

DROUGHT RELIEF PROGRAM
FOR THREATENED AND ENDANGERED PLANTS

Final Report

Prepared by
Diane Steeck, Drought Program Coordinator
The Nature Conservancy
Sacramento, CA 95814

Submitted to:

The Natural Heritage Division
Department of Fish and Game
1416 Ninth Street, 12th Floor
Sacramento, CA 95814

Funded by:
California Drought Relief Funds
Contract No. FG-1309

Summer 1994

Introduction

In 1991, during the fifth consecutive year of drought in California, the State Legislature passed Assembly Bill 12x (Costa), which provided over 15 million dollars to be used, by the Department of Fish and Game, to "...minimize the effects of the 5-year drought on ecological systems and to maintain and protect threatened and endangered species." Of that amount, \$597,966 was encumbered in a contract with The Nature Conservancy to provide emergency drought relief for rare, threatened and endangered plants and their habitats.

The Nature Conservancy hired a Recovery Planner and support staff to administer the contract and to carry out the tasks associated with this portion of the Drought Relief Program. These staff worked closely with the Department's Endangered Plant Program to identify those projects and methods which would make the most effective use of the Drought Relief funds.

Drought and California's flora

Drought is a natural phenomenon in California. As such, it has occurred repeatedly during the evolution of most of this State's native plant species. For most native species, a prolonged drought may result in the loss or reduction of entire populations, but typically will not result in the loss of the species itself. In California, however, as a result of pressures from an increasing human population, more than 220 plant species are now State or Federally listed as Rare, Threatened or Endangered. The health of these species is poor. Typically they have been eliminated from the much of their historic range, few extant populations remain, and those populations that do remain may occur in degraded or low-quality habitat. For a common species, the combination of multiple populations occurring in a variety of habitats will act to buffer the species from the effects of extreme episodic events (e.g. fire, flood, drought) which may destroy populations in one area or habitat type, but which will rarely strike all populations with equal force. For plants threatened with extinction, that buffer no longer exists.

For these reasons, the drought relief program for threatened and endangered (T&E) plants focused on maintaining and enhancing the overall health of the species and their habitats. Our goal was to improve the ability of these plants to persist through this drought, to increase their resilience to future environmental stresses, and to reduce the need for intensive management of their populations in the future. Improving the health of a species may mean stabilizing or increasing the number of individuals, number of populations, or range of a species. This usually requires an understanding of those factors responsible for their overall decline; factors which may range from encroaching weedy nonnative species, to water diversions, to destruction of the habitat required by a specialized pollinator.

Within this broad goal of improving species health, The Nature Conservancy and the Department sought projects that:

- (1) Employed management practices resulting in longterm benefits to species and their associated ecosystems.** Although shortterm emergency measures, such as supplemental watering, are needed in some cases, we emphasized activities which would maintain or improve the health of the habitat and therefore its ability to sustain the target species under varying conditions. Habitat restoration included such activities as removing or controlling

nonnative species, increasing the water-holding capacities of degraded vernal pools, and constructing fences which would allow control of grazing or other activities needing regulation.

- (2) **Complemented existing conservation strategies.** We worked cooperatively with over 25 agencies and organizations in carrying out drought relief activities for threatened and endangered plants. Coordinating our activities with other agencies and with existing recovery plans was important to the success of the projects and increased the effectiveness of our limited funds.
- (3) **Improved our ability to assess species' health and to respond effectively under similar drought conditions, should they reoccur in the future.** One of the primary difficulties in managing rare plant species is the lack of information available on their biology and population dynamics. In many cases, no thorough pre-drought population censuses were available to help managers assess the response of the species to the continuing drought. In other instances, information on the species response to land use practices (e.g. grazing) during drought were unknown. Just as a doctor must measure vital signs before providing emergency treatment, so biologists must assess the status and health of endangered species in order to develop sound recovery strategies. Thus, assessment became an important part of many drought relief projects, both to plan a course of action and to evaluate the effectiveness of restoration efforts.

Results of Specific Projects

The objectives, methods and results of the specific projects are summarized on the following pages. Reports, as well as photos, newspaper articles and other materials that provide greater detail on these projects are housed at the Department of Fish and Game's Endangered Plant Program.

Conclusions

The results of the Drought Relief program for threatened and endangered plants are impressive. Over a two year period, we've completed over **30 different projects throughout the State**, benefitting at least **28 State or Federally listed plant species**. Through our commitment to coordinate our efforts with other agency and academic biologists, we were able to gain the equivalent of almost **\$100,000 in matching funds and in-kind services** for these projects. The projects described in this report were carried out on over **15 different Wildlife Areas and Ecological Reserves managed by the Department**, as well as on **public lands managed by the California Department of Parks and Recreation, the Department of Defense, Bureau of Land Management and the US Forest Service**.

As impressive as these figures may be, they represent only a small step in the mission to return California's threatened and endangered plant species to healthy levels. Although the rains of 1993 may have signalled the end of California's latest 5-year drought, many species remain in a precarious position. If we're to overcome the need for crisis management of threatened and endangered plant taxa, we must continue our efforts to assess these species and develop and carry out sound management activities that will ensure their continued survival.

SPECIFIC PROJECTS

Habitat Enhancement and Management of T & E Plants

Introduction: Because we know so little about the biology of most T & E plants, methods of habitat management and enhancement are often initially experimental. In addition, the response of a plant species to habitat manipulations may vary depending on the other environmental factors influencing the plants simultaneously (e.g. drought). The objective of this part of the Drought Relief Project was to support pilot projects which will help us effectively manage T & E plant species in their native environments, especially under drought conditions.

Methods/Results: We chose projects which would provide practical information for the management of threatened and endangered plant species, which required only minimal Drought Relief funds, and which involved matching funds or in-kind services from other agencies or organizations.

Vegetation Management for Owens Valley Checkerbloom. Owen's Valley Checkerbloom is an endangered perennial plant which grows only in the wet meadows of Owen's Valley. The prolonged drought has resulted in lower groundwater table levels in the Owen's Valley leading to drier soil conditions in checkerbloom habitat and increasing competition for water from encroaching shrubs. For this project, The Nature Conservancy, Department of Fish and Game, and the Bureau of Land Management (BLM) entered into a Cooperative Agreement to undertake experimental vegetation management activities to enhance checkerbloom habitat. The objective of the project was to determine if vegetation removal had any effect on plant vigor and seedling survival and to compare two methods of removing vegetation: (1) by hand, through clipping and shrub removal, and (2) using controlled burns. In 1993, biologists from DFG and BLM established plots at the manipulation sites, mapped and recorded the number of checkerbloom plants and measured soil water potential and temperature within the plots, manually removed competing vegetation, and conducted controlled burns with the assistance of BLM fire staff. Monitoring in Spring 1994, revealed a significant decline in seedling recruitment from 1993 to 1994, but no differences between control and treatment (vegetation removal) plots. The much lower precipitation in 1994 than in 1993 was probably responsible for the observed decline. Monitoring of these plots for several more years to determine the influence of the treatments on the Checkerbloom.

Soil seedbank, germination, and genetic variation experiments for Springville Clarkia, Lyon's pentachaeta, and Humboldt milkvetch. These three endangered species are all annuals with population sizes that may fluctuate dramatically from year to year, depending on precipitation patterns. Each of these species has an extremely limited distribution: Humboldt milkvetch occurs only in Humboldt County, Springville clarkia is found only in Tulare County, and Lyon's pentachaeta grows within a 10 to 15 square-mile area on the borders of Los Angeles and Ventura Counties. The projects were carried out by University or College professors and graduate students.

