A

APPENDIX A

SANTA CRUZ TARPLANT ADAPTIVE MANAGEMENT PROGRAM

This Appendix includes excerpts from A *Management Program for Santa Cruz Tarplant (Holocarpha macradenia) at Arana Gulch*, prepared by Bruce M. Pavlik and Erin K. Espeland of BMP Ecosciences for the City of Santa Cruz. The report in its entirety includes further technical information regarding the Santa Cruz tarplant. These excerpts include a general discussion of the tarplant and the text regarding tarplant management at Arana Gulch.

TABLE OF CONTENTS

1 INTRODUCTION

Purpose of this Management Program

The purpose of this program is to provide an adaptive management framework for enlarging the population of the Santa Cruz tarplant *(Holocarpha macradenia)* by improving the quality of coastal prairie habitat at Arana Gulch. Persistence in its coastal prairie habitat completely depends upon successful completion of the process of sexual reproduction and the production of seeds. The seeds probably reside in the soil seed bank for five to ten years, providing a reserve of dormant meristems that can wait until favorable conditions (moisture, light, temperature) return. Those conditions are promoted by periodic disturbance by fire, grazing, soil surface exposure or "scraping," that reduce non-native grass cover and thatch, especially with coincidence of ample winter rainfall. Without natural periodic disturbance, or active management such as grazing, mowing, scraping, or controlled burns, to reduce non-native grasses and thatch, Santa Cruz tarplant populations dramatically decline.

These management actions, however, are not well understood, nor have they been consistently applied at Arana Gulch. In the absence of a science-driven, long-term and consistent program of management, the quality of coastal prairie and the vigor of Santa Cruz tarplant will continue to degrade. A framework for guiding the program, known as adaptive management, is needed to bring together motivated stakeholders (the City, scientists, environmental and user groups) in an objective, cooperative process of ecological restoration.

This document provides guidelines for establishing an Adaptive Management Working Group, comprised of stakeholders, to provide direction and oversight of future long-term management efforts at Arana Gulch.

Sections 1 through 4 of this document provide an overview of the biology of the Santa Cruz tarplant and its status within Arana Gulch. Sections 5 and 6 include specific information regarding management techniques and establishing a long-term Adaptive Management Program for Arana Gulch.

Background

Santa Cruz tarplant *(Holocarpha macradenia)* was once abundant and widespread from Marin to Monterey counties, however, it is now known only from nine natural populations that vary greatly in size and stability. The species is listed under the California Endangered Species Act as "endangered" and under the federal Endangered Species Act as "threatened." Critical habitat under the latter statute was designated in 2002, which included the population at Arana Gulch.

At Arana Gulch, the City of Santa Cruz owns a significant remnant of coastal prairie, situated on a coastal terrace with many of its geological and biological features intact. Here, the population of Santa Cruz tarplant has fluctuated greatly in size and spatial extent. Before cessation of cattle grazing in 1988, there were more than 100,000 individuals in four large patches, or subpopulations, spread across the central and southern end of the prairie at Arana Gulch. In subsequent years, the number of plants could vary from zero to 65,000 in two or three subpopulations, depending on the occurrence of fire, soil scraping, or other management actions that removed grass cover and thatch.

The City of Santa Cruz acquired the Arana Gulch property in 1994, after a long history of grazing by dairy cattle. The site is opportunistically managed (i.e. actions are taken when possible, but not consistently or in a programmatic way). Current threats to the Santa Cruz tarplant subpopulations include illegal activities (e.g. arson, off-road vehicles, vandalism) or other activities that bring accidental impacts to plants (e.g. by hikers, mountain bikers, or domestic animals). Development around the perimeter of the site has certainly altered historic hydrology patterns, changing water runoff patterns and perhaps even the total amount of water flowing in the soil column beneath the grassland. Shading by introduced trees creates inhospitable habitat for Santa Cruz tarplant, as could other landscaping associated with development. Development also curtails or greatly complicates the use of certain management actions, such as controlled burns or fire.

But the greatest current threat to Santa Cruz tarplant at Arana Gulch comes from invasion of the coastal prairie by non-native plants, combined with a lack of a program of consistent, appropriate management (Hayes 2002, Hayes, pers. comm., Bainbridge, pers. comm., Hillyard, pers. comm.). Much of the site is home to weedy, non-native plant populations such as the annual grasses. Dense stands of these invasive species provide poor quality habitat for Santa Cruz tarplant. Non-native grasses contribute 38 to 88% of the vegetation cover within subpopulations at Arana Gulch, while non-native annual forbs contribute 30 to 55% (Bainbridge 2003).

Prior to removal of livestock, grazing provided an excellent tool for reducing the cover of non-native plants and the accumulation of thatch. It may also have provided other forms of disturbance to the soil surface, as well as a mechanism for Santa Cruz tarplant seed dispersal among subpopulations. In general, tarplant species are associated with grasslands that receive one or more forms of disturbance, either by fire (Carlsen and Espeland in review) or grazing (Hayes 2002).

2 AN OVERVIEW OF SANTA CRUZ TARPLANT BIOLOGY HIGHLIGHTS

Santa Cruz tarplant is a member of the sunflower family (Asteraceae), long recognized as a unique species in the genus Holocarpha. This unique tarplant is an aromatic, resinous annual with linear, toothed leaves. The basal leaves form a rosette. Flowering individuals can become as tall as 1 meter, with terminal spreading branches that produce multiple inflorescence heads (Keil 1993, Hayes 2002). The leaves on the stem and branches are smaller than those found on the rosette and are hairier.

Flower heads are terminal on the branches, and each head contains both ray and disk flowers. Ray flowers are the outermost flowers on the head, producing a long petal that comprises the showiest part of the inflorescence, while the disk flowers are the innermost flowers with minute petals and protruding black stamens. Each flower produces a dry fruit, known as an achene, which contains one seed.

Santa Cruz tarplant germinates after the first significant rainfall event, usually in the late fall, and the basal rosette of leaves increases in size throughout the growing season until late June (Hayes 2002), although plants can bolt much earlier in the year as well (Bainbridge memo 7/20/05). As the plants near reproduction, a stem bolts from the center of the rosette and eventually produces anywhere from one to 60 flower heads that average 1cm in diameter each (Hayes 2002). Flowers of Santa Cruz tarplant are produced in the summer, any time between April and November (Bainbridge 7/20/05).

Annual plants, such as Santa Cruz tarplant, are completely dependent upon successful completion of the process of sexual reproduction. Unlike perennials, they do not maintain long-lived growing points (meristems) that allow persistence in the vegetative state. Such meristems allow trees and shrubs to live through and recover from adverse environmental conditions, even if sexual reproduction fails. The meristems of annuals, however, are stored in seeds, which only become activated during germination. Once they begin growing, they must produce enough stem length and leaf area to support the costly and uncertain processes of flower formation, pollination and seed formation. During this time they are vulnerable to predation, disease, drought, and other sources of mortality that could defeat reproduction and lead to population decline. In the case of annuals, this decline is best measured as a decrease in the size and quality of the seed bank—the reservoir of dormant meristems that reside at or below the soil surface. It is the seed bank of Santa Cruz tarplant and its attendant processes that will determine persistence at Arana Gulch.

General Distribution and Habitat Characteristics

Santa Cruz tarplant has historically been found in coastal prairies and coastal range grasslands at low elevations (below 300m) in northern and central California. All extant populations of Santa Cruz tarplant occur on marine deposits or on alluvial deposits derived from marine parent materials (Palmer 1982).

The species is currently limited to nine or ten natural populations in Santa Cruz and northern Monterey counties. Eighteen sites in Alameda County have recently supported small reintroduced populations (attachment to Morey memo 12/12/94). The population at Arana Gulch in the City of Santa Cruz (Santa Cruz County) occurs on an ancient coastal terrace hypothesized to be about 100,000 years old (Palmer 1982).

