

Scientific value of herbarium vouchers of botanical garden living collections

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The Desert Botanical Garden's living and herbarium collections are focused on desert plants of the world, with special emphasis on plants from the southwestern United States and adjacent Mexico. Especially noteworthy are the collections of Agavaceae and Cactaceae; the Garden possesses one of the world's largest collections of members of these two plant families. Since the founding of the Desert Botanical Garden in the late 1930's, most plants accessioned into the living collection have documentation that includes collection locality, date of collection, and collector. Such documentation makes the living collection an extremely valuable source of material for systematics research and other botanical investigations. Throughout the early history of the Desert Botanical Garden, botanists associated with the institution occasionally prepared voucher herbarium specimens of materials obtained from documented living collections. For example, founding Director George Lindsay made herbarium specimens consisting of spine clusters and flowers obtained from living specimens of *Ferocactus latispinus* (Haw.) Britton & Rose, acquired for the Garden's living collection from Oaxaca, Mexico in 1937. However, a regular program to prepare voucher specimens from documented living collections was not begun until the early 1990s.

In the late 1980s, funding from a federal program (Institute of Museum Services) provided a professional assessment and report on the Cactaceae in the living collection. This assessment, conducted by Dr. Edward Anderson, strongly recommended the development of an herbarium voucher program dedicated to the preservation of materials from the accessioned living collections. Acting on this recommendation, the Herbarium Voucher Project was begun in 1993. Successful implementation of the Herbarium Voucher Project has been due, in large part, to the efforts of a well-trained team of volunteers. The Assistant Herbarium Curator administers the voucher program and volunteer activities. One lead volunteer has been involved with the voucher program since its inception. This person oversees the daily collecting, data entry, and mounting of specimens by eight to ten other volunteers who regularly contribute to the effort. Before becoming involved with the program, volunteers complete general training for volunteers offered through the Garden's Education Department and specialized training in tasks associated with the voucher program. Each volunteer contributes a minimum of three hours one day per week on the program. The goal of the program is to eventually obtain herbarium specimens from all of the documented living specimens. To date, approximately 1500 herbarium specimens have been made from living garden collections, including 200 from agaves and 900 from cacti.

There are multiple benefits of documenting the living collections of botanical gardens and arboreta with herbarium collections. The most obvious is that despite the horticultural care given to living collections, these living specimens will eventually die. Herbarium specimens of these plants provide a permanent record and physical voucher of the plants for later use and study. For example, nine out of 26 original living specimens of *Ferocactus latispinus* are alive at the Desert Botanical Garden. Only four plants of the once proposed subspecies *spiralis* from Oaxaca, Mexico, including those originally collected by Lindsay in the 1930s, were ever collected with associated data. Although none of those plants is alive today, herbarium specimens made of those plants are essential for systematic research.

Herbarium specimens preserve flowers that are only produced infrequently or only after a considerable period of time. A type of ocotillo, *Fouquieria shrevei* I.M. Johnston, is found only on gypsum soils of Coahuila, Mexico. Few botanists have seen plants in flower. The Desert Botanical Garden has two living plants; one finally

flowered 27 years after it was originally collected. As another example, agaves are monocarpic and typically require 20 to 40 or more years to mature and flower. Howard Gentry added hundreds of agaves to the Garden's living collections for his work on *Agaves of Continental North America* (Gentry 1982) and for study by future students of *Agave* systematics. Gentry and Rodney Engard collected five plants representing *Agave glomeruliflora* (Engelm.) Berger from Coahuila, Mexico in 1972. This rare taxon is infrequently found in Big Bend National Park and Coahuila and is hypothesized to be of hybrid origin. Over the past five years, four of those original living collections have flowered, providing important material for discerning the evolutionary history of this taxon. The flowers provided the materials required for morphological and cytological studies; these materials were also preserved for future study as documented herbarium specimens. This information was incorporated in the taxonomic treatment of *Agave* published in *Flora of North America* (Reveal and Hodgson 2002). Another of many examples concerns a type of prickly-pear. Clover and Jotter (1941) collected and described *Opuntia longiareolata* from the Grand Canyon of Arizona. Benson (1982) viewed this taxon as dubious at best, perhaps representing a lone anomaly, since it was only known from one collection. Live and herbarium material collected by Garden staff from 1947 to 2000 provided evidence that it was a valid taxon and was included in *Flora of North America* (Pinkava 2003) and that it is the dominant prickly-pear in the Grand Canyon and Glen Canyon. All of the plants, with the exception of the 1947 collections, still exist in the Garden's living collection, and all are vouchered as herbarium specimens.

Another benefit of herbarium vouchers is the preservation of materials from plants originally collected from areas where acquisition of new specimens is difficult or impossible. From 1939 through the early 1980s the Garden's living collections grew considerably with plants collected in Mexico, often from remote areas. Since then, it has become more difficult to collect due to more stringent permit requirements. The number of plants collected from Mexico since 1986 has declined considerably. For example, all plants of *Ferocactus latispinus* were collected between 1938 and 1968; only seeds have been collected after 1968. Another example is a more recent collection expedition by Garden staff to the coastal deserts of Peru (McAuliffe 1994). A substantial collection of cacti was added to the living collection in this effort, but in most cases, flowers essential for systematics research were obtained for herbarium specimens years after the living collections were obtained.

The Garden's Rare and Endangered Plant Collection is responsible for 36 species of rare plants in the region that are part of the Center for Plant Conservation (CPC) collection of rare plant taxa of the United States. At the Desert Botanical Garden, living specimens of each rare taxon is vouchered with herbarium specimens that can be referred to by researchers without having to remove additional specimens from wild populations.

The Garden's living collection provides plant materials for study by researchers around the world. Any such plant used, whether it is for molecular, morphological, pollination, pharmacological, or any other of a multitude of studies, is documented with an herbarium specimen made from that particular plant. Information regarding the particular research use is included on the label of that herbarium voucher. For example, University of Chicago scientists performed chemical analyses of creosotebush (*Larrea tridentata*) for possible anti-tumor capability; the particular plants used in those investigations were vouchered with herbarium specimens.

The Desert Botanical Garden's herbarium has an active loan program, providing specimens to bona fide researchers and herbaria. Such a program is an integral and important means by which researchers have access to information about the living collection via herbarium specimens. Providing loan material also benefits the Desert Botanical Garden since it increases the exposure of the Garden and its collections and also increases the percentage of accurately identified taxa. The Garden's living collections and herbarium are inextricably linked. Because of the considerable amount of data associated with many of the plant in the living collection, herbarium specimens of those plants can be of considerable use to researchers. The future value of today's living plant collection is ensured through the permanent documentation of these plants with herbarium specimens.

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