

GORDONIA ALTAMAHA, Sarg.

Alseodendron *diversifolium*

Imp. R. Lanoue Paris

Saving the Rarest

Donald A. Falk

Francis R. Thibodeau

By cultivating endangered native plants a nationwide network of botanical gardens and arboreta hopes to produce stock that can be used to reestablish endangered plants in the wild once their natural habitats have been rehabilitated

Like many desert plants, *Agave arizonica* was in serious decline during the 1960s. By the middle of the decade it had been reduced to two known localities with only a handful of plants. Despite attempts to protect the remaining individuals, the species—which tends to grow in populations of very low densities—continued to suffer from grazing and collecting and was apparently on the road to extinction. In 1968, staff members of the Desert Botanical Garden in Phoenix, Arizona, took an interest in the species. Working primarily with bulbils and tissue cultures, they managed to establish a cultivated stand from which scores of plants have since been propagated for distribution and replanting in the wild. The Garden has also played a key role in public education and has worked cooperatively with the national Fish and Wildlife Service to help locate and manage the remaining wild populations. Thirty-one clonal populations are now known from a one hundred-square-mile area. *Agave arizonica* was officially listed as a protected endangered species in 1984,

which should enhance its chances for recovery.

A dramatic intervention, perhaps, but not so unusual as one might think, for in recent years botanical gardens and arboreta in the United States and abroad have become increasingly active in protecting and conserving native species of plants. Conservation is rapidly becoming a mission of many gardens and arboreta, alongside their traditional missions of display, research, and education. In coming decades, botanical gardens and arboreta should become vital for the conservation and understanding of the world's rarest plants.

The Problem of Extinction

The tragic extinction of species worldwide, which is primarily a consequence of widespread destruction of habitat in the Tropics, is now well recognized (Myers, 1979). Human-induced extinction of species is not limited to the Tropics, however, but is happening in every nation on earth. In the United States alone at least three thousand species of higher plants are believed to be endangered or threatened with extinction, roughly fifteen percent of the nation's entire flora (Prance and Elias, 1977; Ayensu and DeFilipps, 1978). Agencies of the Federal Government charged with protecting these species—most notably the Office of Endan-

Opposite: *Drawing of Franklinia alatamaha Marsh., Franklinia, or the Franklin tree, by Charles Edward Faxon (1846–1918). Franklinia is believed to be extinct in the wild but is widely cultivated in botanical gardens and elsewhere. Many drawings by Faxon, both previously published and unpublished, appear in this issue of Arnoldia. Most are from materials in the Archives of the Arnold Arboretum.*

gered Species in the Fish and Wildlife Service—operate on severely limited budgets and simply do not have the means to evaluate the status of the thousands of plant taxa that have been proposed under the terms of the Endangered Species Act (Anonymous, 1984a). Moreover, very few taxa—one hundred as of this writing—have survived the administrative procedure for officially listing a taxon as “endangered” under the provisions of the Act (Anonymous, 1984b), though they may have such status under state laws. In fact, however, plants do not receive the same degree of protection that animals do because the law regards them as part of the property on which they grow and hence may be privately owned. Thus, under the current formulation of the Act, the sale and interstate transport of endangered plants is restricted, but the destruction or taking of wild individuals from private land technically is not. The Act’s primary effect is to prevent the use of Federal funds for projects that would destroy or alter the habitats of endangered taxa. In this context, when the presence of rare plants might hold up commercial-development projects, it is not unusual for wild populations of rare plants to be destroyed before anyone can protect their habitats permanently. Other Federal agencies (such as the Forest Service, Park Service, and Bureau of Land Management) cooperate with the Office of Endangered Species by law—but they, too, have competing demands for their budgets and for the land they control, especially since Congress is not uniformly friendly to the protection of endangered species when there is a conflict. Outside of the Federal Government, a single private conservation organization—The Nature Conservancy—has been almost solely responsible for the vast majority of natural-habitat acquisition in the nation. The Conservancy has managed to protect more than two million acres of prime natural habitat in over three thousand locations across the

country.

