APPENDIX 5

Short-leaved Dudleya Enhancement and Restoration Plan for the Carmel Mountain Preserve

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Short-leaved Dudleya Enhancement and Restoration Plan for the Carmel Mountain Preserve, San Diego, California

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1.0 Introduction

1.1 Existing Locations of Short-leaved Dudleya

The five remaining natural populations of short-leaved dudleya (*Dudleya blochmaniae* ssp. *brevifolia*) are found on sandstone mesas of the Del Mar and La Jolla region of San Diego County. Carmel Mountain and the main portion of Torrey Pines State Park nearby, support the largest populations of short-leaved dudleya. Smaller populations are found at Crest Canyon in Del Mar Heights; Skeleton Canyon at the University of California, San Diego (UCSD); and the Torrey Pines State Park extension north of Peñasquitos Lagoon. The short-leaved dudleya populations are in southern maritime chaparral within the fog belt of coastal San Diego County.

1.2 Purpose, Goals, and Objectives

The purpose of this Plan is to establish management procedures to ensure that the subpopulations of the short-leaved dudleya, a species that is extremely restricted in range, is not extirpated on Carmel Mountain. To this end, the following goals have been established for the Carmel Mountain Preserve:

Goal: Protect and preserve the existing subpopulations of short-leaved dudleya.

Objective: Eliminate disturbance within the existing short-leaved dudleya populations to minimize weed invasions and damage to the dudleya from trampling and vehicles.

Goal: Expand the existing populations of short-leaved dudleya.

Objective: To maintain and enhance the genetic diversity of the dudleya populations to make them more resistant to stochastic changes

Goal: Establish new populations with a minimum of 10,000 short-leaved dudleya.

Objective: To reduce the risk of population losses due to catastrophic events such as fire and resulting weed invasions.

2.0 Management Actions

The goals and objectives will be successfully attained by implementing the management actions.

Goal: Protect and preserve the existing subpopulations of short-leaved dudleya.

Objective: Eliminate disturbance within the existing short-leaved dudleya populations.

Action A: Reroute trails and roads to avoid the subpopulations and to protect the subpopulations from trampling by humans, bicycles and other vehicles, and horses.

Action B: Allow the subpopulations to fill in open spots within the perimeter of the existing populations and to expand outward into newly protected areas for three years before beginning active restoration procedures. Monitor the subpopulations each spring.

Action C: Monitor the subpopulations once yearly for three years.

Close roads bisecting existing habitat by implementation of the proposed trail and road closure program included in this document and through future cooperative agreements with SDG&E and private inholding landowners.

Action C: Restore disturbed habitat inside the perimeter of each of the three subpopulations.

Goal: Expand the existing self-sustaining populations of short-leaved dudleya.

Objective: Restore habitat adjoining the subpopulations.

Action A: Choose an adjoining area with the same physical characteristics as those of the existing subpopulations.

Action B: Remove weedy species by hand or using hand tools.

Preserve, protect, restore, and enhance sandstone terraces dominated by ashy spike-moss and other microbiotic species as habitat for new populations of short-leaved dudleya.

- Reroute foot, bike, and horse trails around existing subpopulations of short-leaved dudleya and potential population expansion areas.
- Enter into an MOU between the City of San Diego and CDFG to allow for collection of 5 percent or less of the seed crop from the Carmel Mountain population annually for a period of approximately 10 years.
- Germinate seed to produce plants for captive seed production.
- Use propagated seed to directly seed appropriate restoration and enhancement sites.
- Propagate short-leaved dudleya from seed to grow mature plants for translocation into existing and new population sites.
- Repair of tire ruts with hand tools in areas where repair activities will not adversely affect existing sensitive species or microbiotic crusts.
- Implement an exotic plant control measure in short-leaved dudleya habitat. Control measures can include hand removal using cutting devices that minimize soil disturbance, the use of leaf blowers/vacuums to remove weed seeds from microbiotic crust/dudleya habitat areas and limited herbicide spraying where sensitive resources

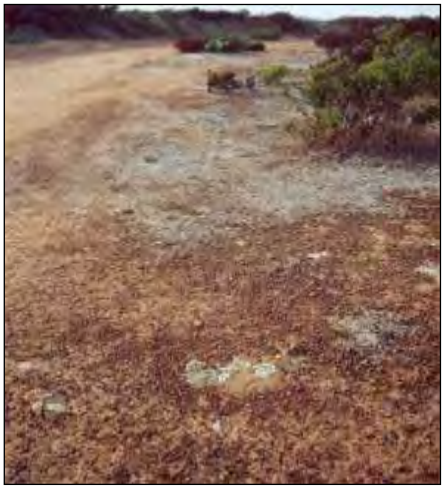
including the short-leaved dudleya will not be impacted. Replanting/reseeding with site appropriate natives grown from locally collected seed.