The Humboldt milkvetch project involves determining whether dormant soil seedbanks exist in areas where the plant no longer seems to be present. Because this plant is now known from only one

ridgetop location, it was hoped that surrounding areas where it was previously recorded, would still support dormant seeds in the soil. Sites where the plant had previously occurred were identified through discussions with the owner of the ranch where the milkvetch grows. Over 180 soil samples were collected from these sites and sorted in the lab to locate milkvetch seeds. Only 8 seeds were found in the 180 samples. Apparently, either the soil seedbank which remains from past populations is depauperate or the location of previously recorded populations was not accurately identified. A future phase of the project, funded by The Nature Conservancy, will involve sampling over a larger area, but at lower intensities.

Lyon's pentachaeta is a small annual of the Sunflower Family (Asteraceae) that grows in openings in chaparral and other shrublands. Other annual herbs of this community are known to maintain dormant seedbanks in the soil that may carry populations through periods of environmental extremes, such as prolonged drought. A knowledge of the effects of fire or seasonal cues on germination will help us determine the likelihood of a soil seedbank for this species and the conditions which may promote high germination in the field. For this project, seeds of Lyon's pentachaeta were subjected to 12 different treatments consisting of combinations of chilling, heating, exposure to charate, smoke, varying light/dark regimes, and varying temperatures. A substantial proportion (40-60%) of the seeds tested germinated without any fire-related cues (heat, charate, smoke) and germination was similar across a broad range of temperatures. The germination tests will continue over a 12-month period and later tests will involve seeds that have been buried to simulate field conditions.

For Springville clarkia, researchers explored genetic variation and seed germination. Tissue analyses from plant material collected from several populations in 1993, show that there is less genetic variation than expected between populations of Springville clarkia, when compared to other plant species with similar life-history characteristics. This suggests that either there is currently significant gene flow occurring between populations or that populations have only become distinct from one another in the recent past. Germination tests show that fresh seeds exhibit some dormancy when compared to one-year old seeds found in old seed capsules still attached to the plants. This, in turn, suggests the possibility of a dormant soil seedbank; in fact, soil samples that were collected from three populations in late spring (after germination but before seed dispersal) did contain viable seeds which germinated under moist greenhouse conditions. One portion of this study which was to compare pre- and post-drought genetic variation in a population could not be conducted, as seeds that had been collected eight years ago, and were to serve as the pre-drought sample, failed to germinate. Although this reduced the scope of the project, it did provide valuable information on the longevity of the seeds (or lack thereof) under room-temperature storage conditions.

The effects of Spring vs. Fall burning on annuals in chaparral habitats. Controlled burning is often used as a vegetation management activity to reduce fuel loads and to improve wildlife habitat in chaparral communities. Because of the extreme wildfire danger in the Fall, however, land management agencies sometimes conduct controlled burns in the late winter or spring, during the season of active growth for many California plants. This project was initiated by the Forest Service and researchers at San Francisco State University to determine how annual chaparral species differ in their response to spring and fall burns. More than six other agencies and organizations also contributed funding to the project. Although no T & E plant species were included in this study, there are over 70 State-listed species that occur in chaparral habitats throughout the State; their

seasonal response to burning is likely to be similar to the common herbaceous species of chaparral examined in this study.

Study plots have been set up, soil samples collected and greenhouse germination comparisons are underway. The Spring controlled burn was carried out successfully in Mendocino National Forest in 1993, however due to personnel and weather problems, the Fall burn did not take place that year; it has been rescheduled for 1994. Final results of this project will be available in late 1995.

Recovery Activities for Clara Hunt's Milk Vetch

Introduction: Clara Hunt's milk vetch (*Astragalus clarianus*) is an endemic annual forb currently known from only four locations in Napa and Sonoma counties. One of the Napa populations was seriously damaged in 1990 when the drought-exposed lakebed of Lake Hennessy was excavated to expand the capacity of the reservoir. The stockpiled soil was inadvertently dumped on what was then considered to be the largest extant population of the milk vetch. The objective of this project is to promote the recovery of this damaged population and to assess the health of other populations of this species.

Methods: The bulk of the stockpiled topsoil was mechanically removed from the damaged Lake Hennessy site in 1991. Some additional soil was removed by hand over several visits in 1992. Invasive species were inventoried at the site from February to May 1993 and one test plot for exotics control was set up. Because Lake Hennessy is a public water supply, the use of herbicides as a treatment method was not permitted. Dense goatgrass was clipped twice, once in May and again in June 1993.

Population censuses were conducted at all sites in 1993 and repeated for Lewelling and Lake Hennessy in 1994. Soil samples were taken from all four sites and analyzed for physical properties, pH, and nutrient supply. Slope, aspect, and plant associations were described for all sites and rainfall data were collected from the closest field station for three of the sites.

A small pollinator exclusion experiment was conducted in 1994 to determine if the species is capable of self-pollinating.

Results: With the exception of Lewelling, all populations have shown a 40-50% decrease from the counts made in 1992. After the stockpiled soil was removed, the Lake Hennessy population rebounded with 325 plants. However, it decreased to 156 plants in 1993 and there are now from 8 to 22 different weedy species invading the site. The Alpine site decreased 40% from 4433 plants in 1992 to 2660 plants in 1993, while Bothe dropped only slightly from 109 to 101 plants. Lewelling showed a 500% increase from 1992; however, this is an artifact of the different survey methods used in 1993.

Soils were acidic at all sites and parent material was either serpentine or basalt or a combination of both. Preliminary observations indicate that only about one half to one third of flowers produce fruit. Results of the pollinator exclusion experiment suggest that the milkvetch is able to produce seeds in the absence of pollinators. It was not possible to determine if isolated flowers produced fewer seeds than open-pollinated flowers (a sign of inbreeding depression), due to high seed predation rates in the open-pollinated plants. Some evidence of herbivory and predation of fruit were observed.

Recommendations: Additional restoration activities suggested for the Lake Hennessy site include: removal of the remaining topsoil, additional exotics control, installing signage at the site, and development of an annual monitoring program. Protection and management efforts which would assist in the recovery of this species include: 1) conducting a limited control burn at the Bothe site, 2) negotiating a landowner protection agreement for the Lewelling site, and 3) conducting additional research on such topics as reproductive biology, effects of grazing, and the extent of the soil seed bank.

Loch Lomond Vernal Pool Habitat Protection Program

Introduction: The Department of Fish and Game's Loch Lomond Ecological Reserve consists of a single, 8-acre, high-elevation vernal pool in Lake County. This unique vernal pool supports the only known population of the State-listed Loch Lomond button-celery (*Eryngium constancei*). Although the land for the Reserve was purchased more than 6 years ago, we still know little about the button-celery's biology, population size or ability to withstand severe climatic conditions. This two year project was undertaken to provide a baseline census of the button-celery population, to identify the associated flora of the pool, to identify the factors which may inhibit the growth and survival of the button-celery, and to provide recommendations for management of this unique wetland habitat and the plants it supports.

Methods: Field surveys were conducted at the Reserve throughout two growing seasons and all vascular plants were vouchered and identified. The microhabitat of the button-celery was characterized and observations of herbivory and disease, as well as other factors potentially affecting growth and survival were recorded. Volunteers were organized and a monitoring system was developed to estimate the size of the button-celery population in the pool.

Results: Over 170 different plant species were identified from the pool and its adjacent upland habitat. A grid-based monitoring strategy was developed which can be used in future years to conduct a very thorough census (like that which was conducted in 1994) or to make quick population estimates, depending on the need at the time. In addition to the project lead and DFG employees from Headquarters and Region 3, volunteers from the California Native Plant Society and the US Fish and Wildlife Service participated in the Spring 1994 census; the post-drought population of Loch Lomond button-celery in the pool was estimated at over 1.9 million plants. Because the census was very thorough (a complete count of all button-celery plants in 1 square meter was made every 16 square meters throughout the pool) any significant change in the number of button-celery plants in the future due to drought, roadway chemical spills, changes in adjacent forest cover, etc., should be evident. A draft management plan for the preserve was also produced, with the assistance of Department staff, which focused on protection of the pool's unique resources.