Meanwhile, extinction accelerates. Commercial, industrial, and agricultural “development” continues to destroy tens of thousands of acres yearly; much of this land is logged, mined, or converted for recreational uses, even though it technically remains “protected” under the jurisdiction of a Federal or state agency, such as the Bureau of Land Management. Other sources of danger are more subtle but no less insidious. Elias (1977) estimates that twenty-two percent of the flora of the United States consists of naturalized species, many of which (*Lythrum salicaria*, the common purple loose-



Calochortus obispoensis Lemmon, the San Luis maniposa, a candidate for legal protection under the Endangered Species Act. Further information on wild populations of this species is needed before it can be officially listed, however. This drawing, by C. E. Faxon, is from the Archives of the Arnold Arboretum.



Iris tenuis S. Wats., the Clackamas iris, drawn by C. E. Faxon. Native to northwestern Oregon, this species is no longer a candidate for listing under the Endangered Species Act because it has "proven to be more abundant or widespread than was previously believed and/or [is] not subject to any identifiable threat." Taxa of this type are said by the Fish and Wildlife Service to be in "Category 3C."

strife, for example) compete with native plants and may literally crowd them out of existence. Native species have suffered from such introduced diseases as Dutch elm disease and chestnut blight, against which they have no resistance.

In the face of such multifarious threats to species diversity, it is essential that every available resource be mobilized. In recent years, botanical gardens and arboreta have become important new members of the conservation community. Although their enormous potential to intervene in species extinction has only begun to be realized, there are many hopeful signs that they will be increasingly active in the preservation of endangered plant species.

The Increasing Importance of Botanical Gardens and Arboreta

Recently, Dr. Peter Ashton, Director of the Arnold Arboretum, noted that botanical gardens and arboreta should view themselves as "basic resources" in conservation and research. He notes (Ashton, 1984) that

botanic gardens have an opportunity, indeed an obligation which is open to them alone, to bridge between the traditional concerns of systematic biology and the returning needs of agriculture, forestry, and medicine for the exploration and conservation of biological diversity.

Others—Schultes (1983), Lucas (1984), and Synge and Townsend (1979), for example—have similarly noted the potential importance of gardens for research on and conservation of endangered species. The roles gardens and arboreta can play are by and large extensions of their traditional areas of expertise in plant collecting, propagation, cultivation, and research. A sampling of activity in United States botanical gardens illustrates the diverse functions that gardens are already developing as they concentrate increasingly on work with endangered native plants.

Cultivating Rare and Endangered Plants

Where botanical gardens truly excel is in the propagation and cultivation of plants. Gardens and arboreta in this country have had many decades of experience in propagating and cultivating rare and fastidious species. Although they traditionally have applied their skills primarily to horticultural varieties and exotics, many gardens and arboreta have begun turning their skills to the conservation of rare native taxa (Huckins, 1983). For instance, a recent survey of botanical



Elliottia racemosa Muhlenb. ex Elhott, the Georgia plume, a member of the Ericaceae. A deciduous shrub that reaches twenty feet in height, this is the only species in the genus. It is native to eastern Georgia and southern South Carolina. The Fish and Wildlife Service has placed *Elliottia racemosa* in Category 3C. The drawing, which is by C. E. Faxon, is from the Archives of the Arnold Arboretum.

gardens and arboreta in the United States revealed that at least sixty-eight of them are currently raising some regionally or nationally rare native taxa. It is an encouraging sign that these institutions are dispersed among all regions of the continental United States and Hawaii and that they include many of the newer, smaller gardens as well as the more established institutions. Yet despite these encouraging signs, fewer than one in ten of the taxa that are endangered in this country are in cultivation anywhere (Brumback, 1981).

There are a few bright spots on the map. Among the largest collections in the continental United States is that of the North Carolina Botanical Garden in Chapel Hill, which maintains in cultivation thirty-eight protected taxa, including three Federally listed species and candidates for listing such as *Shortia galacifolia*. Another significant collection is that of the Garden in the Woods in Framingham, Massachusetts, which currently has more than two hundred fifty specimens of plants representing eighteen regionally or nationally endangered taxa. The Desert Botanical Garden in Phoenix, Arizona, cultivates thirty rare native taxa, seventeen of which are either listed or proposed for listing on the Federal Government's "List of Endangered Plant Species." Rancho Santa Ana Botanic Garden in Claremont, California, conserves upwards of one hundred rare or threatened native plants, including major collections of *Arctostaphylos* (manzanita), *Ceanothus*, and *Dudleya* (live-forever). In Hawaii, the Waimea Arboretum currently cultivates over three hundred taxa that are rare or endemic to the Hawaiian Islands. Other gardens that cultivate threatened or endangered species include the State Arboretum of Utah in Salt Lake City; Bok Tower Gardens in Lake Wales, Florida; the Denver Botanic Gardens; the University of Nebraska Statewide Arboretum; and the San Antonio Botanical Center.