- Collect, propagate, and broadcast appropriate species of native seed into restoration sites where weeds are under control.

3.0 Short-leaved Dudleya Biology

3.1 Habitat

Typically, the short-leaved dudleya occupies openings that are dominated by microbiotic crust, a combination of species such as lichens, mosses, and ashy spike-moss, within the southern maritime chaparral. Herbaceous plants such as Cleveland's shooting stars (*Dodecatheon clevelandii*), dot-seed plantain (*Plantago erecta*), pygmy weed (*Crassula connata*), skunkweed (*Navarettia hamata*), spineflower (*Chorizanthe* sp.), herba impia (*Filago* sp.), popcorn flower (*Plagiobothrys* sp.), and everlasting nest straw (*Stylocline gnaphaliodes*) are also common associates in the openings.



Photograph A5-1. Short-leaved Dudleya Habitat (Subpopulation 3), showing ashy spikemoss and lichens

Photograph A5-2. Short-leaved Dudleya Habitat (close-up), with manganese nodules and lichens, on the Edge of the Mesa at Carmel Mountain

The southern maritime chaparral that surrounds the short-leaved dudleya populations on Carmel Mountain is about eight feet tall and includes chamise (*Adenostoma fasciculatum*), mission mazanita (*Xylococcus bicolor*), black sage (*Salvia mellifera*), wart-stemmed ceanothus (*Ceanothus verrucosus*), and an occasional Del Mar manzanita (*Arctostaphylos glandulosa* ssp. *crassifolia*).

3.2 Phenology

Like other members of the subgenus *Hasseanthus*, short-leaved dudleya is drought-deciduous in summer, surviving on starch reserves stored in a subterranean tuberous caudex (stem). Short-leaved dudleya typically grows on shallow sandy soils that overlay a cemented sandstone hardpan. These soils where the dudleya grows are frequently so shallow that the underground stem will grow downward for a centimeter, hit the hard pan, and continue growing horizontally along the surface of the hardpan layer (Dodero pers. obs.). In the thin soil areas the stem of the short-leaved dudleya can be very irregular in shape.

Annual growth is initiated after the first significant autumn rains and the plants grow actively through early April, as long as soil conditions are moist. After growth is initiated, dry periods of several weeks in mid-winter can cause the plants to cease growing and become dormant for the rest of season (Dodero 1995). In some cases, even if additional rains fall later in the winter or spring, the plants will not respond. This drought dormancy effect seems to be most common in smaller plants, whereas larger plants will usually maintain their leaves unless drought conditions are prolonged by higher than normal temperatures and low humidity. This dormancy response can lead to the mistaken determination that the plants have died or did not occupy a particular location, even though they are actually present underground.

Short-leaved dudleya can begin flowering as early as late April and continue flowering through early June, with seeds being set in late June and July. Short-leaved dudleya generally flowers later in the season than populations of the closely related Blochman's dudleya (*Dudleya blochmaniae* ssp. *blochmaniae*) elsewhere in San Diego County (Moran 1951). Populations of short-leaved dudleya on Carmel Mountain also begin to flower somewhat earlier than non-specific populations at Torrey Pines State Park, where longer lasting fog cover causes more mesic conditions (Dodero pers. obs.).

The percentage of flowering individuals in a season is correlated with the amount and frequency of rainfall during the winter and early spring. Well-spaced rains throughout the winter, at one- to two-week intervals, leads to a greater number of flowering plants than in dry years or when long dry periods occur in the middle of the normal rainy season. Small plants typically do not flower in a dry year, but in a year with above average or well-spaced rains, the same plant is capable of successful reproduction (Dodero 1995). In any given year only 10 to 30 percent of the individuals in a population will flower. Population estimates made from flowering individuals alone significantly underestimate the total number of plants in a population. Reproduction is primarily by seed; however, short-leaved dudleya is also capable of vegetative reproduction via detached leaves both in nature and in cultivation (Dodero 1995). Within one to three weeks after leaves are removed from the plant, they develop roots at the petiole base and are ready for planting.