Recommendations: The button-celery population on the Reserve appears to be vigorous and healthy at this time. The boundaries of the Reserve extend only a few meters up from the edges of the pool, however, leaving most of the pool's forested watershed unprotected. The owner of one adjacent parcel recently contacted the Department with an interest in selling his property; the Department is currently considering acquisition of this site. Protection of the rest of the pool's watershed should remain a high priority. Interpretive signs should also be installed at the Reserve to educate local people of the pool's value; this may also help reduce vandalism to the Reserve's split rail fence which has been partially dismantled in the past.

Chorro Creek Bog Thistle Recovery Project

Introduction: Chorro Creek bog thistle (*Cirsium fontinale* var. *obispoense*) was State-listed in 1993. It occurs only in San Luis Obispo County, where its habitats are very localized in springs and seeps on serpentinite-derived soils. Prior to this project, only 12 sites were known for the species, and the type locality on Chorro Creek had apparently been extirpated. Little is known of the ecology of the bog thistle, particularly of the susceptibility of existing populations to environmental stresses, such as drought. The objective of this study was to assess the health and threats to existing bog thistle populations and to investigate the feasibility of reintroduction into historic habitat.

Methods: New populations and potential reintroduction sites were surveyed and mapped within the historic range of the bog thistle, using geological and hydrological criteria. Sites were prioritized in terms of potential for permanent protection. Life-history data was collected for a subset of existing populations, and data on potential threats were gathered for all existing and newly discovered populations.

Results: A total of 10 populations and subpopulations of the Chorro Creek bog thistle were discovered, one of which was the presumed extirpated Chorro Creek Reservoir site. At least 5 of 29 sites surveyed for populations of the bog thistle were deemed to have a high potential as reintroduction sites, based on persistence of water during drought, grazing pressure, and potential for permanent protection and management. The protection status, population health, and population size were determined for the 22 extant populations and subpopulations. Nineteen were judged to be healthy with stable or increasing population sizes. Seventeen sites are located on private lands, and at least 6 of these were judged at high risk from development. Appropriation of spring waters represents a threat to plants in the San Simeon Creek area, and sites at Froom Ranch are threatened by active development plans. Ecological and life-history data indicated that while grazing itself is generally not a threat, trampling by cattle can cause considerable damage and mortality to plants, and may represent a moderate threat at some sites.

Recommendations: If reintroduction efforts are to be undertaken, consideration of potential sites should include the following criteria: (1) year-round moist soil conditions, even during dry years; (2) serpentinite bedrock below the spring; (3) the typical black boggy soils of serpentinite bogs; and (4) the ability to protect and manage a site. The sites which fit these criteria include two in Poly Canyon, two at South Street Hills, and several at Cuesta College Hills.

Recovery of Endangered Wetland Plants in Black Lake Canyon

Introduction: The wetlands of Black Lake Canyon, in San Luis Obispo County, contain two of California's most endangered plants, the marsh sandwort (*Arenaria paludicola*) and Gambell's watercress (*Rorippa gambellii*). Because of the extreme rarity of these species, immediate efforts were needed to assess their health during the drought and to ensure their survival in the face of this and other environmental stresses. The purpose of this project was to assess the current status of these species, explore methods of propagating them to increase seed reserves (for future recovery activities), characterize their habitat, explore their reproductive biology and the possibility of dormant seeds in the soil seedbank. Matching funds for the project were provided by a National Science Foundation Grant awarded to the Principle Investigator at UC Santa Barbara.

Methods: The number of individuals of both species were estimated at Black Lake Canyon in 1993. Micropropagation of the species was also initiated in 1993 using cuttings from wild plants which were rooted in the greenhouse and later further divided. Soil core samples were collected from the populations on four separate occasions, from June 1993 to March 1994 and were placed under conditions appropriate for seed germination. Associated species were identified within the populations and preliminary studies of the potential breeding system of Gambell's watercress were conducted in 1993 and augmented in 1994.

Results: In 1993, only 10 marsh sandwort plants survived to flower at the Black Lake Canyon site, while more than 50 plants of Gambell's watercress matured. Seeds of both species germinated from the soil samples that were collected in 1993, suggesting that a soil seedbank exists which may provide a small reserve for these populations during periods of drought or other climatic extremes. The plants from the soil samples and the individuals which developed from the single-cutting grew vigorously in the greenhouse throughout the winter of 1993/94, but failed to flower, even when subjected to various temperature and light regimes in the growth chambers, greenhouse, and outside. Plants of both species are still being grown at SBSU in an effort to induce flowering.

In the field in 1994, survivorship to maturity of Gambell's watercress seedlings was over 90%, suggesting that this is not one of the factors responsible for the small population sizes of this species. Fruit production is as high in plants isolated from pollinators as it is in plants open to pollinators, indicating that Gambell's watercress is capable of self-pollinating.

Recommendations: These plants remain critically endangered and the failure of plants to flower in the greenhouse underscores the importance of protecting the habitat in Black Lake Canyon where populations currently grow. Using the habitat characteristics of the species identified during this project, suitable habitat near Black Lake Canyon and other historic sites should be searched for these species. If no additional populations are discovered, alternative methods of inducing flowering in propagated plants should be explored in an effort to bulk seed.

Monitoring and Management of Drought Affected Populations of Palmate-bracted Bird's Beak,

Introduction: Palmate-bracted bird's beak (*Cordylanthus palmatus*) is an endangered annual plant which grows in alkali ephemeral wetlands of California's Central Valley. Like other wetland plant species, the bird's beak may experience lowered reproductive success during drought years due to water stress and loss of habitat to encroaching nonnative upland species. The objective of this project was two-fold: (1) to determine how various environmental factors and management techniques influence species viability and (2) to produce a simple means of annually assessing population sizes at the Springtown Alkali Sink. Past monitoring of this species was funded by the US Fish and Wildlife Service and the Department of Fish and Game. This project received donated labor from faculty and students at University of Nevada, Las Vegas.

Methods: Using monitoring data collected over the past four years, researchers developed and tested a simple method of estimating population sizes at the Springtown alkali sink in Alameda County. Other known populations in the Central Valley were visited and their sizes estimated. Studies were conducted to identify pollinator species and to determine their role in the reproductive success of palmate-bracted bird's beak. Graduate students at University of Nevada analyzed tissue samples collected from remaining populations of bird's beak in Colusa, Alameda, and Fresno Counties to determine genetic variability among and within populations. Soil parameters, including salinity, pH, and profile development were analyzed in an effort to identify which soil factors correlate with species distribution. The influence of fire on bird's beak habitat was also investigated by establishing plots in areas recently burned by a small wildfire.

Results: The simplified monitoring methodology should allow DFG biologists or volunteers to obtain an accurate estimate of population sizes with a minimum of effort. Populations in the northernmost part of the bird's beak range, at Colusa and Delevan National Wildlife Refuges (Colusa Co.) are the largest, containing 10,000 - 100,000 plants in 1993, while those in the southern end of the species range at the DFG Mendota Wildlife Area (Fresno Co.) are the smallest with only 400-500 plants. The Springtown population, centrally located within the range, was the most methodically censused and contains an estimated 10,000 - 12,000 plants.