Numbers are not the whole picture, of course; in some cases, botanical gardens are actually growing the last living individuals of a species that has been extirpated from the wild. The Fairchild Tropical Garden in Miami maintains specimens of *Goetzia elegans* from Puerto Rico, a species that has been reduced to one plant in the wild. The plant appears to be self-incompatible, so the plants at the Garden (which were propagated from root cuttings) may soon be the only remaining living individuals of the species. The Fairchild also cultivates *Amyris balsamifera*, a plant once found in the subtropical hummocks of southern Florida. All of the wild United States populations have disappeared, though the species is still relatively common in Central America and South America.

Franklinia

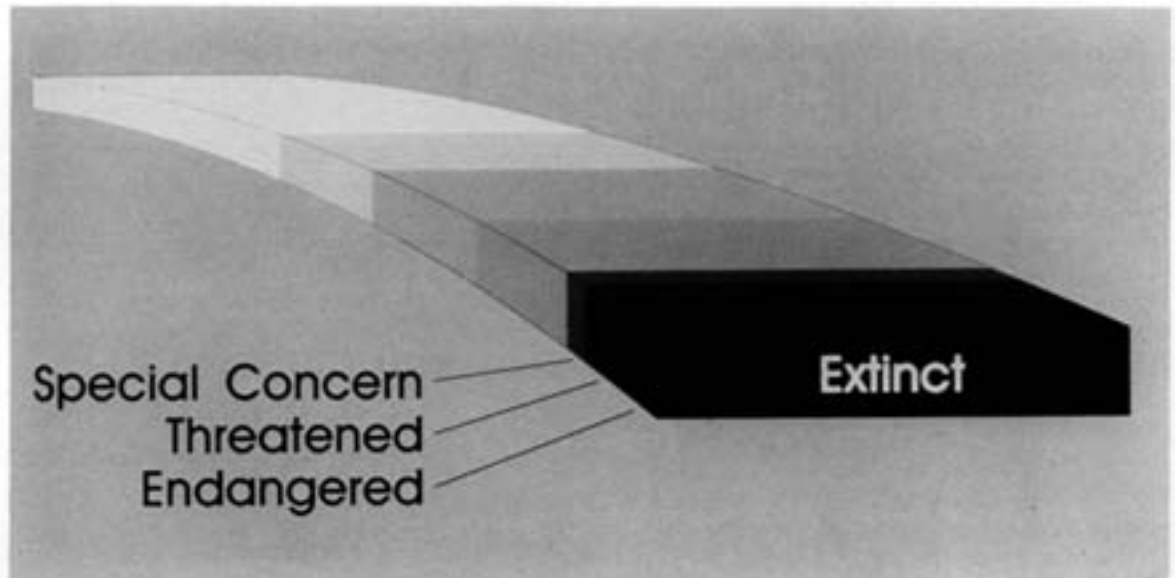
The best known example of the cultivation of a species no longer found in the wild is, of course, *Franklinia alatamaha*. The species was observed by John and William Bartram along the Alatamaha River in Georgia in 1765 but never elsewhere. The last person to see the plant in the wild, Dr. Moses Marshall, revisited the site in 1790 and found *Franklinia* to be locally plentiful over an area of two to three acres. It has not been seen in the wild since and is presumed to have been extirpated. It has found an alternative niche, however, as a cultivated ornamental and is now widely grown. All living specimens are descendants of the material collected in 1790 by Marshall (Barnhart, 1933; Harper and Leeds, 1937).

Predictably, some of the most successful work with endangered species has been done by gardens that have given native plants high priority in their accessions and collections policies. The staff of the Garden in the Woods in Massachusetts, for example, is able to maintain the Garden's collection of

rare species as part of an overall accessions policy that emphasizes native plants of the Northeast, particularly New England. The Garden's collection currently includes populations of *Trollius laxus* (spreading globe-flower), *Helonias bullata* (swamp pink), *Sabatia kennedyana* (Plymouth gentian), and several unusual species of *Sarracenia* (pitcher plants). The Garden also maintains species from other regions, such as *Echinacea tennesseensis* (Tennessee coneflower) and *Shortia galacifolia* (Oconee bells).



Camassia cusickii S. Wats., a species native to northeastern Oregon and to Idaho. It is in Category 3C. Drawing by C. E. Faxon.