Natural Disturbance Processes in Coastal Prairie

Wildfire was a common feature in the California landscape prior to European colonization and the adoption of suppression policies (Keeley 2002). Natural fires in coastal prairies were probably started by lightning strikes in the late spring or fall when storms were likely and fuels dry, but human-ignited fires were probably more common. Some have suggested that prior to arrival of Europeans; the frequency of fire in coastal prairie may have been as high as once per year (Heady et al. 1988). The indigenous people of the Santa Cruz area regularly used fire as a vegetation management tool to increase local biotic productivity, to facilitate the growth of their food plants, and to maintain open landscapes for ease of human and large mammal movement (Skowronek 1998). Early explorers frequently mentioned the burning practices of the indigenous peoples of California, and Father Juan Crespi's diary of the Portolá Expedition described entirely burned grasslands all along the Santa Cruz coastline in October of 1769 (Bolton 1971).

Grazing by large herbivores has been important in California grasslands—historically by elk and more recently by cattle and sheep. During the late Pleistocene, up until the appearance of indigenous peoples, California sustained as heavy a grazing pressure as the East African savannah does today (Wagner 1989). Certain grazing regimes appear to favor establishment of some native perennial grasses (e.g. *Danthonia californica)* in coastal prairies (Hayes 2003).

Research in the Central Valley grassland has shown that grazing reduces competition between developing perennial grass seedlings and non-native annual grasses (Marty et al. in review)—a competitive interaction that California's native plants generally lose (Heady 1956, Bartolome 1979, Carlsen et al. 2000). Many tarplant species respond well to grazing disturbance. Like other California wildflowers, they can benefit from removal of aboveground thatch (Meyer and Schiffman 1999) and a more open canopy environment (Hayes 2003). It is possible that these effects are more pronounced since the invasion of non-native annual grasses, which have higher thatch accumulation rates and form denser canopies over the landscape than typical California native perennial grasses (Meyer and Schiffman 1999). Grazing at Arana Gulch has been intense in the past, with a dairy operation persisting until 1988 (Hayes 1997), and prior to that, Spanish colonists submitted the state's grasslands to intense grazing pressure starting in the mid 1800s (Stromberg and Griffin 1996).

Fossorial mammals can be another source of disturbance in coastal prairie. Gophers can slow the aboveground accumulation of phytomass (Stromberg and Griffin 1996). This accumulation, which results in thatch, can be quite large in communities with introduced annual grasses. This thatch can greatly inhibit both the growth and survivorship of California native plants (Meyer and Schiffman 1999, Carlsen et al. 2000). By reducing thatch accumulation, gophers and cattle can have a similar effect on stimulating the growth and persistence of California native plants. However, while gophers have the positive effect of reducing the competitive effect of annual grasses, the disturbance they create can inhibit establishment of California native plants by creating inhospitable germination environments (soil of gopher mounds, while open, has lower water-holding capacity then surrounding areas) or by simply burying developing seedlings (Stromberg and Griffin 1996). However, Santa Cruz tarplant appears to respond poorly to conditions on mounds (low germination, seedling death due to burial) (Bainbridge memo 7/20/05), perhaps because the small scale of gopher disturbance may not significantly enhance light levels or deter herbivory by slugs and other microherbivores (Hayes memo 8/8/05, Maze unpublished ms. 2005).

3 SANTA CRUZ TARPLANT POPULATION AT ARANA GULCH

Census data for Santa Cruz Tarplant at Arana Gulch were first obtained by Randy Morgan in 1977 (CNDDB # SPNXFJ3). Previous to this, the plant was thought to be extinct (Munz 1959, Palmer 1982). In the early 1980s, Palmer visited many occurrences of the species in Northern California during his dissertation research. Details of how the Palmer's census was originally conducted at Arana Gulch are absent from his dissertation. Anecdotally, Bill Davilla who actively participated on many field trips recalls that Santa Cruz tarplant population density at Arana Gulch was moderate to low and the plants were small and unbranched. The coastal prairie community was dominated by non-native grasses and heavily impacted by cattle traffic and foraging. At that time, the dairy was still in operation and 35-40 head were routinely kept on the property.

At that time, collections of Santa Cruz tarplant were taken mostly from the southern portion of the property, which is now designated subpopulation A. No comprehensive census or survey took place on those trips, and there was no awareness at that time of separate subpopulations. After the cattle were removed, Santa Cruz tarplant plants became apparent in areas of the site where they had not been observed on cursory surveys, but in subsequent years non-native forbs to develop dense cover, especially in the northern half of the property (Davilla, pers. comm.).

In 1989, R. Doug Stone at EA Engineering Science and Technology Inc. (EAESTI) first designated and roughly mapped the subpopulation structure of Santa Cruz tarplant at Arana Gulch (Stone memo 7/11/89). He recognized four subpopulation areas, A, B, C, and D that occupied what appeared to be distinct areas in the southern end of the property (Figure 1). Stone did not find any plants in area C in either 1988 or 1989, but confirmed that Randy Morgan had observed around 10,000 plants in that area in 1986 (Stone memo 7/11/89).

These four recognized subpopulations (A, B, C and D) became the basis of all subsequent census efforts, although it was not until 2004 that they were accurately documented and logged with GPS data. The subpopulations became the focus of management activities and observations at Arana Gulch, in particular the largest and southernmost subpopulation A (Bainbridge 2003), although in 1998 plants were found in areas between the mapped subpopulations (CNDDB 2000) and Bainbridge's experiments include areas within subpopulation D and other areas at Arana Gulch.

Demographic data for Santa Cruz tarplant were collected by Dr. Susan Bainbridge (UC Jepson Herbarium) at Arana Gulch during 2000-2002 as part of her experiments on management techniques. Although much of these data are not yet available, it is clear that information on germination, survivorship, plant growth, and reproduction were obtained in response to small-scale, replicated mowing, soil scraping, and burning treatments. Demographic data were also obtained by Dr. Grey Hayes for artificial populations used in his dissertation research (Hayes 2002). Hayes, working on questions of coastal prairie ecology and management with Dr. Karen Holl at UC Santa Cruz, conducted his field experiments on three introduced populations to the north and south of Arana Gulch.

Population Census at Arana Gulch

The total number of aboveground plants at Arana Gulch has ranged from zero to an estimated 115,000 during the 18 census years of 1977 to 2004 (City of Santa Cruz memo, December 2004). The authors of this document assume that all of the plants found and tallied were reproductive, but this was not always indicated by the field worker. The largest reproductive population sizes, 10,000, were observed in 1986, 1988, 1997, 1998, and 2002. The smallest sizes, 100 or less, were observed in 1977, 1993, and 1995, the latter year producing no aboveground individuals. A summary of census data at Arana Gulch is included in Table 1. Census data for 2004 and 2005 are depicted in Figures 2 and 3.