Bumblebees (*Bombus* species) appear to be the primary pollinator of palmate-bracted bird's beak and insect pollinators are necessary for successful fertilization and seed production in this species. Based on the genetic analyses, researchers determined that the southernmost population is genetically distinct, while the two large northern populations are quite similar (genetically) to one another. The central population at Springtown is intermediate. The results of the comparison of burned and unburned plots in the wetlands suggests that native species in the bird's beak habitat are favored by burning; cover of native species in the plots that were burned was almost twice that found in unburned plots. Finally, researchers found that soil pH and soil profile development best account for the distributional patterns of the bird's beak.

Recommendations: Volunteers should be recruited to monitor the bird's beak at the Springtown Alkali Sink annually, so that accurate assessments of the plant's response to precipitation patterns can be made. It appears that the use of controlled burns may be a means of restoring bird's beak habitat where nonnative species are dense; further investigations are needed in this area, particularly to determine how the bird's beak responds to controlled burns conducted during different seasons and how long the results of a burn positively influence this species habitat. Special management attention should be focused on the bird's beak population located at DFG's Mendota Wildlife Area as it appears to be genetically distinct and is one of the smallest populations of this species in existence.

Cuyamaca Lake Downingia Habitat Restoration

Introduction: The inundated portions of the Cuyumaca Valley and the surrounding streams and swales that drain into them support the Cuyumaca Lake Downingia (*Downingia concolor* ssp. *brevior*), a State-listed endangered plant taxon found nowhere else in the world. Many drainages in the moist meadow habitat of this species are eroding into deep channels due to past overgrazing, mining, logging, and water diversions. Continuing erosion of these channels leads to rapid runoff during storm events, reduced overland flow, and scouring of channel edges, further removing soil; the Downingia cannot grow where this occurs. In Cuyamaca Lake State Park, some drainages have been obstructed by the dumping of fill dirt; other channelization is occurring due to excessive horse use in moist meadows. The objective of this project was to restore drainages and meadows to increase the habitat available for this endangered species.

Methods/Results: This project was carried out by a Research Scientist and students from San Diego State University (SDSU), with some assistance from the local Park personnel. An extensive literature search of the causes of erosion in meadows, methods of erosion control, and the history of land use and erosion in the Cuyumaca Valley was conducted. Project staff then made an assessment of the hydrology of the area where Downingia grows in Cuyamaca State Park. Initially, a plan to restore the drainages around little Stonewall Creek was developed. Although the appropriate approvals were obtained from the State Park authorities during the planning of the restoration, due to changes in Park's personnel during the intervening months it could not be carried out as planned. Restoration activities undertaken during this contract include:

- (a) Introduction of Downingia to unoccupied suitable habitat within its historic range. Seeds of Downingia were collected in the spring of 1993 and 1994 from those populations vigorous enough to withstand seed collection. In Spring 1994, the first seeds were introduced to four locations on State Park lands, two undisturbed habitats and two restored habitats.
- (b) Removal of old road fill from drainages which should be able to support Downingia when restored. Fill was removed from the drainage of an old homesite within the Park by hand. Downingia seed from a site downstream was introduced to the restored site in summer 1994.
- (c) Installing erosion control devices along two channelized trails in Paso Picacho meadow. Erosion control devices composed of several different materials (broom corn, bamboo, brush, and cleaned rice straw) were installed in 1994. In several years, the effectiveness of the different materials for restoration efforts throughout the Park can be compared.

Recommendations: Monitoring of the Downingia seed introduction sites should continue for several more years to determine if the taxa becomes established. Using the baseline data gathered during this project on channel depth, width, and number of scour holes, the effectiveness of the different erosion control materials should be assessed in two to three years.

San Diego Vernal Pools Habitat Protection and Restoration

Introduction: Vernal pools provide habitat for State-listed threatened or endangered plant and animal species throughout California. Unfortunately, they are being lost or degraded by human activities at an alarming rate. Vernal pools that have been degraded often have diminished water-holding capacity and are more likely to be colonized by nonnative weedy species than pristine pools, reducing their ability to support the characteristic native pool flora. During prolonged drought these effects become more severe and, even in pristine pools, competition from nonnative upland weeds may increase. The objective of this study was to restore degraded vernal pools in San Diego County to provide high-quality habitat that could be colonized by sensitive or listed vernal pool species.

Methods: A 120-acre parcel of vernal pools in need of restoration was identified at the Miramar Naval Air Station, San Diego County. Road construction and farming or ranching had degraded the site early this century. More recently, extensive off-road vehicle use had damaged and destroyed pools.

Aerial photographs were used to identify areas where vernal pools had occurred on the parcel prior to its degradation. This was followed by surveys of the site to assess the condition of soils and vegetation, to identify rare species in the pools, and to determine which areas had saturated soils in the winter or showed evidence of ponding. Based on this information, areas with the appropriate clay soils or hardpan were chosen for excavation and resculpting, which took place in Fall 1993.

When earth moving was complete, the pools were inoculated with seed salvaged from nearby pools that were being destroyed by development. Approximately 360 boxes of duff and seed were scattered onto the new pools and mounds. Jute was placed on the mounds to reduce erosion. The source and amount of seed used in each pool was recorded and the length of inundation and vegetation establishment in the new pools was monitored throughout the spring of 1994.

Results: Two State-listed species, Otay Mesa mint (*Pogogyne abramsii*) and Parish's button-celery (*Eryngium aristulatum* var. *parishii*) were found in intact pool clusters on the site and were also present in the source seed for the restored vernal pools. Both species were therefore added to the resculpted pools. During the first spring following resculpting, the waterholding capacity, length of inundation, and vegetation establishment varied dramatically between pools. Some of the new pools may need slight recontouring or improved control of erosion during winter storms; monitoring during the next two years will help determine where additional work is needed. Of the listed species, the mesa mint survived to reproduce in all of the restored pools to which it was introduced and the button-celery survived in about 75% of the pools to which it was introduced. Some labor was donated to this project by the US Navy; the Project Lead (a plant ecologist from San Diego State University) also recruited student volunteers from SDSU to help carry out many of the restoration activities. Several students conducted individual study projects at the restoration site during the 1993-1994 school year. The U.S. Navy will fund continued monitoring of these pools for at least another three years.

Recommendations: Remedial actions which should be taken to improve the performance of some pools include: placement of additional jute on the mounds to reduce erosion, additional manual moving of earth to even the contours of some pools, and weed removal.

Cooperative Recovery Planning for T & E Plant Species (Statewide)

Introduction: One possible means of ensuring that sensitive species persist through cyclical, natural stresses such as drought is to improve their overall status. Before this can be accomplished, it is necessary to assess the species overall health, and gather the necessary baseline information required to make sound management decisions. The Endangered Plant Program (EPP) sponsored the first series of recovery workshops in 1993 to promote assessment and recovery of several high priority species. At each workshop, a species overall status is evaluated and recovery needs are identified. In addition, a list of management actions and tasks that participants can volunteer for and can realistically complete within about 18 months is developed. Several of the management actions identified at the 1993 workshops have been undertaken using drought funds. To facilitate the assessment process, EPP has also developed a species management data base to track information on management actions, recovery needs and funding.

Methods/Results: EPP in coordination with regional staff, selected a pilot group of high priority species and natural communities for assessment and recovery efforts. Information on current research, management, and mitigation activities was compiled and entered into the species management data base and summary reports were generated for use at the workshops.

Four recovery workshops were conducted involving five state-listed species and one sensitive community: the San Diego thormmint (*Acanthomintha ilicifolia*), Munz's onion (*Allium munzii*), slender-horned spineflower (*Dodecahema leptoceras*) and its associated alluvial fan sage scrub community, Otay tarplant (*Hemizonia conjugens*), and Santa Cruz tarplant (*Holocarpha macradenia*). Participants included state, federal, and local agency personnel, representatives from the academic community and local botanists. After reviewing the species' status, recovery needs and management actions were identified. Participants at each workshop volunteered to take on some of the recommended actions.