Census numbers generated through the San Diego Multiple Species Conservation Program (MSCP) monitoring program for the three subpopulations of short-leaved dudleya on Carmel

Mountain show an increase in the number of flowering individuals in 2001 from the two previous years (City of San Diego 2001). Monitoring has resulted in the following population data for Carmel Mountain:

Year	Rainfall	Number of Individuals
1999	6.5	27,317
2000	5.7	23,487
2001	8.6	66,637
2002	3.0	1,446
2003	10.4	113,134
2004	4.2	18,907
2005	22.49	123,200

These numbers likely reflect responses of the populations to the timing and amount of rainfall each of those years and probably do not indicate an actual increase in population numbers in light of the continued disturbance and ongoing spreading of weeds. In 1999 and 2000 rainfall was well below average and long dry periods of up to several weeks occurred in midwinter. As described above, this type of weather pattern is not favorable for most short-leaved dudleya plants to flower. Even though rainfall was still below normal in the 2001 season, the rains that did occur were well spaced and effective for sustaining plant growth, which is probably the reason more plants flowered plants than in previous years. The 2003 rainfall season total of 10.4 inches was near the annual average rainfall and this is reflected in the increase in plant numbers observed in 2002, the driest year on record.

Potential pollinators that have been seen visiting short-leaved dudleya flowers include bee flies (Bombyliidae), hover flies (Syrphidae), soft-winged flower beetles (*Dasytes* sp.; family Melyridae), honey bees (*Apis mellifera*), bumble bees (genus *Bombus*), and digger bees (family Anthophoridae). The ovoid, striated seeds, at approximately 0.8 millimeter long, are very small and are generally dispersed by wind and water. They have no appendages for attaching to other material or animals for dispersal. Seedlings are frequently seen aggregated where water collects during sheet-flooding across the sandy surface of the mesa. Also, dried inflorescences of this species have been observed blowing across the sand on windy days after they have become detached from the parent plant. This presumably disperses seed as well (Dodero 1995).

4.0 Current Conditions of Subpopulations
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Photograph A5-5: Bicycle Tire Tracks and damaged Microbiotic Crust

Photograph A5-4. Horse Hoof Imprint in Microbiotic Crust

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Photograph A5-7. Weed Invasion into Short-leaved Dudleya Habitat after Disturbance from Pocket Gophers

Damage to the dudleya areas has been particularly severe when vehicles have been driven through the habitat during rainy periods when wet soils and microbiotic crusts are most easily damaged.

Although access is more restricted since developments have been built adjacent to the preserve, vehicles, bicycles, horses, and foot traffic continue to crush short-leaved dudleya plants on Carmel Mountain. In addition, these disturbances are breaking and crushing the surrounding microbiotic crust, which allows and promotes weed invasion.

After the initial disturbance, pocket gophers frequently move into the disturbed area to feed on non-native plants, and their burrowing further churns the soil and promotes additional weed growth. The gopher disturbance results in further weed invasion as more non-native annuals invade the disturbed soils (RECON 1999). Access by illegal off-road vehicles is still possible from the SDG&E access road.

5.0 Habitat and Population Management of Existing Populations

5.1 Site Protection

The first priority for the three areas is to protect them from further disturbance from vehicle, horse, and foot traffic as outlined in the trail and road closure program. A locked gate should be installed at the southern terminus of the SDG&E access road to prevent continued unauthorized vehicle traffic into the Preserve. The roads/trails that bisect subpopulations two and three on Carmel Mountain are proposed for closure or rerouting of the trails around the short-leaved dudleya habitat. The SDG&E access road that runs immediately adjacent to Subpopulation 1 is not proposed for closure at this time. This road should be considered for closure if alternate access to SDG&E transmission towers and the private inholdings can be arranged through negotiations between the City, the landowners, and SDG&E. Barriers such as split-rail fencing could be installed along the edge of the road/trail to protect Subpopulation 1. The existing roads/trails that go through Subpopulations 2 and 3 are proposed for closure and fencing barriers and signage can be placed at appropriate locations to discourage foot and vehicle traffic.