Table 1 Census Estimates and Management Actions for Subpopulations at Arana Gulch **1989-2005**

Y = present, but no counts available   [U] indicates mowing type (scythe-type or chopped mulch) unknown   [M] indicates chopped mulch type mowing conducted

subpop/year	total # of plants[a]	**management:** July (previous) to June
SUBPOPULATION A		
1989	Y[b]	no management
1993	2	no management
1994	0	no management
1995	0	mowed[M], mowed[M]/raked
1996	7,420	mowed[U]/raked, scraped
1997	12,941	fall fire (arson) 10/96
1998	65,000	fall fire (prescribed) 10/97
1999	1,228	mowed[M], fall fire (prescribed) 10/98
2000	1,053	no management
2001	619	experiment (see Table 6)
2002	10,230	no management
2003	2,536	no management
2004	797	no management
2005	1,552	no management
SUBPOPULATION B		
1989	Y[b]	no management
1993	0	no management
1994	0	no management
1995	0	mowed[M], mowed[M] /some raked
1996	0	mowed[U]
1997	0	mowed[U], scraped small plots 10/96
1998	5[c]	mowed[U]
1999	0	mowed[U], fall fire (prescribed) 10/98
2000	0	mowed[U] (*)
2001	n/a	mowed[U]
2002	0	mowed[U]
2003	0	mowed[U]
2004	0	mowed[U]
2005	0	mowed[U]
SUBPOPULATION C		
1989	0	no management
1993	0	no management
1994	0	no management
1995	0	mowed[M], mowed[M] /some raked
1996	0	mowed[U]
1997	0	mowed[U]
1998	20[c]	mowed[U]
1999	0	mowed[U]
2000	0	mowed[U]
2001	na	mowed[U]
2002	0	mowed[U]
2003	0	mowed[U]
2004	0	mowed[U]
2005	0	no management
SUBPOPULATION D		
1989	Y[b]	no management
1993	131	no management
1994	0	no management
1995	0	mowed[M], mowed[M] /some raked
1996	0	mowed[U]/raked/scraped
1997	21	mowed[U]/raked /scraped (small plots)
1998	60	no management
1999	1	fall fire (prescribed) 10/98
2000	1	no management
2001	na	experiment (no data available)
2002	156	no management
2003	57	no management
2004	2	no management
2005	0	no management

[a] When more than one population estimate is provided, the larger is used for this table

[b] Plants recorded as present in this subpopulation but no census data are provided

[c] Plants found at the periphery of this subpopulation location included

(*) Harris (memo 10/16/99) indicates that spring 2000 mows would be bailed (scythe-type and "raked") but there is no confirmation that this type of mow was performed

Seed Bank Dynamics

Seed bank studies found only ray seeds [achenes] in the soil (Palmer 1982, Bainbridge 2003), indicating that nearly all disk seeds germinate or are eaten in the year following production (it is possible but unlikely that these achenes could have also dispersed. Seed bank densities can be highly variable due to the spatial aggregation of dispersal in the landscape and also possibly due to different environmental conditions, including those due to different management practices.

Ray seeds comprise the persistent seed bank in the soil because the more easily germinable disk achene may mostly germinate each year, or, disk achenes may be more likely to be eaten due to their more delicate seed coats. The lack of a thick pericarp for disk seeds means that not only are they more likely to germinate with the first rains, but if they don't germinate, they are extremely likely to get eaten and therefore die. Predation experiments conducted on Santa Cruz tarplant disk achenes found predation rates of well over 90% in a 1-month interval (Hayes 2002). Seed predation, infection, and death all contribute to the loss of seeds from plant seed banks. Persistent seed banks can be quite low, even for annual plants that depend on seed banks as the only mechanism to maintain their populations over reproductive cycles.

Seeds of Santa Cruz tarplant can germinate after 6 to 9 years of room temperature storage (attachment to Morey memo 4/25/95), so may be able to persist even longer in the soil if they avoid predation, although older seeds, in general, have been found to produce less robust plants than younger ones (Priestley 1986).

4 MANAGING POPULATIONS OF SANTA CRUZ TARPLANT

The Arana Gulch population of Santa Cruz tarplant has been subjected to a wide range of management actions in the past. A few years after grazing cattle were removed in 1988; the number of aboveground individuals began to rapidly decline, leading to the conclusion Santa Cruz tarplant cannot persist without management.

In January of 1995, after the City acquired the Arana Gulch property, a Santa Cruz tarplant recovery workshop was convened by the California Department of Fish and Game. The workshop was attended by local botanists, Santa Cruz City staff, and concerned citizens. As a result of this workshop, several management actions were prescribed and implemented, including soil scraping and mowing. Similar workshops were held in subsequent years, through 2003. These workshops served to collate and disseminate information on much of the conservation and restoration research conducted on Santa Cruz tarplant at Arana Gulch and other population locations

It is now understood that long-term effective tarplant management would need to replace natural disturbance by native grazers, herbivores, and intense, regular fires that had long been absent from this fragment of coastal prairie. In the absence of these disturbances, grasses would out compete forbs such as Santa Cruz tarplant, especially non-native annual grasses that form thick stands with dense canopies and root systems. The grass stands provide low quality habitat (e.g. limited light and water) and build a thatch layer on the soil surface that probably retards Santa Cruz tarplant germination (Hayes and Holl, in review).

While effective management increases Santa Cruz tarplant population viability and decreases non-native grass cover, it may also control noxious weeds. It is important to recognize that effective management may have the unwanted effect of abetting the establishment of noxious weeds and additional weed control measures may be needed to prevent a biological invasion. Actions and research efforts focused around non-native grass control have attempted to determine what management actions might benefit Santa Cruz tarplant subpopulations and their ability to persist by simulating disturbance of the non-native grass canopy. Typically, these studies have measured demographic or individual plant characteristics in the summer

following some kind of site manipulation (e.g. soil scraping) or accidental disturbance (e.g. uncontrolled fire).

Soil Scraping

During November and December of 1995, two types of scraping were used to remove the canopy, thatch and upper organic layers of the soil at Arana Gulch. A bulldozer was used to scrape the soil surface of Santa Cruz tarplant subpopulation A after no plants had been found during the previous summer. This mechanical form of soil scraping was considered a drastic action, required to simulate catastrophic disturbance over a fairly large area of habitat. Hand scraping using garden hoes was also performed to remove the same canopy and soil surface layers. In the following summer of 1996 over 7,000 plants flowered and reproduced in the scraped areas and mechanical scraping appeared to be slightly more effective (although rigorous evaluation was not performed). Subsequent management actions and experiments examined soil scraping as a technique for releasing tarplant seeds from the seed bank. Experimental scraping at Arana Gulch resulted in high recruitment of tarplant compared with mowing, burning, or no management (Bainbridge 2003).