A diagram illustrating the several categories of rare (and extinct) plants.

Another excellent example of commitment to threatened native plants is the new Transition Zone Horticultural Institute in Flagstaff, Arizona, which operates The Arboretum at Flagstaff. The Institute's charter specifically commits the Arboretum to the cultivation and conservation of rare and endangered taxa from its region whenever possible. As a result, the Institute has been able to acquire a collection that includes several endangered species of *Pediocactus*, *Cowania*, and *Sclerocactus*.

Waimea Arboretum and Botanical Garden in Hawaii has stated in its accessions policy that a "primary role" will be to cultivate endangered plant species and to distribute them widely. It is committed to working with national and international conservation efforts. Another important Hawaiian garden is the Pacific Tropical Botanical Garden, which has been chartered by the United States Congress to work toward the conservation of endangered plants. Other larger and more established institutions, such as the Missouri Botanical Garden in St. Louis,

have recognized conservation as a priority and are beginning to integrate endangered species into their permanent collections.

A particular application of the skill of gardens in cultivation is the transplanting of wild plants into a cultivated setting as part of an emergency "plant-rescue" program. The plant-rescue program at the North Carolina Botanical Garden has operated for over fifteen years and is among the oldest in the country, sending staff and volunteers to dozens of sites threatened with imminent destruction. The program is designed to preserve plants when all attempts to protect their habitats have failed. One recent series of expeditions managed to transplant over twenty-five hundred plants of *Shortia galacifolia* from a site slated for recreational development—ironically, the construction of a hiking path—by a power company. An excursion to another, isolated *Shortia* site was also successful even though the team had to be ferried to the site by motorboat. Other collecting trips have yielded living material of *Camassia scilloides*, *Trillium pusillum*,

and *Kalmia cuneata*. Plants are transported either bare-rooted or in blocks of soil and are reestablished in the Garden. In every case, collectors obtained permission from the landowner to enter a site and to remove plants. Efforts to secure permanent protection for plants in their natural habitats continue.

Rescue operations are not always successful, even when arrangements seem secure. For instance, the Berry Botanic Garden was scheduled to collect seeds and plants from the largest remaining population of *Lomatium bradshawii*, which was situated in a city park in Eugene, Oregon. Unfortunately, the Parks Department's grounds crew was not informed of the arrangement and mowed the entire population before the fruits ripened.

Species that are rare in the wild are not necessarily difficult to raise in cultivation. Many are rare simply because their poor abilities to compete restrict them to a narrow range of habitat types in the wild. If the necessary habitat is threatened, then the species is threatened. An example is *Sabatia kennedyana* (Plymouth gentian), which grows on the sandy margins of ponds on Cape Cod, Massachusetts. Given the proper conditions under cultivation and unimpeded by other species, the plant thrives. A recent transplant experiment in England revealed that, of a group of very rare plants, only a third were unusually difficult to raise, while another third were actually weedy (Cranston and Valentine, 1983)!

Horticultural Value

Genetic conservation is not the only reason for raising endangered plants. Many of them are stunningly beautiful as well. While some endangered taxa are not especially attractive, Dr. Linda R. McMahan of the Center for Plant Conservation (formerly of the World Wildlife Fund-U.S.) estimates that



C. E. Faxon's drawing of *Cypripedium californicum* A. Gray, the California lady's-slipper Native to California and Oregon, *Cypripedium californicum* is also in Category 3C.

fully two-thirds of the endangered species native to the United States belong to genera of proven horticultural merit. Among them are endangered lilies, larkspurs, orchids, roses, rhododendrons, heathers, asters, columbines, violets, meadowbeauties, phloxes, daisies, sunflowers, and gentians, as well as oaks, hollies, birches, pines, cypresses, and many cacti.

