Excerpt from "Genetic Resources Conservation Program Annual Report 1985-1986". 1986. P.E. McGuire and C.O. Qualset, eds. Report No. 1, University of California Genetic Resources Conservation Program, Davis CA. 30 p.

IMPORTANCE OF GENETIC RESOURCES

Genetic resources are sometimes called the "first resource" of the natural resources on this planet - the others being land, air, and water. Genes are the link from generation to generation of all living matter. Therefore, attention to genetic resources means attention to the vast diversity among and between species of animals, plants, and microorganisms. Within this diversity there is a hierarchy of organization and the term genetic resource has meaning at each level. At one level, genetic resources include all the individuals of a species, particularly if it is threatened with extinction. Genetic resources also include populations, gene pools, or races of a species which possess important attributes not found uniformly throughout the species. Breeding lines and research materials, such as mutant, genetic, or chromosomal stocks, are also genetic resources and are important in animal and plant breeding and in all phases of biologic research. Finally, genetic resources can refer to genes themselves, maintained in selected individuals or cloned and maintained in plasmids.

Genetic resources are the substance of agriculture and food production, major economic enterprises in California. For example, more than 250 crops are grown commercially in California, yet less than 1% of them are native to this state. California leads the nation in production of many of these crops. In 1985, 8.8 million of California's 100 million acres were devoted to crop production. Of these 250 crops, 61 are considered major, grown on a commercial scale. A summary of these with their individual acreages, production levels, and dollar values for 1985 are listed in Table 1. This high level of productivity has resulted from the development of new crops and new uses for old crops, the protection of annual productivity by means of pest-resistant varieties and pest-management schemes, and continuing research into the genetic systems that give rise to critical characteristics of crop species. These developments are totally dependent on the availability of genetic resources.

There is an analogous situation with regard to animals. Genetic improvement has profoundly increased productivity of livestock, dairy, and poultry operations. A summary of such productivity is also in Table 1. As with plants, agriculturally important animals are not native to California and continued productivity depends on genetic diversity acquired from outside the state. However, financial constraints for research have begun to limit researchers' abilities to maintain the large populations of animals that are necessary to maintain potentially useful genetic diversity. Research funding has typically not taken into account maintenance costs of genetic resource collections, yet research continuously needs and produces more genetic resources.

Beyond the easily recognized plants and animals used directly for human sustenance are lesser known useful genetic resources, such as yeast, microorganisms used in fermentation for bread, beer, and winemaking. Plants and animals in their natural habitats are valuable for their aesthetic values, their potential uses by humans, and for maintaining functioning ecosystems. California is one of the truly unique states of the United States for its range of habitats and wealth of endemic species. Special considerations for protecting the biologic and habitat diversity are needed.

Genetic resources must be maintained as an investment for the future. Past results from research with genetic resources in California have yielded very high returns on the public investments in research. Genetic resources have been capitalized by the public, including large and small farming operations, food and fiber processing organizations, banking and investment companies, many related industries, and ultimately, by consumers who have enjoyed the end products.

Table 1. Important agricultural commodities in California

Commodity category	Number in category	Quantity	Product value (million $)
Plants		(acres)	
Field crops	13	5,834,000	3,000
Vegetable crops	23	985,000	3,100
Fruits and Nuts	23	1,960,000	2,900
Nursery & Flowers	2		1,294
Animals		(units)	
Cattle and Calves		5,000,000	1,090
Hogs		145,000	22
Sheep and Lambs		1,065,000	52
Dairy cattle		1,030,000	2,076
Chickens - meat		174,000,000	282
Eggs		8,052,000,000	336
Turkeys		20,500,000	205
Insects			
Bees - pollination fees*			30
Bees - honey & wax			11

*It should be noted that a majority of the fruit and nut, vegetable, seed, and forage crops rely on honey bees for pollination.
(Data from California Dept. of Food and Agriculture. 1986. California Agriculture Statistical Review 1985.)