If protective fences or barriers are installed, the location and design of the fences should be carefully considered so that the fence installation and maintenance activities do not impact the dudleya populations or the microbiotic crusts in the vicinity. The short-leaved dudleya populations on Carmel Mountain are being censused annually as part of MSCP rare plant monitoring program conducted by the City of San Diego (City of San Diego 2001).

5.2 Maintenance

Hand irrigation for new seedlings and transplants will likely be needed the first season. If dry periods longer than approximately two weeks occur (or if plants look desiccated) after seedlings have germinated or flats of seedlings have been planted, supplemental water will be needed to ensure the greatest survivorship of individuals. Watering of seedlings and transplants should be done gently to minimize any soil disturbance that can uproot seedlings or expose the stem of the plants to the air. The plants should be kept moist until natural rainfall occurs. If natural rain events occur at regular intervals less supplemental watering will be required.

5.3 Monitoring

As mentioned previously, the short-leaved dudleya are part of an ongoing MSCP monitoring program. The goals of the annual monitoring program are to: (1) document ecological trends, (2) evaluate the effectiveness of management activities, (3) provide new data on species populations, and (4) evaluate the indirect impacts of land uses and construction. The following are additional monitoring recommendations for the restoration and enhancement program for short-leaved dudleya on Carmel Mountain intended to meet these stated goals.

With careful monitoring, researchers can detect changes in managed and unmanaged populations and communities over time (Primack 1996; Sutter 1996). Monitoring can be used to obtain basic biological information regarding life history traits of species including seed production, pollination, herbivory, dispersal, and seed and plant dormancy (Sutter 1996). With these goals in mind, the restored and newly created populations will be monitored for a minimum of five years. Monitoring activities will include:

- Photographing plots from permanent locations during the active growing period of short-leaved dudleya (February);
- Collection of quantitative data on total counts of short-leaved dudleya individuals in early February (MSCP Biological Monitoring Plan);
- Collection and identification of insect pollinators from the existing population of short-leaved dudleya at Carmel Mountain and the new population sites in May and June to assess on-site pollinator diversity and to ensure sufficient preservation of open ground habitat for pollinators;
- Collection of quantitative data on total counts of flowering individuals at the new population sites in May and June; and
- Collection of detailed qualitative and quantitative information regarding the success of exotic species eradication efforts at the restoration/translocation sites each year in spring. The extent of exotic and native species will be quantified using global positioning system (GPS) technology and the resulting changes in the distribution of these plants, including the dudleya, which will be monitored throughout the five-year monitoring period.

In addition, seedlings established at new population sites will be monitored for collection of detailed data on dudleya growth rates. A minimum of 40 seedlings will be marked and followed through their development from germination through five consecutive growing seasons. Data to be recorded includes number of rosette leaves, maximum length of rosette leaf, number and height of inflorescences, and presence of seed. Leaf measurement data will be recorded annually during late February–early March when the plants have reached their maximum leaf size for the season. The number and height of the inflorescences will be recorded annually in late April–early May during the flowering period.

Based on growth data recorded for variegated dudleya and Blochman's dudleya, short-leaved dudleya seedling plants germinated in the field are not expected to reach flowering maturity under natural conditions until at least the third season of growth (Dodero 1995).

All monitoring activities should be conducted with care to minimize impacts to short-leaved dudleya and microbiotic crusts caused by foot traffic. Even occasional foot traffic can have negative effects on habitat quality when microbiotic crusts are broken and weeds invade a site as a result of disturbance. Land managers should evaluate the effects of monitoring on habitat quality and adjust the monitoring program schedule and tasks accordingly if damage is occurring.

6.0 Population and Habitat Enhancement and Restoration

6.1 Procedures for Enhancement and Restoration

6.1.1 Site Selection

There are a number of characteristics to consider when selecting a translocation site. Fiedler and Laven (1996) suggest these selection criteria fall into four general categories: physical, biological, logistical, and historical. Physical characteristics for site selection can be straightforward and typically focus on soils and landscape characteristics. Biological criteria are considered to be the ecological characteristics of a species. Translocation sites should be selected based on the presence of appropriate habitat parameters, including similar plant community structure and successional stage. In addition, potential competitors of the plant species being translocated, including weeds, should be identified and a plan developed and implemented for the control of these other species. Logistical criteria to consider when choosing the translocation site should include how well the site can be protected from unauthorized human access, as well as the level of difficulty in accessing the site for monitoring and remediation efforts. Historical selection criteria include two issues: (1) the use of currently occupied versus potential habitat and (2) consideration of a species evolutionary history, including its specific habitat requirements. Knowledge of how the habitat, occupied by the species, changes over time and how new habitat arises and becomes occupied by the plant is important to the success of restoration efforts. The site selection criteria outlined by Fiedler and Laven (1996) are reflected in the choice of the proposed population creation sites depicted in Figures A5-1a and A5-1b.