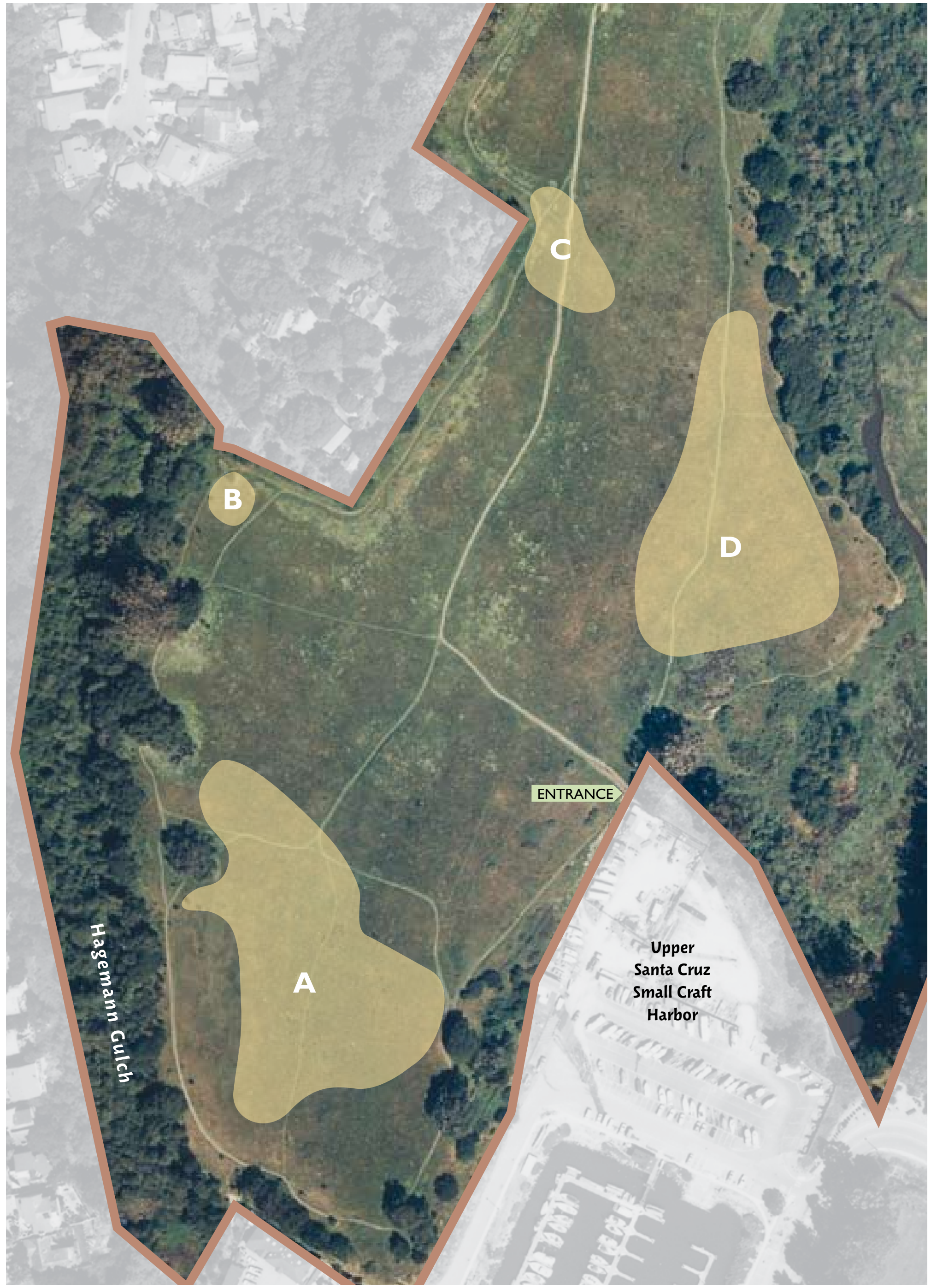
The precise mechanism for the increased tarplant population in scraped areas is unclear. Other native forbs also benefit from scraping (Bainbridge 2003) and the mechanisms may be similar among species. Bainbridge (memo 7/20/05) found that survivorship was similar among grazing, mowing, burning, and no management treatments and found that fall thatch cover significantly affected tarplant recruitment (Bainbridge 2003). The effects of scraping may be some combination of soil compaction, removal of thatch, removal of competitor seed, soil nutrient depletion via biomass removal, or removal of indirectly harmful agents (e.g. herbivores). Hayes (2002) found that large amounts of thatch were associated with higher levels of herbivory on tarplants. Thatch removal might then deter herbivores from finding and eating tarplant (Maze unpublished ms, 2005).

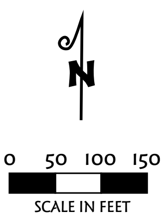
Soil scraping could also have adverse effects, including removal of tarplant seed, removal of seeds of other native forbs and grasses, increased predator access to seeds, soil nutrient depletion and excessive soil compaction. Recent modeling has demonstrated that forcing seeds to germinate ("flushing") can reduce the buffering effect of a large seed bank and diminish persistence across unfavorable years (Satterthwaite et al. unpublished ms, 2005). Given its drastic impacts on the soil surface and its ability to stimulate release of tarplant from the seed bank, scraping should be regarded as a catastrophic form of disturbance to be used infrequently through time and sparingly across Santa Cruz tarplant habitat.

Fire

During the fall of 1996, a portion of subpopulation A within the previously scraped area was burned in an accidental fire. By summer of 1997, the subpopulation had greatly increased to about 12,000 reproductive plants and expanded its distribution inside and outside the fire's boundary. The relative contributions of scraping and burning could not be ascertained. A prescribed burn conducted in the fall of 1997 was followed by the summer 1998 appearance of over 65,000 reproductive plants in subpopulation A. But the prescribed burn of October 1998 in subpopulation D produced only 1 plant in 1999 where 17 had occurred in the prior year (Table 1). Experimental fires in 2001 at Arana Gulch did not result in increased germination or survivorship of SCT (Bainbridge 2003), and laboratory experiments show that fire may stimulate germination of ray fruits but that resulting plant vigor is lower (Bainbridge memo 7/20/05).

Fire can be beneficial by removing thatch that inhibits native forb germination (Carlsen et al. 2000), and by destroying seeds of competing non-native grasses (Meyer and Schiffman 1999). Santa Cruz tarplant germination may respond positively to the fire itself, not just the associated thatch removal. Creating open areas through fire may also facilitate seed dis-



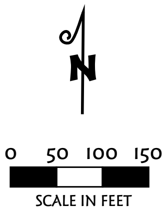


Approximate location of Santa Cruz Tarplant subpopulation areas identified in 1989.

Arana Gulch
MASTER PLAN

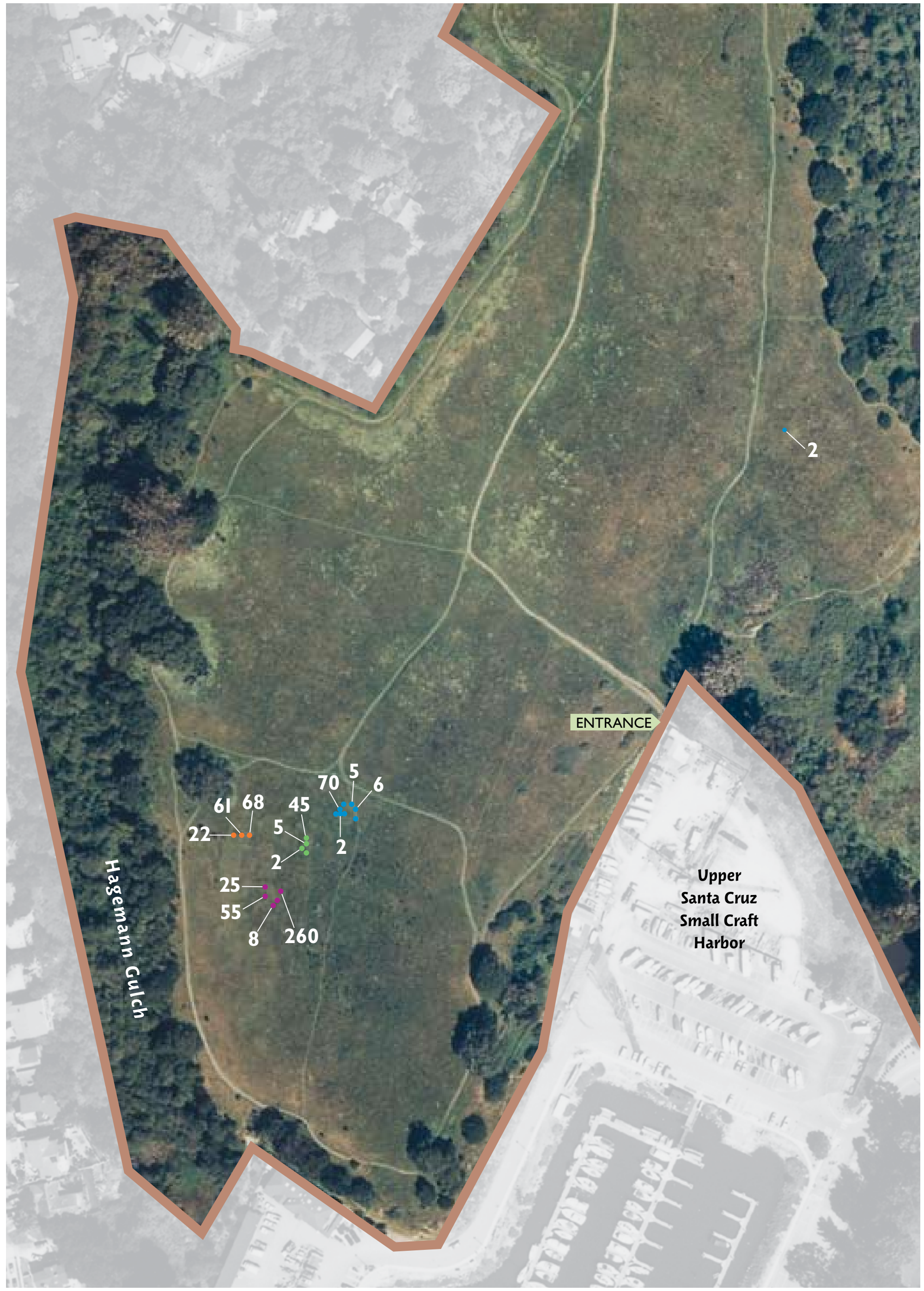
TARPLANT SUBPOPULATION AREAS

Figure 1



Positions of patches and individual Santa Cruz Tarplants in subpopulations A and D from the 2004 Census at Arana Gulch. Subpopulations B and C had no above-ground individuals. Colors indicate patches (see Appendix A data tables), the pointers indicate the number of individuals at a particular GPS location (WGS 84) within a patch. Unlabled points represent single SCT plants.