With a few notable exceptions, the color and form of native species in the garden tend to be subtle and understated rather than showy. One would not pit *Hydrastis canadensis* (goldenseal) against the latest gener-

ation of Holland's tulips, for instance. Consequently, in botanical gardens the most successful horticultural applications often are those that integrate plantings of native species into their natural settings. At the Garden in the Woods, for example, naturalistic plantings are maintained in a diversity of habitats, including acid- and limestone-woodland, pine-barren, meadow, bog, and pond environments. Another example is the United States National Arboretum in Washington, D.C., where over twenty nationally rare species are grown in Fern Valley, which is maintained as a natural woodland. Similarly, the Holden Arboretum in Mentor, Ohio, works with some thirty-six endangered plants in seventeen representative habitat plantings, including woodland, stream- or marsh-border, prairie, and wet-meadow plantings. The North Carolina Botanical Garden maintains collections in several habitat types typical of the southeastern mountains and coastal plain. The Desert Botanical Garden in Phoenix integrates its rare-species plantings into a variety of Sonoran Desert habitat types, including a shallow alkaline plain and a rocky outcrop, where the plants are kept alongside other species associated with them in the wild. In these settings, native plants (including those that are endangered) can be best appreciated for their natural aesthetic virtues.

Seed Storage

Besides raising plants in greenhouses and out-of-doors, botanical gardens can maintain living plant material in storage facilities, such as low-temperature seed banks. An example is the Rare and Endangered Seed Bank at the Berry Botanic Garden in Portland, Oregon. Initiated in 1982, the Seed Bank currently includes seeds of over one hundred rare and endangered species found in Oregon. Curator Julie Kierstead observes that

the goal is "to preserve a representative genetic sample of each endangered species in Oregon as insurance against extinction of the species in the wild." Collecting for the facility is done by Garden staff and volunteers, and emphasizes species that are clearly endangered in the wild but that have not yet been accorded formal protection under the Endangered Species Act. Specimens are stored at minus 18 Celsius (0 Fahrenheit) in sealed glass vials in which the relative humidity is kept below five percent. Among the plants currently in storage are species of *Lomatium*, *Arabis*, *Astragalus*, *Lewisia*, and *Lilium*. Viability trials are conducted periodically to determine how long the seeds remain alive, and their rates of germination. Because many specimens may be kept easily, seed storage provides perhaps the simplest means for gardens to maintain ade-



Lonicera hirsuta Eat., the hairy honeysuckle, which ranges from Quebec to Pennsylvania and west to Nebraska. It is listed as endangered in Massachusetts by the Massachusetts Division of Fisheries and Wildlife but does not appear on the Federal list. Drawing by C. E. Faxon.

quate populations of plants, making it possible to preserve a greater cross-section of the genetic diversity of each species. The cost per species can be quite low also, especially if the garden is able to use an existing facility that has been made available for the purpose.

The United States Department of Agriculture, which operates the largest seed-storage facilities in the United States, has begun to work on the conservation of seeds of endangered American plants. The Department's interest arises in part because many native species belong to genera with important food, fiber, oil, or horticultural species. But the Department's mandate is even broader than this, encompassing conservation work through the Forest Service and the Agricultural Research Service. The National Plant Germplasm System, which includes the National Seed Storage Laboratory in Fort Collins, Colorado, along with several other facilities nationwide, is now conducting trial storage of rare species through the Center for Plant Conservation. Readers interested in details about current seed-storage work should refer to the review article by Holden and Williams (1984).

Research

In its 1978 report, *Conservation of Germplasm Resources*, the National Research Council of the National Academy of Sciences concluded that one of the most important facets of a botanic garden's involvement with endangered plant species is the opportunity to perform significant research (Committee on Germplasm Resources, 1978). Many of the rarest and most unusual species in the United States are virtually unstudied beyond basic botanical description, because of the difficulty of working with populations in the wild. It is hardly possible to study thoroughly a species's bio-

chemistry, for instance, when there are only a dozen individuals left in the wild. Dr. Thomas S. Elias of Rancho Santa Ana Botanic Garden observes (Elias, 1977) that "the threatened and endangered species are one of the poorest-known assemblages of plants in the U.S. Little is known about their natural history, their reproductive mechanisms or their life cycles." As a response to this problem, he suggests that botanic gardens and arboreta can play a major role in the preservation of endangered species by assuming "a leadership role in the study of the natural history and life cycle of such endangered plant groups as the cacti, orchids, cycads, some of the attractive wild flowers, and others."



Rhododendron maximum L., the great laurel, or rosebay, a species listed in Massachusetts as threatened. Like *Lonicera hirsuta*, it does not appear on the Federal list. Drawing by C. E. Faxon.