Guerrant (1996) performed modeling experiments on a number of rare plant species for which reintroduction programs were implemented. He found the risk of population extinction is greatly reduced if plants of even slightly larger than seedling size are used in a translocation program.

Guerrant also found that the size of the created populations after 10 years is strongly correlated with the size of the plants used. The use of the largest individuals of a species resulted in the largest population size. These size factors have been taken into account in designing the methods for propagating and establishing a new population of small-leaved dudleya at Carmel Mountain.

In addition, Guerrant (1996) points out that one of the most serious problems associated with reintroduction is a loss of genetic diversity. Research has shown that reduced population size can rapidly result in the loss of genetic variability. One way to avoid the loss of genetic diversity is to rapidly expand the size of the newly established population

Figure A5-1a; COLOR–OVERSIZE

HIGHWAY 56

Carmel Creek Road

Tang Road

Carmel Country Road

MATCHLINE
SEE MAP 2

Image Source: 2001 Aerial Fotobank (flown September 2001)

Carmel Mountain Preserve

Private lands

Proposed Restoration and Enhancement Areas
Existing Short-leaved dudleya population area proposed for enhancement
Potential Short-leaved dudleya translocation/restoration area

Dudleya brevifolia population
Source: City of San Diego

0 Feet 400

FIGURE A5-1a

Potential Short-Leaved Dudleya Restoration Enhancement, and Translocation Areas on Carmel Mountain Preserve (Map 1)

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SEE MAP 1
MATCHLINE

Carmel Creek Road

Longshore Way

East Ocean Air Road

Way

Image Source: 2001 Aerial Fotobank (flown September 2001)

Carmel Mountain Preserve

Private lands

Proposed Restoration Areas

Potential Short-leaved dudleya translocation/restoration area

0 Feet 400

FIGURE A5-1b

Potential Short-Leaved Dudleya Restoration Enhancement, and Translocation Areas on Carmel Mountain Preserve (Map 2)

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(Guerrant 1996). By increasing the number of individuals soon after the population is established, much of the genetic variability present in a population can be maintained.

The natural populations of short-leaved dudleya are found on hard sandstone terraces, a mixture of sandstones and clay with iron concretions that have formed by weathering of the rock. The dominant plants in dudleya habitat include ashy spike-moss and herbaceous species. The proposed creation sites have similar soils and plant communities to those found at the natural population sites nearby.

Dodero (1995) notes that the range of this and other closely related species have probably expanded and contracted throughout the evolutionary history of the group, as areas of appropriate habitat have been exposed and subsequently eroded. The mosaic of occupied and potential dudleya habitat changes over time and probably causes populations to come into contact or become isolated as habitat areas shrink and then expand. Limited dispersal capabilities of short-leaved dudleya reduces the chances that suitable habitat nearby will be colonized naturally.

Three sites, corresponding to the subpopulations identified in the City of San Diego MSCP monitoring program report (City of San Diego 2001) and chosen to expand the subpopulations, have been selected as enhancement areas for short-leaved dudleya (see Figures A5-1a and A5-1b). All conditions at the sites are favorable for growing short-leaved dudleya.

6.1.2 Site Preparation

Because short-leaved dudleya will be established in existing, albeit somewhat disturbed, habitat on intact soils, no soil testing will be necessary. The intact sites most likely support the mycorrhizal associations important to the successful establishment of native plant species. No native species are anticipated to be displaced by this restoration project, which is designed to enhance native habitat for the small-leaved dudleya.

The sites have non-native weedy species, particularly annual grasses, that must be removed before the short-leaved dudleya and its associate plant species are planted. Weeds will be removed by hand.

6.1.3 Site Rehabilitation and Maintenance

Because short-leaved dudleya will be established in existing (albeit somewhat disturbed) habitat occurring on intact soils, no soil testing will be necessary. The sites have non-native weedy species particularly annual grasses that must be controlled and replaced by native species. No native species are anticipated to be displaced by this restoration project, which is designed to enhance the site. The intact sites most likely support the mycorrhizal associations important to the successful establishment of native plant species.

