual budget for operating expenses and outreach that reflects the full costs of these activities including maintenance on facilities and equipment and depreciation on equipment (Executive summary table 1).

17. The CVC needs funding for first-time and one-time expenses to bring its physical facilities to a level adequate to meet its needs as a California repository of citrus genetic resources (Executive summary table 1).

18. Funding to enhance and sustain the CVC's role in conservation and utilization of citrus genetic resources for California properly involves the US Government, the State of California, the University of California, and the citrus industry.

19. An endowment fund should be established with interest earned being dedicated to meet annual operations costs of the CVC. The fund should be organized under the auspices of the UC Riverside campus with contributions from the diverse enterprises comprising the California citrus industry and individual donors. A committee

composed of representatives of USDA NPGS, UC, CDFA, and CRB and individuals having strong interest in the preservation of citrus varieties and diversity should be convened to develop this fund.

Administration

20. The relationship of the management of the CEBs to management of the CVC should be formalized and the extent of the effort required by the CVC curator to manage the CEBs needs to be defined to ensure that these activities do not come at the expense of CVC activities.

Executive summary table 1. Costs of personnel, equipment, and facility requirements for the CVC.

Category	Initial and replacement cost (dollars)	Annual cost (dollars)
Personnel		
Curator (1.0 FTE)		65,000 ^{a,b}
Technical Assistant (1.0 FTE)		40,000 ^{a,b}
Database/website specialist (0.5 FTE)		21,000 ^{a,c}
Temporary assistance		10,000 ^{a,d}
Supplies		
Nursery and lab supplies		5,000
Acquisition, research, & evaluation		
		25,000 ^e
Equipment		
Vehicle: minivan	20,000	
Vertical illuminator and filter sets (Zeiss)	5,000	
Computers (2)	5,000	
Printer	600	
Electric cart	5,000	
Services received		
Annual tree maintenance ^f		24,000
Annual tree pruning		2,000
Annual fruit reduction		7,000
Annual vehicle maintenance		2,000
Facility		
Greenhouse (36'x60')/headhouse (20'x36')	200,000	
Utilities for field facilities		2,000
Subtotal	235,600	203,000
Contingency fund reserve		
12% of annual budget		24,360
Total	235,600	227,360

^aincludes benefits;

^bestimate, actual amount will depend on job title;

^cbased on Computer Resource Specialist II title, entry level;

^dWork-study and summer students;

^eReserved for supplies, travel, and staffing

^fPerformed currently by UCR Agricultural Operations, does not include pruning.