Only recently has the role of experimental cultivation in relation to habitat conservation been recognized in the United States. Frequently, habitat managers have to base recovery and management plans on inadequate data about the species in their care. Consequently, the wild populations of a species may continue to decline, despite continued efforts at preservation. Particularly in the case of very rare species, research is further hindered by the inaccessibility of the



Monardella leucocephala A. Gray, the Merced monardella, which was native to Merced and Stanislaus counties in California but which now appears to be extinct in the wild. The Fish and Wildlife Service has placed *Monardella leucocephala* in Category 1, which means that enough information is available to justify giving it immediate protection under the Endangered Species Act. This drawing is by Adel Hagar of the Center for Plant Conservation and is used with her permission.

populations and by the necessity to avoid damaging any of the wild individuals. Dr. Robert E. Cook, Director of Cornell Plantations at Cornell University in Ithaca, New York, explains (Cook, 1984):

Many recovery plans fail to place sufficient emphasis on critical components of the natural history of all life stages of a species. Furthermore, because individuals of endangered species are rare and irreplaceable, experimental manipulations are seldom feasible, and recovery procedures cannot be tested. We believe that the preservation of endangered plants depends upon an understanding of the population biology of each species.

By bringing plants into cultivation, a garden may then propagate a large number of expendable individuals that can be subjected to types of experimental treatment never desirable—or even possible—in the wild. Gardens can thus make a valuable contribution to species management, especially by providing data on environmental tolerances, growth requirements, physiology, and life histories. When coupled with field studies of population dynamics, pollinators, and associated species in the wild, for example, the data can begin to suggest the best line of management. Garden-based *ex situ* research is increasingly being joined with fieldwork at institutions such as Cornell and the Center for Conservation Biology at Stanford, to provide a solid scientific footing for conservation.

Many gardens, of course, are already participating in research on the biology of endangered plants. In many cases, simply attempting to cultivate a species will require research, since so few of the plants have ever been cultivated. The normal range of factors that can be manipulated—soil composition, moisture, pH, sunlight, fertilization, stratification, and so on—constitutes an important contribution to understanding the biology of the species. As William E. Brumback, propagator at the Garden in the Woods, observes (Brumback, 1983):

Propagation research can provide important insights into a species' behavior in the wild. For instance, what might account for a species' ease of propagation and cultivation in the controlled environment of a botanical garden while the wild populations continue to decline? For each species, the answer lies in the long-term study of the species' biology, but propagation research can supply valuable information regarding the potential success of the species under "ideal" conditions in the wild.

A notable example of such research is currently being conducted by Brian Parsons and Tom Yates at the Holden Arboretum on

Trollius laxus (spreading globeflower) under contract to the Ohio Department of Natural Resources (ODNR). Holden is investigating the cultural requirements of the species in the Arboretum. ODNR is using their recommendations to manage the remaining wild populations of *Trollius* in Ohio. Similarly, the Transition Zone Horticultural Institute in Flagstaff, Arizona, and Cornell Plantations, among other gardens, are working under contract with the Fish and Wildlife Service to help develop more accurate and effective "recovery plans" for an increasing number of endangered species.



Oreonana purpurascens Shevock & Constance, the purple mountain parsley. Endemic to Tulare County, California, this species is in Category 2—i.e., it is a candidate for protection under the terms of the Endangered Species Act, but more information about it will be required before it can be proposed for listing. This drawing was done by Amy Eisenberg and is used with her permission. Copyright © 1981 by Amy Eisenberg.

Conservation of Habitat and Reintroduction: Closing the Circle

In the long run success in the gardens will be a hollow victory if it does not enhance efforts to conserve species in their native habitats. Many of the instances cited in this article are the result of close cooperation among botanical gardens and agencies that manage natural habitats. Much of the cooperation naturally revolves around the gardens's ability to perform or assist in research. By learning more about plants in cultivation, habitat managers can make more-informed choices about populations in the wild.



Trifolium bolanderi A. Gray, Bolander's clover, a rare clover known only from a few scattered localities from Yosemite National Park south to Sierra National Forest, California. Like *Oreonana purpurascens*, *Trifolium bolanderi* is in Category 2. Drawing by Amy Eisenberg. Copyright © 1981 by Amy Eisenberg. Used through the courtesy of the artist.

One area where gardens have been particularly active is in the reconstruction of habitat types and the reconstruction of damaged habitats. An instance is the Prairie Restoration Project at the University of Wisconsin. The Project, directed by Dr. William Jordan, has included both scientific study and experimental re-creation of northern-prairie types. The University also publishes *Restoration and Management Notes*, a semi-annual journal devoted to the reconstruction of damaged habitats. A recent instance of a garden's role involved the restoration of a population of *Hudsonia tomentosa* that had been nearly destroyed by off-road vehicles on land in Vermont owned by The Nature Conservancy. The Conservancy arranged for the propagation in a commercial greenhouse of cuttings taken from the site. The resulting material was rooted and then transplanted in the original location, thus helping to reestablish the population.