Exotic plants will be controlled throughout the length of the program. Non-native species will be removed primarily using hand tools, although some plants may need to be controlled by Roundup® or another appropriate herbicide sprayed by a licensed pesticide applicator under the supervision of the project biologist. As exotics are removed, these areas will receive hand-broadcast native seed collected including the short-leaved dudleya from on-site in order to enhance the quality of the habitat. Native seeds other than short-leaved dudleya will not be placed directly in the dudleya planting sites in order to avoid competition early in the establishment process. Also, seeds will not be raked into the soil, as this action enhances weed germination and competition. The use of supplemental water for native species other than the dudleya is not anticipated because native seeds will be broadcast during the winter rainy season.

The restoration sites should be actively maintained for a minimum of five years depending on funding. If adequate money is not available in the early years, then the focus should be placed on limiting disturbance to habitat and restoration activities may be extended for a longer period at any particular site. Maintenance will commence following placement and establishment of dudleya seed, transplanted adults, and leaf cuts, if they are used. Maintenance activities will include continued control of exotics and visual inspections to identify incipient problems such as herbivory or vandalism. The monitoring biologist shall direct weeding crews to remove weeds and determine which plants require control during the five-year maintenance period. The need for weeding is expected to decrease substantially by the end of the five-year period, provided successful habitat restoration has been achieved.

6.1.4 Dudleya Seed Collection

After an MOU agreement for seed collection of this state listed species has been negotiated with CDFG, seeds from individual short-leaved dudleya found in the three subpopulations on Carmel Mountain should be collected annually. Seeds from individuals of short-leaved dudleya found in the populations on Carmel Mountain will be collected in the summer. Dried inflorescences should be collected and placed in paper envelopes, which allow for the evaporation of residual moisture to prevent molding. Seeds are then stored in a cool, dark location to prevent desiccation and maintain viability. Dudleya seeds remain viable for many years under these conditions (Dodero 1995) and germination tests using seeds from *Dudleya multicaulis*, a closely related species, indicate no significant reduction in viability over a two-year storage period.

The seed would be used to propagate plants at a nearby growing facility for later translocation to the Preserve and also to grow plants that will used to produce seed for direct application to the restoration sites and for dispersal into appropriate but currently unoccupied areas of the Preserve.

To ensure the maintenance of genetic diversity in the enhanced and newly created subpopulations, seed should be collected from individuals in each subpopulation. In the

absence of any genetic information it is probably the best strategy to keep seeds and plants from each subpopulation separate to maintain any genetic differentiation between the subpopulations. Plants propagated from these seeds should only be used in the same subpopulation area that they originated from.

For newly created populations disjunct from the existing sites, plants and seeds from the three different subpopulations could be mixed to create as genetically diverse populations as possible. In theory then the created populations would have the best chance of having at least some individuals that are adapted to the varying types of conditions that may be present at the proposed creation/expansion sites. Past experience with translocation of Blochman's dudleya suggests that plants will do well at the new sites as long as they are properly planted and herbivory is not too severe and weeds are controlled (RECON 1996 and 2001).

6.1.5 Propagation

To propagate short-leaved dudleya for translocation and seed production the following methods should be used. Salvaged soil collected on-site can be placed in standard greenhouse flats to a depth of approximately one inch. Flats should be filled with soil that has a higher clay content than pure sand. The clay is a more stable growing medium than sand and will be easier to transplant into the restoration sites. Clumps of plants grown in sand have a tendency to break apart and will not transplant well.

Soil could be salvaged from nearby locations with the same soil type that are slated for development. Another option would be to salvage soil from the cut edge of the mesa adjacent to the park where the soil has already been disturbed by grading activities.

The dried dudleya fruits can be broken apart by hand to release the seeds that are then sprinkled on the surface of the moist soil. Because of their small size the short-leaved dudleya seeds should not be not covered with any soil. The seeds should be immediately watered with a fine mist several times a day to keep them continuously moist for a period of approximately two weeks although in the cool fall and winter seasons most viable dudleya seeds should germinate within one week. To produce plants that will attain the greatest possible size during the first growing season short-leaved dudleya seed is best sown after the first cold front of the season has past, usually in late October. Plants started at that time have the potential to reach flowering size in cultivation in approximately six months.