THREATENED GENETIC RESOURCES

There is no one means for attending to the various issues of genetic diversity and its conservation within the State of California. For native plants and animals, and some naturalized ones, there are numerous State and Federal agencies, private nonprofit organizations, and dedicated individuals who are involved with protection and preservation of individual species, their habitats, and whole ecosystems. Both public and private plant and animal breeding programs make use of national and international collections of genetic resources. Finally, researchers maintain collections of genetic stocks as they acquire or produce them.

As special collections of genetic resources increase in size and complexity while financial resources change or become scarce, a mechanism is needed to insure their accessibility and security. Rare and endangered plants and animals face extinction. Loss of habitat means loss of populations which reduces the genetic diversity of a species and can ultimately extinguish it. For the most part, the centers of wild genetic diversity of agricultural plants and animals important in California are outside our borders and usually outside the United States. Uncertain political

climates, poor ecological practices in these areas, and inaccessibility, all factors outside the State's control, can render these resources unavailable. These considerations make existing collections even more valuable. Vigorous programs for habitat protection and consolidation of certain genetic materials into preserved collections are essential. In the research arena, unstable funding and death or retirement of researchers can threaten existing genetic collections. There are several examples of loss of major collections of germplasm of crop plants, for example. Research funds cannot maintain collections produced by the funded research; with no alternative funding, such collections can be lost.

STRATEGIES FOR GENETIC RESOURCE CONSERVATION

There exist two main approaches to genetic resources conservation: offsite (*ex situ*) conservation, by which is meant the maintenance of the resources in a site or facility which is not their natural or native habitat, and onsite (*in situ*) conservation, by which is meant the preservation of the resources in their native habitats. Four strategy levels for conservation can be distinguished.

- Conservation of cloned genes, gametes, embryos, seeds, tissues, or whole organisms in a quiescent state.

- Conservation of plants, animals, or microorganisms in a confined or controlled environment, such as plantations, gardens, zoological parks, reserves, or on host organisms in the case of obligate parasites.

- Conservation of plants, animals, or microorganisms in their natural habitats where population size and structure are managed.

- Conservation of plants, animals, or microorganisms in their natural habitats without regard to population size or structure.

The successful conservation of any given genetic resource may involve combinations of two or more of these strategy levels, employing both onsite and offsite methods.

A variety of agencies are involved in onsite conservation (i.e., habitat protection) in California with the result that about half of California's 100 million acres can be considered to have some level of organized protection status. The federal government administers about 45.9 million acres; the state government administers about 2.5 million acres; and local governments administer about 1.7 million acres (California Statistical Abstract, 1986). Included in the state government holdings are about 85 thousand acres managed by the University of California Natural Reserve System. Private nonprofit organizations own or manage less than 100,000 acres for conservation purposes in a series of small holdings throughout the state. These levels of protection status include wilderness areas, multiple-use managed areas, parks and recreation areas, and research areas. Implicit in several of these designations is an intent to safeguard the natural resources that lie within the boundaries of the various areas. To the extent these areas protect the habitat of the native biota, they are protecting genetic resources primarily at the

species level. The identity, distribution, and density of California's flora and fauna are increasingly well documented, so that the attention of the management of these areas is especially focused on designated rare and endangered species. However, preservation of the genetic diversity within these species, i.e., genetic resources at the population or gene level, is not assured simply by protecting the individuals of a species that happen to fall within the boundaries of a designated area (unless the species is so rare that it consists only of those individuals). To assess the extent and distribution of genetic diversity within a species is a complicated task and obviously will never be achieved for most species. However, there are methods for sampling and measuring diversity that can indicate how well existing habitat protection will protect that diversity. Research using and improving such methods must be one facet of genetic resource conservation.