Reports summarizing each workshop were prepared and distributed and accounts in the species management data base were updated to include recovery needs and management actions identified in the workshops. Information was compiled and entered and summary reports generated for 33 species or 50% of the high priority taxa initially identified by EPP for entry into the data base. The system was refined to allow links to other important data sets and was demonstrated to departmental staff and interested outside agencies to solicit additional comments and suggestions for development.

Drought funds have contributed to completion of several high priority tasks identified in the workshops. Assessment of the post-drought size and health of populations of the San Diego thormmint and Otay tarplant have been conducted and community sampling of alluvial fan sage scrub has begun. A cooperative effort with the U.S. Forest Service to fence a site for San Diego thormmint has begun and should be completed in the Fall of 1994. Academic grants are funding genetic research for both Munz's onion and San Diego thormmint.

Recommendations: Tracking and implementation of high priority management actions should continue. Follow-up workshops should be conducted for species reviewed in 1993 and additional workshops should be held for new species in 1994-95. The data base should continue to be used for species assessment and conservation planning and additional high priority taxa should be entered.

San Diego Thornmint Population Assessment following Drought

Introduction: San Diego thornmint, a State-listed endangered plant, grows in grasslands in clay soils in western San Diego County. In addition to the extensive urbanization of its habitat in this fast-growing area, the thornmint appears to be threatened by weedy, nonnative species once the clay soils in which it grows are disturbed. In 1993, the Department of Fish and Game sponsored a Recovery Workshop for this species. As a result of that workshop, Department botanists realized that vital information on the health and current status of known populations of this species was missing. No thorough surveys of the thornmint populations had been conducted in over 6 years, a period which encompassed five years of drought and extensive construction in western San Diego County. The objective of this project was to assess the health of all populations on public land and some populations on private land, record their vigor, size, probability of protection (or maintenance), and perceived ability to persist through environmental stresses (e.g. drought).

Methods: Using information from the Natural Diversity Data Base and assessors office, parcels where the thornmint occurred were identified and their owners contacted for permission to enter. Most populations were visited during the period of peak flowering and information was gathered on population size, area covered, vigor, habitat characteristics (including density of nonnative weedy species), and feasibility of protection. At each site, Investigators photographed individual plants, the habitat, and associated species and remapped the population if the Data Base information was incorrect.

Results: Twenty element occurrences (EOs) that were presumed extant were surveyed. At only one of these sites were the surveyors unable to find a thornmint population; from the condition of the habitat they believe the population originally found at this site may be extirpated. At two sites, the surveyors discovered additional subpopulations. About one-half of the sites surveyed during this project supported thornmint populations that equalled or exceeded past population size estimates.

Of the four transplant sites surveyed, two appeared stable and were small (30 and 160 individuals), one had declined and one appeared to be doing well. The most robust populations appeared to be those that occurred in undisturbed habitat with few nonnative weedy competitors.

Recommendations: Site specific management recommendations are available in the report prepared for this project. For the species as a whole, the known thornmint sites that could not be visited during this project should be surveyed within the next two years. Identifying landowners and obtaining permission to visit sites on private land is a very time-consuming process and should be started six months before the visits are to be made.

Endangered Plant Habitat Protection and Restoration on Public Lands (statewide)

Introduction: In some instances, grazing may be a useful management tool to reduce densities of nonnative species encroaching on rare plant populations. When it is unregulated, however, grazing may damage or degrade publicly owned areas which support State-listed threatened or endangered species. During periods of prolonged drought, impacts to sensitive species such as crushing and trampling of plants, soil compaction and introduction of nonnative species can be amplified as herbivores expand their range in search of scarce forage. In addition, plants which have been drought stressed for long periods may be less able to recover from the effects of grazing. The objective of this project was to promote the recovery of endangered plant populations by protecting habitat at selected sites on public lands.

Methods/Results: The majority of sites chosen for protection efforts were on Department of Fish and Game Ecological Reserves, with two additional locations on BLM and USFS lands.

A cooperative fencing effort with the BLM is in progress at River Spring Lakes in Mono County, to protect an alkali meadow and spring area supporting several sensitive plant and animal species. Unauthorized grazing by sheep and cattle have damaged portions of the sensitive wetland community. The Department and the BLM own adjoining lands which, when fenced, will protect the spring and meadow from further damage.

Portions of two ecological reserves in Tulare County were fenced to protect populations of Kaweah brodiaea (*Brodiaea insignis*) that had been damaged by cattle wandering onto the Reserve from adjacent lands in search of forage. Approximately 25 acres of a large meadow were protected at Blue Ridge Ecological Reserve; at the Kaweah Brodiaea ER, both sides of an easement were fenced to prevent cattle from straying into the reserve while being moved through it. Crews from the California Conservation Corps constructed both fences.

Nonnative broom was removed from the DFG's Corte Madera Ecological Reserve in Marin County. Native shrubs will be planted at the site in late Fall 1994. Work was carried out by the California Conservation Corps.

Degraded sites within the BLM's Clear Creek Recreation Area were fenced to protect the San Benito Evening primrose (*Camissonia benitensis*) which occurs along serpentine alluvial terraces within the Clear Creek watershed. This area supports a number of sensitive species as well as unusual botanical resources such as small vernal ponds and serpentine-based riparian habitat. BLM staff provided all labor for fence construction at this site.

An existing boundary fence at Hill Slough ER was repaired and secured to protect the endangered soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*). Fencing materials remaining from this project will be used on additional ecological reserves in Region 3 such as Fagan Slough, Bonny Doon and Laguna De Santa Rosa to protect other sensitive plant populations.

Approximately 2-3 miles of barbed wire fence were constructed on the Cleveland National Forest, where populations of the San Diego thormint (*Acanthomintha ilicifolia*) had been adversely affected by unauthorized cattle grazing. Matching funds for this project were provided by the US Forest Service.

Recommendations: Research on timing, frequency, and intensity of grazing may be necessary for sites which show serious encroachment by annual grasses in the absence of grazing.

Identification and Mapping of Sensitive Wetland and Upland Communities at Ash Creek Wildlife Area.

Introduction: Wetlands are one of California's most critical resources for plant and animal species and are therefore a focus of many management efforts. Already threatened by conversion to agriculture, water diversions, and pollution, wetland habitats and the array of plant communities they support are particularly vulnerable to the effects of prolonged drought. Changes in site hydrology may facilitate invasion by aggressive nonnative species which can outcompete the native mesic species or bring about undesirable ecological/successional changes in the communities. The objective of this study was to inventory the major plant communities of the Ash Creek Wildlife Area; evidence suggests that the recent drought may have intensified adverse effects of surface water diversions on these communities. This baseline information will be valuable in management of the Ash Creek Wildlife Area in both high and low rainfall years.

Methods: False color infrared aerial photos of the Wildlife Area were taken in early summer. Field surveys were then conducted to verify plant community types discernable on the photographs. The photos were analyzed and the different plant communities delimited. A series of vegetation maps showing the size and distribution of the different communities was prepared. Each community was briefly described and a list of the common associates prepared. The vegetation maps were digitized and put into a Geographic Information System.

Results: The Ash Creek Wildlife Area supports approximately eight major plant communities, four of which comprise a wetland complex which covers over 50% of the area's 14,163 acres. These four communities are transmontane freshwater marsh, transmontane alkali marsh, alkali meadows and Great Basin riparian scrub. Additional communities include northern basalt flow vernal pools, upland sagebrush steppe, alkali scrub and Great Basin juniper woodland. Twenty-five percent of the Wildlife Area is disturbed.

Maps, descriptions of the plant communities, species lists, and aerial photos of the Wildlife Area will be distributed to Department staff involved in its management.