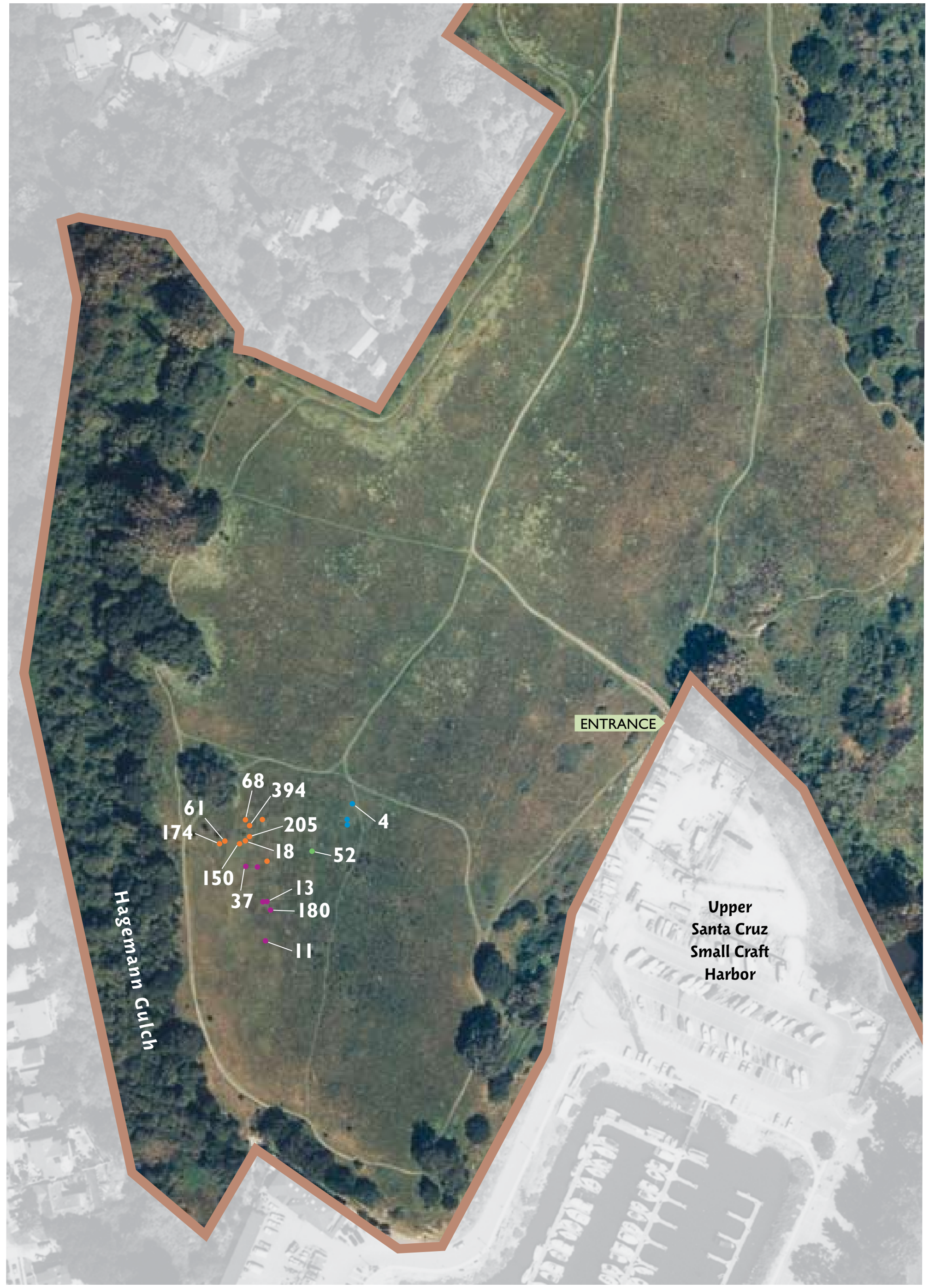
2004 PATCH			
• 1	• 2	• 3	• 4



Arana Gulch
MASTER PLAN

SANTA CRUZ TARPLANT
2004 Census

Figure 2



0 50 100 150
SCALE IN FEET

Positions of patches and individual Santa Cruz Tarplants in subpopulations A from the 2005 Census at Arana Gulch. Subpopulations B, C and D had no above-ground individuals. Colors indicate patches (see Appendix A data tables), the pointers indicate the number of individuals at a particular GPS location (WGS 84) within a patch. Unlabled points represent single SCT plants.

2005 PATCH			
• 1	• 2	• 3	• 4

Arana Gulch
MASTER PLAN

SANTA CRUZ TARPLANT

2005 Census

Figure 3

persal into these open areas (Carlsen and Espeland in review). However, fire can also have adverse effects on the target species by killing seeds with high temperatures (Odion 2000, Brooks 2002), and increasing seed predation (Espeland et al. 2004). Timing of fire may be important.

Overall, a controlled burn at should be regarded as a catastrophic form of disturbance to be used infrequently to drastically alter soil surface conditions. On a large scale, controlled burns have many logistic hurtles to be resolved, including safety requirements (e.g. trained burn control crew, fire control vehicle access), regulatory constraints (e.g. air quality, "burn day" system), and potential public relations problems (e.g. neighbor objections, user disappointment). On a small scale, however, they can be an important experimental treatment that returns an important disturbance factor to the habitat. Small-scale techniques (Pavlik et al. 1993, 2000) should be used for research purposes at Arana Gulch.

Grazing

The Santa Cruz tarplant population at Arana Gulch was able to maintain a large size, greater than 10,000 plants, under a high intensity, year-round grazing regime produced by domestic dairy cattle. This regime came to an abrupt end in 1988.

Grazing probably improves habitat quality for Santa Cruz tarplant by removing annual grass cover and phytomass, thus preventing aboveground competition during the growing season and reducing thatch accumulations that inhibit tarplant germination. Grazing also brings trampling, which opens, roughens and compacts surface layers of soil.

Grazers might also have been responsible for most of the pre-1988 dispersal of Santa Cruz tarplant seeds at Arana Gulch, as the sticky ray seeds could have adhered to the legs of passing animals. If long-distance dispersal was facilitated by these large, mobile grazers, then there must have been more genetic exchange between subpopulations in the past. The importance of this exchange to maintaining large, vigorous subpopulations and seed banks is currently unknown.

Grazing should be considered as an appropriate form of long-term, frequent disturbance that can benefit Santa Cruz tarplant and its coastal prairie habitat at Arana Gulch. However, there are significant logistical constraints associated with using cattle for this purpose, including requirements for substantial barbed wire or electric fencing, transport to and from the site, contractual specifications for intensity, duration and timing, and public relations. Other domesticated grazers, such as goats and sheep, may provide a similar service with fewer problems. Grazing should be regarded as an important experimental treatment that returns a critical disturbance factor to the habitat.