DEVELOPMENT OF AN ORGANIZED PROGRAM FOR CALIFORNIA

Given the importance of genetic resources to the State's natural environments and economy, it is in the State's interest to provide a means to assess the needs for genetic resource conservation, coordinate the various existing efforts, direct new efforts at preservation and collection, increase public awareness of conservation issues, and stimulate new research on topics of conservation biology. The UC Genetic Resources Conservation Program was developed to be such an entity. The origin of the program was motivated by a complex history of concerns, studies, and crises. Within the University, there has long been recognition of the need for a far-sighted approach to the conservation of genetic resources. Outside the University, State agencies and individuals have provided impetus to the development of an organized conservation effort. Below is a chronology of events leading to a program of genetic resource conservation in the University of California.

1977 A special issue (Volume 31, No. 9) of California Agriculture, the research progress report journal of the University of California Division of Agriculture and Natural Resources, was dedicated to discussions of the collection, screening, utilization, and conservation of specific plant genetic resources economically important to California.

1980-83 The State contracted with a private nonprofit organization, National Council on Genetic Resources (NCGR), to establish a California Gene Resources Program (CGRP). The NCGR was assisted by a large advisory committee with members from academia, the state legislature, state agencies, industry, a conservation organization, and the general public.

1981 The University of California made two proposals to the Agricultural Investment Program of the California Department of Food and Agriculture:

(1) The California Crop and Range Plant Germplasm Conservation Project was proposed by the Department of Agronomy and Range Science at Davis to establish a germplasm conservation center to focus on field crops and rangeland species of actual and possible importance to California for food and livestock production, soil and water conservation, and aesthetic or

recreational uses with a five-year budget of $1.9 million. This project included 23 faculty investigators.

(2) The Evaluation and Preservation of Animal Genetic Resources for Future Needs of California Agriculture Project was proposed by eleven animal scientists at Davis. Research was proposed to develop and preserve animal genetic resources, to identify criteria and methods of determining the value of different genetic materials with particular reference to adaptability, production efficiency, and resistance to pests and disease, and to assess the suitability of different genetic materials to alternative production systems for optimization of the use of resources available for animal agriculture. This project had a five-year budget of $4.1 million.

Neither of these proposals was funded, but the proposals identified the research and facility needs for protection of a large portion of California agriculture commodities.

1982 Establishment of the National Clonal Germplasm Repository for fruit, vine, and nut crops at Davis, operated by the University of California for the National Plant Germplasm System of the US Department of Agriculture

1983 The California Gene Resources Report was commissioned by the California State Senate Office of Research. This report was prepared by Janet White for a 15-member University of California faculty task force. UC activities and plans for genetic resource conservation were recommended. The report concluded that the formation of an institute within the University of California, formally classified as an organized research unit and permanently funded, could promote continuity of protection of vital genetic resources for the State.

1983 The California Department of Food and Agriculture contracted with the University of California through its Division of Agriculture and Natural Resources (ANR) to evaluate the work of the California Gene Resources Program, to develop a list of biologic entities requiring conservation in California, to hold a symposium to allow expert and public discussion of the issues, and to make recommendations for action that the State should take in genetic resource conservation. A Steering Committee composed of faculty from several UC campuses evaluated the CGRP, compiled a list of California entities requiring conservation (see Appendix IV), held the Symposium and Workshop on Genetic Resources Conservation for California at Napa, California on April 5-7, 1984, and made recommendations for UC action.

1984 Symposium and Workshop on Genetic Resources Conservation for California. The purpose of the Symposium was to present state, national, and international perspectives on the issues, needs, and successes of genetic resource conservation and to describe current conservation methodology and

technology. The meeting concluded with commitments from the University Division of Agriculture and Natural Resources to initiate a program within the University (P.E. McGuire and C.O. Qualset (Eds.), 1984 Proceedings of a Symposium and Workshop on Genetic Resources Conservation for California, April 5, 6, & 7, 1984. Napa, California. 85 pages).

A major recommendation of the Symposium was that the University of California should develop a unit to deal with conservation of genetic resources important for California. This resolution was endorsed by the CDFA and accepted by Vice President Kendrick, L.N. Lewis, Assistant Vice President, ANR, and C.E. Hess, Dean of the College of Agricultural and Environmental Science, Davis. They recommended a Genetic Resources Conservation Program be established in the Office of the President through the Division of Agriculture and Natural Resources. A budget request was made and approved by the President and the Regents for one million dollars annually beginning with the 1985-86 fiscal year. The Governor supported the program, but reduced the annual funding to $250,000.