Recommendations: Future management efforts should focus on restoring and/or maintaining the natural drainage patterns into the wetland regions. Actions to increase water retention on the Wildlife Area could include increasing the flows of Ash Creek and the Pit River, raising the water table by stabilizing natural banks, or installing check dams at strategic locations in inflow channels. Future development of levees or ponds should be limited to disturbed areas and grazing should be avoided or restricted from areas which support vernal pools. In addition, all pools should be surveyed for floristic composition and health, and their restoration needs should be identified.

Rare Plant Surveys at the Antelope Valley, Smithneck Creek and Crocker Meadows Wildlife Areas (Sierra and Plumas Counties)

Introduction: As a result of the recent drought, the Department of Fish and Game proposed timber harvests and prescribed burns on three Wildlife Areas in order to improve deer forage and reduce fuel loads. The purpose of this project described here was to locate, map, and mark populations of sensitive plant species that may be affected by the proposed management activities in the Wildlife Areas.

Methods: Researchers conducted detailed field surveys of the three reserves to locate, map and characterize rare plant populations, recommended measures to avoid long-term impacts to sensitive plants and gathered baseline data to monitor short-term impacts to rare plant populations that result from management activities.

Results: Thirty-eight populations of four sensitive species were located, including thirty populations of Sierra Valley ivesia (*Ivesia aperta* var. *aperta*), six populations of Sierra Valley evening-primrose (*Camissonia tanacetifolia* ssp. *quadriperforata*), one population of Lemmon's clover (*Trifolium lemmonii*) and one population of dwarf draba (*Cusickiella douglasii* var. *crockeri*). In the Antelope Valley Wildlife Area three populations of ivesia and two populations of evening-primrose will be within a proposed timber harvest area. In the Crocker Meadows Wildlife Area eight populations of ivesia are in, or on the border of, a prescribed burn area. Three ivesia populations in the fire zone and one population out of the zone have been marked as permanent sample plots to assess plant recovery from fire. In the Smithneck Creek Wildlife Area eight populations of ivesia and one population of evening-primrose are in, or on the border of, a prescribed burn area. Three ivesia populations in the fire zone and two out of the zone have been marked as permanent sample plots to assess plant recovery from fire.

Recommendations: In the Antelope Valley Wildlife Area, researchers recommended minimizing impacts to the affected populations by creating buffer zones, alternate road sites and "no fueling, no maintenance" zones. In the Crocker Meadows Wildlife Area and the Smithneck Creek Wildlife Area, researchers recommend that the fire area be altered to avoid populations on the border of the proposed burn. Researchers have, additionally, identified wetlands issues and made recommendations to minimize wetland impacts from the proposed management activities on all three sites.

Monitoring and Management of Drought-affected Populations of Large-flowered Fiddleneck (*Amsinckia grandiflora*) and San Mateo Thornmint (*Acanthomintha duttonii*), 1993-4

Introduction: Large-flowered fiddleneck and San Mateo thornmint are two critically endangered grassland species whose entire distributions include only two to three sites in the Bay Area. The objective of this study was to establish new populations of these two plant taxa and to monitor and maintain natural and reintroduced populations using habitat enhancement activities. The results will be incorporated into a long-term management plan for both species.

Methods: Large-flowered fiddleneck: Originally the project proposed to use controlled burns to reduce competition by nonnative grasses in the fiddleneck populations, however, weather conditions and difficulties with fire personnel prevented several of the planned burns. Recovery activities were conducted at five fiddleneck sites. At two reintroduction sites, investigators established experiments to test the demographic performance of seeds from the newly discovered Carnegie Canyon population to seeds from previously discovered populations. If the Carnegie Canyon seeds show superior growth or reproduction in a variety of habitats it may be important to include seeds from this source in future reintroductions of this species. At two other reintroduction sites, an effort to compare methods of controlling nonnative grasses was undertaken. Half of the plots at these sites were burned and then treated with a grass specific herbicide while the other half of the plots were left untreated to act as controls. A controlled burn was also successfully conducted at one reintroduction site now in its fourth year.

In addition, researchers worked with the owner of a reintroduction site located on a private ranch, to design a fence that will offer protection for the fiddleneck while still allowing grazing on the property. At the natural population, which grows on land managed by Lawrence Livermore Laboratories, four subpopulations were treated with grass specific herbicide to try and control nonnative grasses that threaten the fiddleneck.

San Mateo thornmint: Continued recovery activities for San Mateo thornmint included streak sowing twenty new plots at the reintroduction site and efforts to uncover a dormant soil seedbank at the natural site in Edgewood County Park.

Results and Recommendations: Since this project is one phase of a continuous restoration/reintroduction project, results will be presented in an annual report to be submitted at the end of 1994.

Monitoring and Management of Soft bird's beak

Introduction: Soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*) is an endangered annual plant now found only in the salt and brackish marshes of Napa, Solano, and Contra Costa Counties. Several historic sites have been extirpated and declines were reported for several other populations during the recent drought. The purpose of this project was to determine the status of existing populations, and to explore the life history and environmental factors which may influence the population dynamics and management of this species.

Methods: The most recent location and population information was assembled from the Natural Diversity Data Base and other sources. All known sites of the species were visited and their population sizes estimated. The habitat of soft bird's beak was characterized by recording tidal inundation, elevation, and associated plant species. Timing of field germination and phenology was also observed over a full growing season. Patches of plants were marked and mapped to determine the extent of their movement from year to year. Observations of flower visitors, seed production and seed predation were also recorded.

Results: Eight populations of soft bird's beak were found to be extant in 1993. Their sizes ranged from a low of 23 plants at one site in Contra Costa County to a high of 141,000 plants at the DFG's Hill Slough in Solano County. Six of the populations contain from 11,000 to 21,000 plants. In 1993 and 1994, germination in the field occurred from late November or early December through April. Flowering started in May and continue through August, with a few plants producing flowers as late as November in 1993. At one site, seed production was estimated to be about 500 seeds/plant. Possible pollinators include bumblebees and other native bees from the families Megachillidae and Halictidae. The two species found growing with soft bird's beak at all sites were woody pickleweed and saltgrass; fat-hen (*Atriplex triangularis*) and marsh dodder (*Cuscuta salinia* var. *major*) were associated with soft bird's beak at seven of the sites.

Recommendations: Most recommendations are site-specific; they include: maintaining the natural tidal inundation in bird's beak habitat, restricting access where livestock use or recreational use appear to be damaging populations, removing stands of nonnative species, monitoring the water-quality of drainages into bird's beak populations, and restoring habitat degraded by ditching or levee construction.

Management of Sandhill Habitats in Santa Cruz County

Introduction: The Sandhills of Santa Cruz County support unique associations of plants found nowhere else in California. These communities occur on specific sandy, well-drained soils and their open, park-like appearance is in contrast to the moist evergreen forests in surrounding areas. Sand Parkland, the rarest of the Sandhills communities, is characterized by widely spaced Ponderosa pines, with scattered shrub cover and many showy annual herbs. Several State and Federally listed plants occur in these communities, as well as unique varieties of species more common outside Santa Cruz County. Sand mining and residential development have reduced most of the sandhill communities to small fragmented patches. Fragmentation may lead to loss of gene flow between once continuous populations of rare species, reduction in the natural fire frequency, and the spread of nonnative species, especially nonnative annual grasses. Human-induced stresses may be compounded when plants are also subjected to natural stresses, such as prolonged drought. The purpose of this project was to determine the current status of the Sandhill communities, assess the "health" of remaining patches of Sand Parkland, and develop recommendations for their protection and management.