Mowing With Phytomass Removal

Many management experiments involving Santa Cruz tarplant have utilized mowing to simulate grazing disturbance with varying degrees of success. Mowing may be the most practical method for uniformly removing large amounts of grass biomass and accumulated thatch over large areas of an isolated fragment of coastal prairie. However, timing of mowing may be important, so as not to injure already-bolted tarplant or prematurely kill senescing plants.

Between 1995 and 2003, mowing has been performed every year at Arana Gulch in subpopulations B and C, with no reproductive tarplant individuals ever emerging from the seed bank (which may or may not have been present prior to treatment). This mowing was conducted as part of the City's fuel break mowing and did not include phytomass removal. Other mowed plots at Arana Gulch exhibited no germination compared to burned and scraped plots.

The effects of mowing with phytomass removal on the coastal prairie habitat of Santa Cruz tarplant can be similar to those of fire and intense grazing because all reduce thatch accumulation and aboveground competition from the grass canopy. However, mowing may be different than grazing in that it is less effective at creating open patches and less selective than

would-be grazers. Research in Midwestern prairies has shown that mowing and raking can have similar effects as burning (Tix and Charvat 2005). However, the timing of mowing must take into account different parameters than determining the timing of fire: in order to be effective in the following year: if mowing occurs after non-native grass seeds becomes ripe and disperse, then it may facilitate grass dispersal and increase competition with tarplant during the following year.

Timing is critical to the effects of mowing on tarplants, as is whether the cut grass is removed. Many commercial mowers do not remove thatch or the mowed grass material (phytomass), but merely break it into a mulch of smaller pieces that adheres to the soil surface like a blanket. This type of mowing was performed at Arana Gulch in 1995 (Quintanar 1995) and may have been responsible for the lack of a visible demographic response by the tarplant.

Mowing is less effective than fire, grazing, and scraping at creating bare ground, and it may be bare ground that is ultimately necessary for a positive demographic response. Other California native forbs have had a positive response to the creation of bare ground patches within grassland habitats (Meyer and Schiffman 1999, Espeland and Carlsen 2002). Bare ground can be important if germination and/or survivorship are sensitive to light availability, and bare soils are more compacted than those that have roots in them, possibly increasing seed-soil contact and aiding water imbibition of seeds.

Another benefit of mowing, however, could be the reduction in grass canopy height, which allows the seeds of late-flowering forbs to disperse a greater distance (Coulson et al. 2001). Mowing with phytomass removal should be investigated as an appropriate form of long-term, frequent disturbance that can benefit Santa Cruz tarplant and its coastal prairie habitat at Arana Gulch.

No Management

After the removal of cattle grazing from Arana Gulch in 1988, the number of reproductive Santa Cruz tarplant individuals dropped to less than 1,000 in 1989 (Morey 1995). With no disturbance from grazing, and no surrogate management regime, the number of aboveground, reproductive plants precipitously declined to 133 by 1993 and to zero plants in 1994 and 1995, after a period of only seven years. The population had evidently persisted in the seed bank because more plants were produced after treatment with soil scraping in 1995 and fire in 1996. Presumably the treatments were able to counteract unfavorable habitat conditions that developed between 1989 and 1994. These observations underscore the importance of the seed bank to population persistence of annual forbs like Santa Cruz tarplant.

Varied Responses to Management Regimes

As the multi-year management experiments by Hayes (2002) and Bainbridge (2003) show, management efforts may produce different results at different sites and years. Other studies have found that a management action that is beneficial in one year may be detrimental the next (Schultz and Crone 1998, Lesica and Martin 2003, Espeland et al. 2004, Carlsen and Espeland in review). It may not be possible to predict if an action will be beneficial in the upcoming year, but with a consistent schedule of actions and appropriate data feedbacks (i.e. monitoring programs), evaluation and adjustment will be possible.

Perhaps only certain subpopulations or even portions of subpopulations would receive the same management every year, allowing for variable responses across the Coastal Prairie/Tarplant Management Area within Arana Gulch. Although detrimental responses to consistent management may occur, it is probably more important to increase the probability of a favorable coincidence between the seed bank, the conditions of the growing season and the management regime. This coincidence would result in maximum seed production and replenishment of the seed bank, which in turn will allow persistence.

A more sophisticated aspect of developing a management regime is being able to respond to "good years" and "bad years" as they develop during the growing season. A season with early rainfall and warm temperatures can produce a dense, competitive sward of grasses that ultimately will inhibit subpopulations of Santa Cruz tarplant. Careful clipping and early removal of this canopy could maximize tarplant survivorship in what would otherwise be a "bad year". Other, "surgical" actions might be used to maximize seed output in "good years" by removing grass cover in spring. The mechanisms by which such actions survivorship or fecundity (by soil compaction, light infiltration, fire-cued germination, aboveground competition) need to be more clearly elucidated with a focused program of research as discussed in the next section.

5 SANTA CRUZ TARPLANT MANAGEMENT PROGRAM 2006-2026

Given the present understanding of Santa Cruz tarplant, this management program is based upon the following emergent biological principles:

1) the distribution, abundance and persistence of Santa Cruz tarplant subpopulations at Arana Gulch are largely controlled by factors affecting the size and dynamics of the seed bank,
2) seed bank characteristics are primarily determined by habitat quality within and between the subpopulations,
3) habitat quality mostly depends on minimizing the detrimental effects of high cover by non-native grasses, and
4) non-native annual grass cover can be reduced by restoring the proper disturbance regime to the coastal prairie of Arana Gulch.

This program is also based upon the following management principles:

1) stakeholders (with respect to Santa Cruz tarplant and coastal prairie) must commit adequate time and resources to a cooperative, decision-making process known as adaptive management,
2) the initial phases of the adaptive management program will emphasize consistency and precision, rather than optimization, of actions,
3) all management actions and research must be evaluated and reported within the annual cycle of Santa Cruz tarplant activity to allow timely adjustments, and
4) enlarging and expanding the seed bank of Santa Cruz tarplant by restoring disturbance to its habitat will require a long-term, science-driven commitment by all stakeholders.

Implementation of the Adaptive Management Framework

Given these biological and management principles listed above, there are five directives that should be implemented over the next 20 years (2006-2026). These include:

1) Implement an adaptive management framework which allows stakeholders to scientifically conduct and evaluate actions by establishing an Adaptive Management Working Group,
2) conduct a two-tracked program for improving overall habitat quality during the first seven years with

   a) semi-annual mowing with phytomass removal (or possibly prescription grazing) to reduce annual grass reproduction and cover over large portions of the Coastal Prairie/Tarplant Management Area, combined with

   b) ongoing experimental manipulations in reserved portions of the Management Area to improve existing, and to develop new, management actions
3) develop a schedule of "surgical" and "catastrophic" management actions,
4) build monitoring into the evaluation of every management action and research effort, and
5) develop public educational opportunities associated with

the coastal prairie of Arana Gulch and efforts to conserve and restore its rare resources.

Cooperative and committed management of Santa Cruz tarplant and coastal prairie habitat at Arana Gulch will depend on motivated stakeholders who participate in the decision-making process and work to implement basic actions. Those decisions and actions must be informed and evaluated by sound scientific, economic, and public policy information. Scientific information is generated by monitoring programs as well as directed (i.e. management-oriented) research. The best way to combine science with a stakeholder-controlled decision-making process is through an adaptive management framework.

Adaptive management is iterative: it evaluates decisions or actions through carefully designed monitoring and proposes subsequent modifications (Mulder et al. 2000). The modifications are in turn tested with an appropriate, perhaps redesigned, monitoring protocol. Adaptive management is logical, can deal with uncertainty and data gaps, and is similar to the scientific process of hypothesis testing. It recognizes that each stakeholder brings a unique perspective, but all are ultimately focused on enhancing Santa Cruz tarplant subpopulations and habitat quality by cooperating in an open, non-adversarial process.