1985 The UC Genetic Resources Conservation Program was initiated July 1, 1985. An *ad hoc* group of UC faculty and a representative from CDFA were convened to aid in the initial organization and direction of the program (see Appendix I for the composition of this group). The agenda for this group at a November 25, 1985 meeting included establishing the objectives of the program, priorities among the objectives, and the optimum organization within the budget constraints to address the objectives. The program was organized, for the most part, as recommended by the discussants at the Napa Symposium.

MISSION

The mission statement of the GRCP is derived from the recommendations of the Napa Symposium and the *ad hoc* advisory group of 1985-86. The mission has four components. The Program should:

- Develop a Genetic Resources Conservation Plan for California, working in concert with state, federal, and international organizations as appropriate, to develop policies and programs for conservation of genetic resources;

- Identify critical animal, plant, and microbial genetic resources and support their onsite and offsite conservation;

- Develop improved methods and strategies for procuring and maintaining genetic resources;

- Foster the adoption of genetic resources conservation theory and practice through training, workshops, conferences, seminars, publications, and other outreach activities.

ORGANIZATION OF THE CALIFORNIA PROGRAM

At the end of fiscal year 1985-86, GRCP consisted of a Management Office operating under the office of Assistant Vice President L. N. Lewis of the Division of Agriculture and Natural Resources. For this first year, the Program Director provided a 25% time commitment to GRCP to implement the recommendations of the *ad hoc* advisory committee. In February 1986, the shared use of two offices was generously donated by the Department of Agronomy and Range Science on the UC Davis campus for use by the GRCP. Remodeling was necessary to accommodate the GRCP needs in this limited space.

Roberta A. Hooker was appointed as full-time Administrative Assistant on April 28, 1986. Prior to this appointment, as a member of the office staff of the Dean of the College of Agricultural and Environmental Sciences, she had served the GRCP on a part-time basis. Dr. Patrick E. McGuire was appointed as a Genetic Resources Analyst on a half-time basis beginning December 1, 1985.

GRCP held discussions of how the program can be best advised to carry out its mission. A Policy Advisory Board will be appointed which will include academic and administrative representatives from throughout the University and representatives from appropriate state and federal agencies. Its purpose will be to advise the program administrators on policy matters, to review current and projected GRCP activities, to review and assist in budget development, and individually, to provide advice and guidance for genetic resource conservation activities to GRCP. Technical Advisory Committees for plant, animal, and microbial species will be appointed as appropriate. A broadly based Public Advisory Committee will function to review GRCP programs, identify important needs in genetic resource conservation, and assist in promoting and facilitating GRCP activities. This committee will include public and private sector representatives as well as representatives from the University of California and other universities.

PROGRAM ACTIVITIES

Because GRCP was not fully funded, not all components of its mission could be addressed. Priority was given to genetic resources collections that were in great danger of being abandoned, lost, or otherwise dissipated. In fact, it was the imminent loss of valuable materials that provided a major impetus to this program. A survey was conducted (see Appendix II for format) to develop information on the status of special collections of plant, animal, and microbial species.

Seventeen individuals responded to the survey producing a list of 115 collections that they considered imperiled. Of these collections, 108 involved plant taxa, five involved animal taxa, and two involved fungal taxa.

Rescue of Imperiled Collections Program. Of this large number of identified imperiled collections, some were in dire danger of being lost. A common situation was that a collection had been amassed during the career of a researcher and upon the researcher's retirement from University service, no means was available to maintain the collection. This situation was anticipated from many case studies presented at the Napa Symposium in 1984. Therefore, GRCP established, as its first priority activity, a program to rescue imperiled collections. In such cases, GRCP could provide short-term financial support for the assessment, inventory, consolidation, or proper storage of the collection, thereby reducing upkeep demands on space and personnel, until support for long-term conservation could be arranged. In other cases, a particular piece of equipment was required to institute more specialized storage or maintenance procedures that would in the long run be more cost- or space-efficient.