The sowing of the seed in the flats should be covered with shade cloth to reduce evaporative water loss from the soil and to minimize mechanical disturbance from watering. Each flat requires weeding as needed throughout the growing season. Supplemental watering should be given as needed during dry periods and small seedlings should never be allowed to dry out during the growing season. By late April, supplemental watering should be discontinued to allow the plants to enter their normal dormancy cycle, which starts at the onset of the summer drought.

If flats are intended for translocation into sites with thin soil, the amount of soil placed in the flats can be adjusted to accommodate the depth of the soil at the translocation site. The soil in the flats should always be somewhat more shallow than the soil at the translocation site. The reason for this is that the translocated plants should be planted flush with or slightly below the existing soil surface to ensure that the newly translocated plants are in a slightly depositional rather than an erosional environment. If the underground stems are exposed above the soil surface by erosion the plants are likely to die. Short-leaved dudleyas and closely related species are adapted to live in areas where there is slow deposition of sand and clay (Dodero 1995). The plants can keep pace with the deposition of soil by elongating their stem upward through the soil. As long as deposition of soil is not too rapid, the plants can grow well in this type of environment.

The goal of any translocation or habitat restoration plan is the establishment of a self-sustaining population with a minimum population size which enables the species to retain the genetic resources necessary to adapt to changing environmental conditions (Guerrant 1996). To achieve the goal of creating a self-sustaining population, up to three establishment methods could be used: hand broadcasting of dudleya seed to weed-free areas, planting individuals germinated from seed collected on-site or if necessary planting of whole leaves that develop into new plants after a period of a few weeks. Each method of establishment, whether by seed, cuttings, or transplants, may have drawbacks, depending on site-specific conditions (Guerrant 1996).

Previous restoration experience with Blochman's dudleya, a closely related species, indicates propagation of seed-grown plants in cultivation results in the greatest survivorship of seedlings (approximately 90 percent) over direct seeding (approximately 10 percent). Because of the very thin soils or the presence of intact microbiotic crusts at some of the enhancement sites, flats of cultivated seedlings may not be able to be planted in many locations that otherwise have high restoration potential. In thin soil areas direct seeding may be the only method available to establish plants because flats of seedlings will not be able to be successfully translocated into soil only one centimeter thick. Direct seeding should also be used where planting of cultivated short-leaved dudleyas would impact existing microbiotic crusts.

Another option to solve the problem of thin soils is to bring in relatively small amounts of soil to replace soil lost through road grading and erosion in Subpopulations 2 and 3 on Carmel Mountain. Small amounts of salvaged sandy soil could be collected from the graded edge of the Neighborhood 8A park where it abuts the Preserve and this soil could be thinly spread across the graded road areas that have little or no soil. Soil could be placed up to one inch deep to restore growing areas for the dudleya. At this maximum depth the soils would still be too thin to support shrubs but the short-leaved dudleya is adapted to these conditions. The intent is to establish plants wherever the habitat is appropriate within the restoration sites using the methods and criteria outlined above.

6.1.6 Introduction of Other Plant Species

The following herbaceous species are suitable for use in restored and enhanced short-leaved dudleya habitat: Cleveland's shooting stars, dot-seed plantain, pygmy weed, skunkweed, spineflower, herba impia, popcorn flower, and everlasting nest straw. Other associated herbaceous species may also be suitable for revegetation around newly created dudleya populations. All native plant species intended for reintroduction into the restoration and enhancement sites should be collected within the Preserve and hand broadcast. Since the dudleya habitat areas to be restored relatively small, sufficient seed can probably be collected in the vicinity of Carmel Mountain for hand broadcast. Seeds of other plant species directly into newly planted short-leaved dudleya patches to keep competition low. Seeding should be conducted in the fall or early winter just prior to anticipated rainfall. Timing seed dispersal to coincide with rainfall events reduces the amount of time the subject to herbivory and fungal attack and therefore is likely to increase germination success.

6.2 Maintenance of Enhancement and Restoration Sites

Exotic plants will be controlled throughout the length of the program. Non-native species will be removed primarily using hand tools, although some plants may need to be controlled by Roundup® or another appropriate herbicide sprayed by a licensed pesticide applicator under the supervision of the project biologist. Herbicides proposed for use in the Preserve must be on the pre-approved Park and Recreation list.