The process of adaptive management is often represented as a cycle of strategy, design, implementation, monitoring, and evaluation. The first and most important task for implementation of the process is to develop a strategy that includes goals and objectives for Santa Cruz tarplant and its coastal prairie habitat, an inventory of known tools or actions for advancing the objectives (e.g. mowing, grazing), and the development of Key Management Questions that structure all subsequent monitoring and research activities. It is absolutely essential that stakeholders serving on the Adaptive Management Working Group cooperatively develop these elements of the strategy.

Goals and objectives are needed to provide a vision for the long-term conservation of Santa Cruz tarplant, its habitat and for Arana Gulch as a whole. That vision, whether it includes prairie restoration, subpopulation enhancement, or public access for education, must be defined through consensus in order to have the broadest possible stakeholder support. Without that support, opposition or apathy can prevent implementation to a halt. The vision cannot be forced upon stakeholders by regulatory agencies; it can only be guided and facilitated.

One of the first tasks of the Adaptive Management Working Group should be the development and adoption of broad, visionary goals and objectives that speak to the desired future state of Santa Cruz tar plant subpopulations and coastal prairie habitat at Arana Gulch. Once the goals and objectives are adopted, other elements in the strategy can be developed. Especially important will be the key management questions that focus science on specific management issues and data gaps and realize the vision set out in the goals and objectives.

Adaptive Management Working Group

Successful implementation of an adaptive management framework requires that committed stakeholders convene as an Adaptive Management Working Group. Stakeholders in this group should be interested in the outcomes of decision-making and in the technical process of managing the resources of Arana Gulch. This group may include personnel from public agencies (e.g. City of Santa Cruz, California Department of Fish and Game, U.S. Fish and Wildlife Service), private interests (e.g. California Native Plant Society) and scientific organizations (e.g. University of California).

Members of the Working Group would define and prioritize goals and objectives, develop key management questions, implement management actions, design and implement necessary monitoring programs, and utilize monitoring data to evaluate progress. A subset of the Adaptive Management Working Group, to be known as the Technical Advisory Group (TAG), would convene to address tactical scientific problems associated with data analysis and experimental design. The Working Group and Technical Advisory Group would utilize and expand this management program in concert with the efforts of state and federal agencies charged with conserving the species as a whole (including implementation of the federal recovery plan, when finalized).

The Adaptive Management Working Group would work cooperatively to enlarge and expand the seed bank of Santa Cruz tarplant at Arana Gulch by improving habitat conditions within the Coastal Prairie/Tarplant Management Program. The work would require a combination of management actions, research and monitoring while seeking public and private sector support for meeting the goals and objectives (vision) of the program.

Between the Adaptive Management Working Group, the public and representatives of the associated government agencies, there should be a structured flow of information. Policy and political issues can be brought to the Working Group for discussion. If a technical solution is appropriate, the Technical Advisory Group would be charged with its development using a science-based approach. Research and monitoring data can then be objectively reviewed and applied to the problem at hand. The results of the Technical Advisory Group deliberations are then taken back to the Adaptive Management Working Group for review. This flow is designed to bring issues to the table, provide objective feedback from monitoring and research, develop science-based solutions, and ensure that management actions, funding efforts, and regulatory requirements have follow-up and timely implementation. Although conflict among stakeholders is inevitable, structured information flow will help to resolve those conflicts over the long run and thus affect institutional synergy.

Conduct a Two-Tracked Habitat Management and Research Program

Evidence supports the conclusion that the average life of Santa Cruz tarplant seeds in the seed bank is between five and 10 years (Bainbridge pers. comm., Hayes pers. comm.). Appropriate disturbance must occur within that period to allow seeds to produce robust reproductive plants, thereby enlarging the seed bank. In the absence of that disturbance, annual grass and thatch cover inhibit germination and deter the establishment of large, reproductive individuals. Seeds that remain ungerminated in the seed bank die of old age, disease, or predation.

It is therefore critical that during the first seven years of this management program (at a minimum), a two-tracked program for enlarging the seed bank should be conducted by improving overall habitat quality in the coastal prairie of the Coastal Prairie/Tarplant Management Area. The emphasis would be on reducing cover and thatch by non-native annual grasses within the Management Area using a) semi-annual mowing regime (spring and fall, above 10 cm, with phytomass removal), combined with b) ongoing experimental manipulations (e.g. founding new subpopulations, plot-based testing of mowing, grazing and controlled burns) in reserved portions of the Management Area to improve existing, and develop new, management actions.

Invasion of coastal prairie by non-native grasses, combined with the elimination of disturbance by grazing and fire, have greatly modified the structure, composition and function of these grasslands. With respect to Santa Cruz tarplant, these changes have reduced the seed bank (and subpopulation sizes) by decreasing seed germination, plant survivorship and reproductive output. Annual grasses develop dense swards with high canopy cover, presumably leading to direct competition with young tarplant individuals. In the absence of disturbance (i.e. grazing and fire), the cover persists as an impenetrable overstory canopy or as a layer of dead thatch on the soil surface.

Reducing the canopy and removing the thatch have demonstrated beneficial effects on Santa Cruz tarplant demography (Hayes 2003, Hayes and Holl in review) and on grasslands in general (Meyer and Schiffman 1999). Therefore, improving the seed bank and habitat of Santa Cruz tarplant mostly depend on minimizing the detrimental effects of high cover by non-native grasses. These effects can by minimized by restoring the proper disturbance regime to the coastal prairie of Arana Gulch.

But exactly what is that disturbance regime? Recent research has shown that mowing the grass canopy and removing the clippings at least twice a year can improve germination, survivorship, flower output and seed output of Santa Cruz tarplant at some sites and in some years (Hayes and Holl in review). A small but heavy-duty lawn tractor, fitted with a mower and collector could readily navigate between the subpopulation areas, and would also be capable of treating the larger, unoccupied tracts of prairie within the Coastal Prairie/Tarplant Management Area.

The goal would be to reduce the standing cover of the grasses at least twice a year: once to cut off developing inflorescences in early spring, and once to reduce the final amount of grassland phytomass in late fall. The spring mowing could reduce grass reproduction (a greater detriment to the annual, non-native grasses than to native perennial grasses) and canopy cover without harming low-growing tarplant rosettes. The fall mowing would reduce thatch deposition, thus improving soil surface conditions for tarplant germination. It is important to note that fall mowing conducted before complete senescence would have a negative effect on the tarplant population.

The mowing disturbance regime would only mimic the phytomass removal effects of grazing by native and domesticated ungulates over large portions of the Coastal Prairie/Tarplant Management Area and would not incorporate soil disturbance or selectivity that grazers supply. However, this "Management Track" would be relatively easy and inexpensive to implement, with minimal regulatory uncertainty that complicates other possible habitat treatments (e.g. large-scale controlled burns). Semi-annual mowing could, therefore, be applied consistently every year for at least seven years to portions of Arana Gulch that are already occupied by Santa Cruz tarplant (the current subpopulation areas) or that could be occupied by tarplant in the future if habitat quality and seed bank distribution were not limiting.

However, the effects of the consistent, large-scale semi-annual mowing on Santa Cruz tarplant and its habitat are not predictable at present. The fall mowing, for example, might affect the dispersal of tarplant seeds, or even remove them from the site. Modifications to the regime, such as avoiding subpopulation areas in fall, may need to be tested (perhaps in control plots), as well as other possible treatments for reducing grass cover and thatch (e.g. small-scale prescription grazing, herbicide or burn treatments).

So, in addition to the first management track of the program, a second research track should be implemented to address key management questions regarding grass cover management. To support this "Research Track", portions of the subpopulations may be reserved as controls or as areas to receive a different treatment. Experimental subpopulations of Santa Cruz tarplant may be introduced to mowed areas beyond the existing subpopulations to test the efficacy of grass cover treatments, and to determine if introduction could be used as a way of enlarging the distribution of tarplant within the Coastal Prairie/Tarplant Management Area.