Methods: Sandhills vegetation was mapped using soil maps and aerial photos, followed by ground surveys. The primary sandhill communities, Sand Parkland, and Sand Chaparral, were defined using releves. Historical distribution of the communities was estimated using information from soil maps, aerial photos, the literature, and personal contacts. The health of remaining patches of these communities was assessed based on abundance and cover of native and nonnative plant species, amount of human disturbance, and related criteria. Land uses in these communities were determined using County zoning information.

Results: Approximately 1,070 acres of Sand Chaparral remains in Santa Cruz County, while only about 193 acres of Sand Parkland remains. This represents little more than 30% of the estimated original extent of Sand Parkland. Of these 193 acres, only 32 are considered high quality habitat based on the assessment conducted during this project. The remaining acreage has been degraded by a variety of factors, but has the potential for restoration. Many stands of Sand Chaparral have not been burned recently and are becoming so dense that they are losing their complement of annual herbs.

Four zoning designations encompass Sandhill habitats: Residential, Mining, Timber Production, and Special Use. The Special Use designation encompasses the majority of these communities; it permits usages as diverse as single-family dwellings and industrial development as long as the development follows the County General Plan.

Maps showing the Sandhills communities and the current County zoning will be housed at the DFG Region 3 Office. A brochure to educate residents of Santa Cruz County about these unique communities is also being partially funded through this project.

Recommendations: Site specific recommendations focus on protecting, through zoning and easements, those remaining patches of high quality Sand Parkland, restoring sites that have been degraded by recreational use, and using fire or other suitable means to restore a balance of successional stages to the DFG Quail Hollow Ecological Reserve.

Research is needed on such topics as the dynamics of the soil seedbank, the biology of rare species, and the timing and effectiveness of prescribed burning as a management tool.

Management of populations of California jewelflower and two Federally listed endangered plant species on the Carrizo Plain

Introduction: Habitat loss through agricultural conversion, petroleum production and urban development has contributed to the decline of many species endemic to the arid habitats of the San Joaquin Valley. Species that have been eliminated from a large portion of their historic range, such as the endangered California jewelflower (*Caulanthus californicus*), may be especially vulnerable to the cumulative effects of drought. This annual species is currently restricted to several small populations in the western portion of its historic range. The objective of this study was to evaluate the effects of livestock grazing and examine the interactions of the federally-listed giant kangaroo rat with several endangered plants at the Carrizo Plain Natural Area (CPNA). This study is part of a larger cooperative recovery effort funded by the US Fish and Wildlife Service, U.S. Bureau of Reclamation and the BLM in the southern San Joaquin Valley.

Methods: Demographic data was collected for the jewelflower, Hoover's wooly-star (*Eriastrum hooveri*), and San Joaquin wooly-threads (*Lembertia congdonii*) at fourteen study sites in the southern San Joaquin Valley. Time constraints prohibited controlled grazing studies; however, demographic monitoring was carried out for the wooly-threads and wooly-star at sites where populations were divided into grazed/ungrazed portion by fences. Plant communities were characterized at all sites and associations between giant kangaroo rats and the jewelflower and wooly-threads were investigated on the Carrizo Plain.

Results: Jewelflower: Populations were monitored at the CPNA and in the Kreyenhagen Hills in Fresno County. Population sizes ranged from 200 plants at Kreyenhagen to 1500 plants at CPNA. Plants at CPNA were significantly greater in size and fecundity than those in the Kreyenhagen Hills. In addition, the jewelflower was significantly associated with giant kangaroo rat precincts (areas with high concentrations of burrows) at the CPNA; however, plants growing on precincts did not differ in size or reproduction from those growing off precincts.

Wooly-star: Monitoring was conducted at four locations, from the CPNA in the south to Jacalitos and Kettleman Hills in the north. Population estimates were generally less than 10,000 individuals. Data collected on grazed vs. ungrazed areas at one site in the Kettleman Hills suggest that 1) survival was higher on the grazed sites, 2) plants were taller in ungrazed areas, and 3) fecundity did not differ due to grazing.

Wooly-threads: Seven populations were monitored, from the Panoche Hills in Fresno County to the CPNA in the south. Population sizes ranged widely from two million at one site on the CPNA to 72 plants at the Jacalitos Hills. Plants at CPNA, Elkhorn Plain and Kettleman Hills showed exceptional plant size and flower head production compared to the other two sites. In general, grazing appears to have been beneficial to reproduction on the CPNA and in the Kettleman Hills, and had no effect or was detrimental on the Elkhorn Plain. Responses to giant kangaroo rat precincts varied for the two populations studied.

Recommendations: California jewelflower should receive highest priority for future monitoring and research because it has a more limited distribution and fewer individuals than either the wooly-threads or the wooly-star. Possible areas for additional research include: 1) site conditions affecting plant performance and 2) the importance of variables such as precipitation patterns, soil nutrient levels and competition. In addition, more rigorous research is needed on the impact of livestock grazing for both the jewelflower and the wooly-threads. Monitoring of the populations should continue in order to determine long term population trends for these species.

Monitoring and Management of Drought Affected Populations of *Sidalcea pedata* and *Thelypodium stenopetalum* at the Department of Fish and Game's Baldwin Lake Ecological Reserve, 1993/94.

Introduction: The bird-foot checkerbloom (*Sidalcea pedata*) and slender-petaled thelypodium (*Thelypodium stenopetalum*) are two State-listed species endemic to the moist meadows and pebble plains of Big Bear Valley in San Bernardino County. This project is part of a continuing study (started in 1989) to collect baseline data on species demographics in reference to rainfall. Populations for both species have been low during the drought years and there is concern that species viability will be adversely affected by continued drought.

Methods: The sampling protocol first developed in 1989 and refined in 1990 was used to determine demographic trends in populations of the checkerbloom and thelypodium on the Department's Baldwin Lake Ecological Reserve. Measurements recorded for the checkerbloom included total number of plants per plot and life history (divided into first year, flowering and non-flowering). For one plant in each plot, numbers of vegetative stems, flowering stems, buds, flowers and fruits and length of the longest flowering stem were recorded. Measurements recorded for thelypodium included total number of plants per plot, life stage (rosette or flowering), number of buds, flowers and fruits, height of plant, diameter of basal rosette, and number of flowering stems. Researchers added the 1993 and 1994 data to that from previous years and compared it to rainfall data collected over the past 5 years.

Results: Checkerbloom plant numbers increased by 29% from 1992 to 1993. The total number of flowering plants remained the same as 1992, however, flower numbers dropped 27% and fruit numbers dropped 52%. Of the individually marked plants, flower numbers dropped from 21 flowers per plant in 1992 to 7.6 in 1993. Since the monitoring started in 1990, 33% of the marked plants have flowered all four years and 19% that did not flower in 1990 have flowered every year since. Browsing remained relatively constant from 1992 to 1993. Researchers noted that the number of first year plants have continuously declined since 1991 and they attribute this phenomena to a depletion of the soil seedbank. The first year of average rainfall following the drought in this area occurred in 1991. Finally, they note that fruit production has increased with rainfall. Populations expanded to new sites in 1993.

The number of thelypodium individuals increased by 74% in 1992 and again by 83% in 1993. Flowering plants have increased from 13 in 1989 to 415 in 1993. Non-flowering plants have increased from 9 in 1989 to 1146 in 1993. Plant populations are responding well to the increased rainfall of 1992 and 1993. Fruit production has also increased with rainfall. Browsing was widespread throughout the sampling plots in 1993 and probably reduces the number of fruit that reach maturity. Populations expanded to new sites in 1993.

Seeds of both species were collected for longterm storage at Rancho Santa Ana Botanic Garden in 1994.