Fifteen of the 40 example species identified in 1984 (Appendix IV) are represented in the active projects in the Imperiled Collections Programs. These projects only attend to a single aspect of genetic resource conservation. Beyond the protection of special collections of genetic stocks, a comprehensive plan is needed for conservation of the biologic diversity of species important in California, including their use in agriculture and industry and as natural resources in California's wildlands and waterways. These broad considerations of genetic resources conservation will be the subject of GRCP's attention in the immediate future.

Conservation Research. Several of the first year's projects involved a research component along with the rescue of an imperiled collection. Maintenance of living collections of genetic resources is time- and space-consuming, requiring certain population sizes, optimal habitats, control of reproduction, and adequate sampling and storage, whether the resource be flocks, herds, colonies, populations, propagules, or cultures. Cryopreservation (storage by freezing at very low temperatures) is one promising alternative. It offers the opportunity to avoid maintenance of individuals or populations generation after generation just to have a particular genotype or character readily available. Entities that have been successfully preserved for various species are eggs, semen, and embryos of animals; pollen, seeds, or spores of plants; cultures of fungi and microbes; or DNA or tissue of any living thing. Cryopreservation is feasible for many genetic resources and will be used in several of the funded projects. However, its application is very species specific and therefore experimentation is involved in each extension to a new species. The potential for widespread use of cryopreservation justifies research to make it feasible.

Education. Less than 3% of this year's budget was available to be used toward the education function of GRCP. One activity which was supported is the Seed Saving Project at the Student Experimental Farm at UC Davis. A major component of this project is education about genetic resource preservation issues. To this end, the project maintains a demonstration garden displaying the genetic diversity available in a variety of vegetable crops; conducts workshops to demonstrate techniques for seed gathering and cleaning and for maintaining varietal purity; has an active public speaking schedule; and maintains a network of communication among local growers and seed savers and with a similar national program, the Seed Savers Exchange.

In September 1985, GRCP sponsored a seminar at UC Davis by internationally known Dr. Norman Myers, a scientist and writer. His talk was entitled "Conservation of genetic resources - a true priority?"

Collection. Emergency financial support was provided for the transportation of a collection of potato germplasm from Peru representing landraces still in cultivation there. The collection was made in the spring of 1986 by personnel from the Department of Vegetable Crops and the International Agriculture Development Program of UC Davis.

Management Office. About 25% of first year funds went to the establishing of the Management Office. In addition to the normal supplies necessary for administering an office, word processing equipment, filing systems, a computer for resource inventory and office administration, as well as various furniture items were purchased. The two rooms in Hunt Hall also needed remodeling to control noise and to facilitate shared usage.

RESCUE OF IMPERILED COLLECTIONS

The amount of funds presently available to GRCP cannot provide for the perpetual maintenance of collections, but can be used to enable the rejuvenation, consolidation, or transfer of collections. Most importantly, a plan for genetic conservation for special collections will be developed so that financial means for long-term conservation can be established. Permanent funding for the maintenance of collections will be sought by increasing the University budget for genetic resource conservation to GRCP or the designated curators of collections. External sources of permanent funding will also be sought.

A general call for proposals was distributed to all UC campuses (Appendix III). Twenty-two proposals were received, 18 of which were accepted for funding. The funded projects involved collections on five of the nine UC campuses and included eight on plants, six on animals, and four on microbial organisms. These projects dealt with 15 of the 40 high priority examples for California compiled in 1984 for the Napa Symposium (see Appendix IV). The GRCP had $152,364 available for projects in 1985-86. There were 18 imperiled collection projects funded at an average of $8,465 per project. A nineteenth project, at the Davis campus, to promote individual gardeners to conserve heirloom vegetable varieties, also received financial assistance.

Most projects were accepted for two-year funding because funds were not available until late in this first year. The Imperiled Collections Grant Program will be continued in the third year with additional projects expected to receive funding.