Conclusion

Plant extinction is a complex phenomenon, sharing the same kind of interaction between economic and biological processes that is characteristic of all critical environmental issues. The conservation of species cannot realistically be divorced from the national conservation strategy. It will require the full range of resources available to prevent species extinction from reaching massive proportions in this country. The stakes are too high for us to allow plants of unique biological character, potential economic utility, and rare beauty to be lost. Professor Richard Evans Schultes of the Harvard Botanical Museum recently noted that, "A massive effort is urgently needed to ensure the survival of endangered species" (Schultes, 1983). It is a hopeful sign that the considerable resources of botanical gardens and arboreta are being mobilized to this purpose.



Brodiaea insignis (Jeps) Niehaus, the Kaweah brodiaea, which is native to California. It is in the Fish and Wildlife Service's Category 1. Drawing by Amy Eisenberg. Copyright © 1980 by Amy Eisenberg. Used through the courtesy of the artist

References

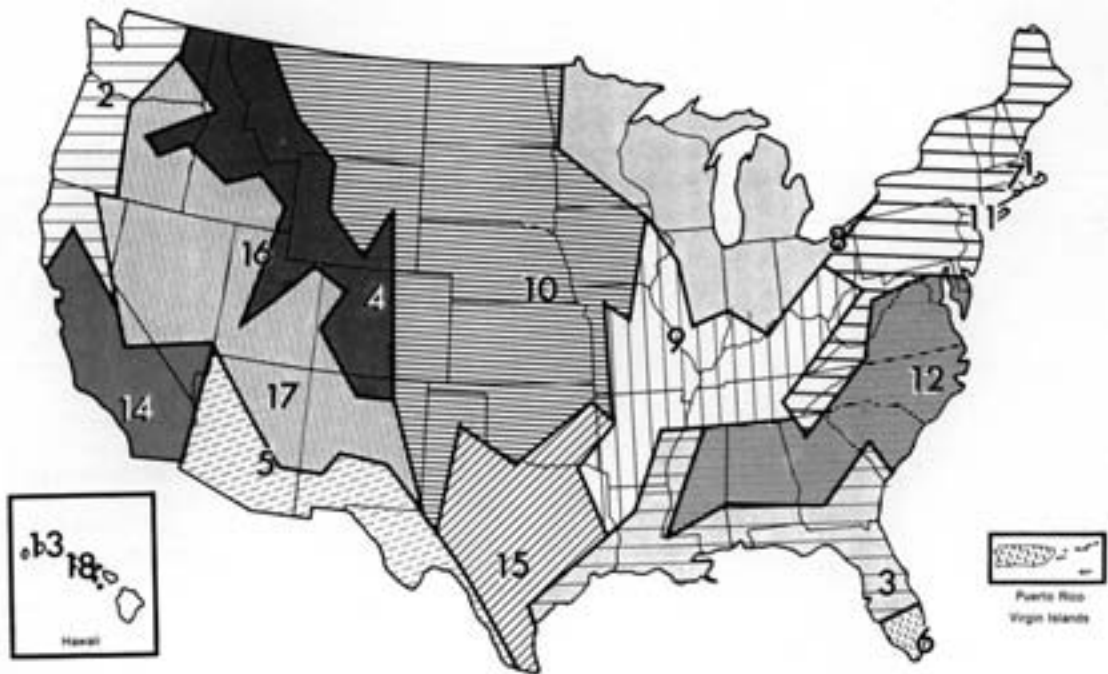
- Anonymous. 1984a. Two Arizona plants listed as endangered. *Endangered Species Technical Bulletin*, Volume 9, Number 6, page 8.
- Anonymous. 1984b. Seven plants in southern U.S. proposed for listing. *Endangered Species Technical Bulletin*, Volume 9, Number 12, pages 1, 6, 7 and 10.
- Ashton, Peter S. 1984. Botanic gardens and experimental grounds. Pages 39–46 in: V. H. Heywood and D. M. Moore, editors, *Current Concepts in Plant Taxonomy*. London and Orlando, Florida: Academic Press. xv + 432 pages.
- Ayensu, Edward S., and Robert A. DeFilipps. 1978. *Endangered and Threatened Plants of the United States*. Washington, D.C.: Smithsonian Institution. xv + 403 pages.
- Barnhart, John Hendley. 1933. *Franklinia alatamaha*. *Addisonia*, Volume 18, Number 1, pages 13 and 14.
- Brumback, William E. 1981. *Endangered Plant Species Programs for Botanic Gardens with Examples from North American Institutions*. Unpublished Master's thesis, Longwood Program in Ornamental Horticulture, University of Delaware. [A survey currently being conducted by the Center for Plant Conservation has confirmed Brumback's findings. Initial data from the survey indicate that fewer than ten percent of the endangered species in the United States currently are in cultivation.]
- Brumback, William E. 1983. Propagating endangered plants: Theory and practice. *Wild Flower Notes and News*, Volume 1, Spring issue, page 4.
- Committee on Germplasm Resources. 1978. *Conservation of Germplasm Resources: An Imperative*. Washington, D.C.: National Academy of Sciences. ix + 118 pages.
- Cook, Robert E. 1984. *Endangered Plant Species: A Program for Presentation*. Ithaca, New York: Cornell Plantations, Cornell University. 6 pages.
- Cranston, D. M., and D. H. Valentine. 1983. Transplant experiments on rare plant species from Upper Teesdale. *Biological Conservation*, Volume 26, Number 2, pages 175–191.
- Elias, Thomas S. 1977. An overview. Pages 13–16 in: Ghillean T. Prance and Thomas S. Elias, editors, *Extinction Is Forever*. Proceedings of a conference. Bronx, New York: New York Botanical Garden. vi + 437 pages.
- Harper, Francis, and Arthur N. Leeds. 1937. A supplementary chapter on *Franklinia alatamaha*. *Barbtonia*, Number 19, pages 1–13.