Recommendations: Researchers suggest that monitoring continue for both populations through a 10 year cycle to understand population response to long-term rainfall patterns. Populations have responded well to increased rainfall, however, more data is necessary to develop a long-term management strategy. Researchers also suggest studying the longevity, reproductive output, and seed viability in both species. For the checkerbloom, researchers recommend a study of rootstock dormancy.

Inventory of Sensitive Botanical Resources at Calhoun Cut Ecological Reserve

Introduction: Vernal pools and other ephemeral wetlands are important to many plant species unique to California. During drought, the species which occur in these communities may be stressed by low winter water levels, rapid loss of soil moisture in the spring, and competition with nonnative species. At the Department of Fish and Game's Calhoun Cut Ecological Reserve, management of vernal pools and their associated grasslands has included grazing. Although regulated grazing may be an acceptable form of habitat management in some years, during drought years, when stressed, plants may be slow to recover from the effects of livestock. The objective of this study was to provide a baseline assessment and mapping of vernal pools, native grasslands, and other vegetation types found at the Reserve and to identify and map populations of rare plants which occur there.

Methods: Aerial photos of the Reserve were taken at low tide at the end of March when vernal pools would be clearly visible. Using the aerial photos and ground surveys, the vegetation types at the Reserve were mapped. A classification system for the stands of native grasses on the Reserve was developed and all stands were mapped according to this classification system. Areas with high concentration of nonnative medusa-head grass were identified and mapped, as well. Background literature on the Reserve was reviewed and available information obtained from the Natural Diversity Data Base and local botanists to locate rare plant populations. Ground surveys for rare plant species were also conducted throughout potential habitat on the Reserve.

Results: Eleven distinct communities were mapped at the Reserve, within three broad vegetation types -- grassland, riparian, and marsh. Approximately two-thirds of the Reserve is grassland habitat and one-third riparian and marsh habitats. Two sensitive communities are found in the grasslands: vernal pools, and purple needlegrass (*Nasella pulchra*) communities. Within the needlegrass community, regeneration appears low and riggut brome and medusa-head, two nonnative grasses, are abundant.

Six rare plant species are found at the Reserve: dwarf downingia (*Downingia pusilla*), legenere (*Legenere limosa*), Suisan Marsh aster (*Aster lentus*), delta tulepea (*Lathyrus jepsonii* var *jepsonii*), Mason's lilaeopsis (*Lilaeopsis masonii*), and delta mudwort (*Limosella subulata*). Several new element occurrences of the marsh aster, delta tule pea, lilaeopsis, and mudwort, were discovered in the Reserve's tidal zone.

Recommendations: In order to promote regeneration of the native bunchgrasses in the needlegrass community, the thatch of the nonnative annual grasses must be removed. The researchers suggest controlled burns or carefully regulated sheep grazing to accomplish this. If sheep are allowed on the reserve they should be excluded from the marsh and riparian communities and their effect on rare plant populations should be carefully monitored.

Drought education project (Region 5).

Introduction: Access to fresh, potable water is one of the most important issues facing California, and the West, this century. As California's population grows, competition for water among its different users is likely to grow, as well. During times of drought this competition becomes more intense and involves farmers, urban and industrial users, and the flora and fauna of the State. Educating citizens about the issues of water shortage and water use is important to ensure that future decisions on water issues are made with an understanding of the longterm costs and benefits to the citizens and environment of California. The objective of this project is to educate students and visitors to the Catalina Island Marine Institute on the issues of water use and water shortage.

Methods/Results: An alternative form of gathering water for revegetation of some of the degraded areas on the island is being explored through the construction of "Fog nets". These 50 - 100 square foot rectangular nets are installed on ridges where fog is frequent. Fog condenses on the nets and is collected in containers beneath it or is routed to native plants which are attempting to establish on hillsides previously denuded by feral goats on the island. For this project, several fog nets were constructed. They will provide a starting point for student discussions of alternative forms of water and water shortage; in addition, the amount of water collected is being measured using nets of different sizes and materials to assess the effectiveness of this method of irrigation for future revegetation projects.

Institute staff have painted a 150 square-foot map of Santa Catalina Island to be used in educational programs to show the Island's streams and canyons, reservoirs, prevailing winds, and other physical and biological features pertinent to water availability on the island. A model of the island is being constructed to demonstrate groundwater flow and recharge and how it can be affected by wells and diversion of surface flows. A learning station has been set up near a canyon stream where students will measure stream flow and discuss data collected over the past year to understand how topography and seasonal changes influence water levels.

A native plant garden is being established which will include succulents, drought deciduous species, drought evergreen species and salt tolerant species, all native to the island. Students will be able to examine plants and their adaptations to water shortage in this garden before hiking to other areas of the island to see the species in their native habitats. The program also features an educational game to teach students about the water cycle, water usage and plant adaptations to water shortage.

All labor for this project was supplied by members of the Catalina Island Conservancy. Features of the drought education program will be incorporated into the educational sessions of students visiting the island starting in Fall 1994.

Monterey Pine Forest Conservation (Region 3)

Introduction: Indigenous Monterey pine forest communities are restricted to three localized areas along California's central coast and two small islands off Baja California, Mexico. Although commercial plantings are widespread in California and several other countries, natural stands of Monterey pine (*Pinus radiata*) on the Monterey peninsula have been reduced and fragmented by urban development. Much of the remaining natural forest is not regenerating, and where regeneration is occurring, indigenous stands may be in danger of genetic contamination from planted stands. In addition, some stands have been heavily damaged by Pine Pitch Canker. Drought and altered hydrologic regimes may make stands more susceptible to these and other pathogens. Phase 1 and 2 of this project were supported by a combination of funds from the Drought Relief Project, McMahan Foundation and the California Native Plant Society. Its objectives were to determine the extent of the forest remaining, assess its health, delineate and map forest community subtypes, and assess the effects of human land use on the forest and on its health. A later phase of this project, funded by the USFWS, Packard Foundation, and the Department of Fish and Game will develop a specific Monterey pine forest conservation and management plan for the Monterey peninsula.

Methods: Using information obtained from literature and geologic maps, the historical distribution of Monterey pine was mapped. Aerial photos were examined, followed by ground surveys, to determine the current distribution, health, and acreage of Monterey pine forest. Information on commercial use, genetic differentiation, and disease was obtained from a literature search and from personal contacts. Current land uses were determined from aerial photos and site surveys, and these were mapped. Species associations were described and mapped using floristic field surveys in order to develop a classification of forest subtypes. Geological maps were used to classify marine terraces and intervening slopes, and this data, along with vegetation data, were entered into a GIS database to produce composite maps, and conduct spatial analyses.

Results: On the Monterey peninsula, historic acreage was determined to be about 18,000 acres, and current acreage of relatively undisturbed forest is about 9,400 acres. Although the overall genetic diversity of Monterey pine is low, within stand genetic diversity is greater than between-stand diversity, meaning most genetic diversity would be represented by a few stands. Pitch Canker, a fungal disease, appears to be infecting non-native trees at a greater rate than native stands, but genetic contamination by planted stock may render native stock more susceptible in the future. Maps were produced of the marine terraces and of current land uses. Plant community composition appears to correspond with geological differences among terraces, suggesting that the Monterey pine forests at Monterey are composed of distinct forest subtypes.

The results of this project were presented at a symposium on the Monterey Pine Forest held in Monterey in April 1994 and co-sponsored by over 14 agencies, organizations, businesses and individuals. A brochure to educate the public about the value of Monterey Pine forest was also partially funded through this project.

Recommendations: A long-term conservation strategy should be developed which takes into account the need to protect sufficient numbers of trees and stands to ensure the survival of indigenous forests. This includes the preservation of stands representing all of the forest subtypes on all the geomorphic surfaces. Encouraging natural regeneration should be a primary goal along with the protection of Monterey pine stands from disease and genetic contamination.