As exotics are removed, these areas will receive hand-broadcast native seed collected including the short-leaved dudleya from on-site in order to enhance the quality of the habitat. Native seeds other than short-leaved dudleya will not be placed directly in the dudleya planting sites in order to avoid competition early in the establishment process. Also, seeds will not be raked into the soil, as this action enhances weed germination and competition. The use of supplemental water for native species other than the dudleya is not anticipated because native seeds will be broadcast during the winter rainy season.

The restoration sites should be actively maintained for a minimum of five years depending on funding. If adequate money is not available in the early years, then the focus should be placed on limiting disturbance to habitat and restoration activities may be extended for a longer period at any particular site. Maintenance will commence following placement and establishment of dudleya seed, transplanted adults, and leaf cuts, if they are used. Maintenance activities will include continued control of exotics and visual inspections to identify incipient problems such as herbivory or vandalism. The monitoring biologist shall direct weeding crews to remove weeds and determine which plants require control during the five-year maintenance period. The need for weeding is expected to decrease substantially by the end of the five-year period, provided successful habitat restoration has been achieved.

In addition, exotic species shall be controlled and replaced with native species by hand broadcasting seed.

6.3 Monitoring of Enhancement and Restoration Sites

6.3.1 Planting and Seeding

After initial planting, the site will be checked twice a week by the project biologist for the first two months, once a week for the next four months, and monthly thereafter to determine if seeding and plantings are successful or if remedial measures including hand irrigation is needed.

Other site problems such as vehicle damage and erosion shall be reported to the City of San Diego and the Wildlife Agencies with recommended remedial measures.

6.3.2 Success Criteria

The success of the population expansion program should be evaluated in light of four goals, which include abundance, extent, resilience, and persistence (Pavlik 1996). The goal of maintaining abundance can be fulfilled by introducing large numbers of plants and propagules into the new site. Extent refers to the number and distribution of populations of a particular species. Resilience is maximized by maintenance of genetic variation, resistance to environmental perturbation, and ability of the plant to become dormant during unfavorable conditions. Persistence of populations is more likely when there is microhabitat variation within the translocation site and the natural community which the species occurs in is maintained.

The goal of the population expansion project is to create viable reproducing populations of short-leaved dudleya which are large enough to survive environmental perturbations and persist for the foreseeable future. Created populations should consist of a minimum of approximately 10,000 individuals. Specific success criteria have been established for enhancing and expanding the numbers of short-leaved dudleya on the Carmel Mountain Preserve. These criteria should be the success goals required of the consultant, agency, or non-profit organization charged with implementing the short-leaved dudleya population expansion project:

If, at end of the five-year period, the population of short-leaved dudleya at the new sites equals or exceeds 10,000 individuals (all age classes), with a minimum of 2,500 flowering plants (in any of the five years) then the expansion effort shall be deemed successful. No further transplanting, seeding of short-leaved dudleya, or other native plant species would be required. Monitoring and control efforts for exotic plants shall continue according to the MSCP guidelines. Since the short-leaved dudleya is a state-listed plant, the project biologist in coordination with the City of San Diego and CDFG plant ecologists will conduct an annual review to assess the effectiveness of restoration and weeding efforts. The long-term management of the

translocation/restoration areas will be performed in accordance with other management activities presented in this Management Plan for Carmel Mountain and Del Mar Mesa Preserves.

6.3.3 Reports

Annual reports will be submitted by September 30 of each year of the program, until the population reaches the success goals, at which time monitoring and reporting will decrease to once every five years for 20 years. Monitoring will then continue or end, based on the results of the 20 years of monitoring. The decision will be that of the Habitat Manager, based on the best science available at the time.

Reports will include the results of control efforts for exotic plants, native seed collection and seeding programs, photodocumentation of the restoration site from permanent locations taken annually, total counts of short-leaved dudleya actively growing each year, total counts of the number of flowering individuals, and annual assessments of the general health and condition of translocated short-leaved dudleya. Annual reports will be submitted to the City of San Diego and the CDFG Natural Heritage Division-Plant Conservation Program.

6.3.4 Restorationist Qualifications

The restoration project biologist should have a minimum of five years of general restoration experience in coastal southern California and a minimum of three years of experience with the monitoring, propagation, translocation of short-leaved dudleya or closely related species. The project biologist should be able to demonstrate an understanding of the special growing requirements of short-leaved dudleya as they relate to the restoration and enhancement of this state listed endangered species.

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