- Holden, John H. W., and J. T. Williams, editors. 1984. *Crop Genetic Resources: Conservation & Evaluation*. London and Boston: Allen & Unwin. xvi + 296 pages.
- Huckins, Charles A., editor. 1983. *Preliminary Directory of Living Plant Collections of North America*. Swarthmore, Pennsylvania: American Association of Botanical Gardens and Arboreta. vi + 73 pages.
- Lucas, Grenville. 1984. Plants: A kingdom at risk. *IUCN Bulletin*, Volume 15, Numbers 1-3, pages 1, 10, and 11.
- Myers, Norman. 1979. *The Sinking Ark: A New Look at the Problem of Disappearing Species*. Oxford and New York: Pergamon Press. viii + 307 pages.
- Prance, Ghullean T., and Thomas S. Elias, editors. 1977. *Extinction Is Forever*. Proceedings of a conference. Bronx, New York: New York Botanical

Garden. vi + 437 pages.

- Schultes, Richard Evans. 1983. *Botanical Museums and Gardens and Their Role in Conservation of Germ Plasm*. Occasional Paper 2. Kuala Lumpur: Institut Penyelidikan Minyak Kelapa Sawit Malaysia [Palm Oil Institute of Malaysia]. ii + 19 pages.
- Syngé, Hugh, and Harry Townsend, editors. 1979. *Survival or Extinction*. Proceedings of a conference. Kew, England: Bentham-Moxon Trust, Royal Botanic Gardens. ix + 250 pages.

Donald A. Falk and Francis R. Thibodeau, Director of Administration and Director of Science, respectively, of The Center for Plant Conservation, cofounded the Center in 1984.



Regions established by the Center for Plant Conservation on the basis of the major biogeographic regions of the United States. Several cooperating arboreta and botanical gardens (eighteen in all) work with the Center, concentrating on species native to their respective regions. The cooperating institutions are the Arnold Arboretum ("1" on the map), Berry Botanic Garden (2), Bok Tower Gardens (3), Denver Botanic Gardens (4), Desert Botanical Garden (5), Fairchild Tropical Garden (6), Garden in the Woods (7), Holden Arboretum (8), Missouri Botanical Garden (9), Nebraska Statewide Arboretum (10), New York Botanical Garden (11), North Carolina Botanical Garden (12), Pacific Tropical Botanical Garden (13), Rancho Santa Ana Botanic Garden (14), San Antonio Botanical Gardens (15), State Arboretum of Utah (16), The Arboretum at Flagstaff (17), and Waimea Arboretum and Botanical Garden (18).