Develop a Schedule of Supplemental Surgical and Catastrophic Management Actions

Actions of the Management Track should take place on a seven-year cycle, owing to the postulated longevity of Santa Cruz tarplant seeds in the seed bank. In addition to regular mowing, relatively minor actions that affect small areas within the known subpopulation areas could be designed as sensitive responses to environmental conditions that develop within the current growing season. These "surgical" actions would counteract the detrimental affects of annual grasses on Santa Cruz tarplant germination and establishment (Hayes and Holl, in review). For example, a typical surgical action might be hand clipping of the developing grass canopy during wet, warm fall and winter months (November to May) while carefully avoiding young Santa Cruz tarplant plants. The objective would be to keep the prairie canopy open to benefit Santa Cruz tarplant with additional light and soil water resources. A quasi-experimental framework would allow costs and benefits of such adjustments to be evaluated using cause-and-effect monitoring.

In year seven of the cycle, a major management action would take place. This "catastrophic" action would affect large areas within and around the subpopulation areas, or anywhere within the Coastal Prairie/Tarplant Management Area. It would take place without regard to (or prior knowledge of) conditions that will develop during the upcoming growing season and before tarplant germination. For example, a catastrophic action might be used to remove thatch and the upper few centimeters of soil organic material by mechanical scraping or an intense, controlled burn. Its timing would always be in late summer and early fall (August to October) before the first rains of the growing season.

A quasi-experimental framework would allow costs and benefits of such actions to be evaluated using cause-and-effect monitoring. If, however, the Santa Cruz tarplant population in year six happened to be very large (e.g. greater than 5,000 reproductive plants), then the catastrophic action should be delayed one or possibly two years before implementation. This is because the benefits of such an action might not compensate for the immediate losses (e.g. mortality of year six seeds). In general, the cyclical schedule should be regarded as flexible so that annual variations in climate can be taken advantage of (e.g. in "good" years) or compensated for (e.g. "bad" years). Guidelines for dealing with such variations are presented in Zedler and Black (1989).

The advantages of having a cyclical schedule of surgical and catastrophic management actions are; 1) surgical actions are immediate responses to each growing season that maximize Santa Cruz tarplant survivorship and reproductive output (seed bank replenishment), 2) catastrophic actions have a frequency that is matched to seed longevity in the seed bank, 3) catastrophic actions improve soil surface conditions to maximize tarplant germination without draining the seed bank, 4) efforts, costs and other logistical elements can be anticipated and developed well ahead of implementation and 5) simplification of the adaptive management process, including clarification of objectives and imposition of regularity on monitoring and evaluation.

Build Monitoring into Evaluation of Every Management Action and Research Effort

Monitoring informs adaptive management. It is designed and implemented with the expressed purpose of determining if the objectives of the adaptive management strategy are being met. Although the specific objectives of this management program have yet to be defined by the Adaptive Management Working Group, some basic elements of monitoring are universal; consistency (repeatable methods applied each year), constancy (applied every year), and appropriateness (for the focal resource). Such design elements are essential for evaluating actions and research efforts, as well as revealing the status of the focal resource, in this case, Santa Cruz tarplant. There are two general types of monitoring that should be used in this adaptive management program, which include "status and trend" monitoring and "cause and effect monitoring," which are described in more detail in the full report.

The AMWG should continue Santa Cruz tarplant subpopulation monitoring at Arana Gulch and integrate the data into the adaptive management framework. This would best be done by a qualified botanist or ecologist, approved by the Working Group and paid for time and expenses, to ensure high quality data collected at the right time of year. A standardized monitoring protocol (see suggestions, Appendix A) should be designed and adopted by the Working Group that would ensure the following:

1) similar effort and intensity of search from year-to-year,
2) inclusion of the entire area in the search (not just the known subpopulation areas,
3) use of GPS technology to map the locations of individual plants and subpopulations,
4) collection of relevant measures of habitat quality (e.g. cover by non-native grasses in subpopulation areas and invasive fronts of noxious weeds), and
5) an accounting of recent management actions or research.

Typically, status and trend monitoring places an emphasis on aboveground plants that survive to flower, but for annuals such as Santa Cruz tarplant, a supplemental program that examines trends in the seed banks of subpopulations is strongly recommended. A standardized data summary sheet and written report form should also be adopted to facilitate timely, year-to-year comparisons.

The seven year cycle proposed for Santa Cruz tarplant must be viewed as a series of management experiments that will test whether subpopulations (and their seed banks) are being enlarged and expanded by restoring disturbance to its coastal prairie habitat. The experiments would include:

1) the semi-annual mowing regime,
2) surgical actions, such as grass clipping, taken during the growing season, and
3) catastrophic actions, such as mechanical scraping of the soil surface, taken every seventh year. In addition, research efforts on the use of grazing animals, fire and other management tools would, by their scientific nature, include this kind of monitoring.

There is already a long history of Santa Cruz tarplant research with cause and effect monitoring at Arana Gulch (e.g. Bainbridge 2003) and elsewhere (Hayes 2003, Hayes and Holl in review) upon which to build. It is the task of the Adaptive Management Working Group to prioritize research needs (according to goals, objectives, and key management questions) for its own decision-making process and to help generate and allocate the necessary funds to support the research. Research funded through the Adaptive Management Working Group should require a final written report, with data files, to be delivered before contract payments have been completed.

Public Educational Opportunities

Broad public support for the management and restoration of Santa Cruz tarplant and its coastal prairie habitat at Arana Gulch are necessary and desirable. Gaining that support requires a demonstration that endangered species protection, habitat restoration, recreational access, and local governance can cooperatively work to protect the public trust. Part of the demonstration will come through concrete implementation of this management program by the Adaptive Management Program. Another part will come through a public access and education program that makes the resources, issues and solutions real; that allows citizens to see Santa Cruz tarplant flowers in a relatively intact natural landscape. Implementation of this program, along with an education and access program, could powerfully demonstrate that public agencies and resource advocates can find a way to make local governance work for the benefit of all.

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APPENDIX 1

Suggestions for the Yearly Census of Santa Cruz Tarplant at Arana Gulch

1) The census should take place during the same period each and every year. Typically, this would be during the earliest reproductive peak, late June to early August, depending on rainfall, temperature and other factors that affect plant phenology.
2) The entire Coastal Prairie/Tarplant Management Area should be searched, including areas beyond occupied patches, treatment areas, and subpopulation centers (A,B,C, D). Detection of the location of quiescent seedbanks is a high priority. Portions of the entire property that burn should be searched during the following summer. The entire Arana Gulch property should be searched during the summer following a burn over the entire property.
3) A standard pattern of search should be adopted by the Technical Advisory Group of the Adaptive Management Working Group. The pattern would allow visual inspection for a thorough search as specified in #2 above. The pattern will be given to the botanist as part of an instruction sheet prior to census.
4) A standard field datasheet should be adopted by the Technical Advisory Group. The datasheet should record plant locations (GPS points), plant size, number of branches, number of floral heads, patch size, and other relevant data.
5) The census should be conducted by a qualified botanist familiar with the species and its habitat. Additional search personnel, trained to recognize the species, will probably be required to insure thorough search in the allotted time.
6) A total crew of four (including the botanist) should be allotted 8 hours in a year when the population totals less than 2,000 plants. In a year with more than 2,000 plants, more time could be required or a sampling protocol devised so that only a representative portion of the population is measured for plant size, etc. The Tehnical Advisory Group can provide the sampling protocol and/or modify these parameters depending on its data requirements.
7) The botanist should summarize the raw data on a standard summary datasheet and presented as a map with precise plant locations shown. These, along with the field datasheets, should be submitted to the Technical Advisory Group before September 30 of that census year.
8) The botanist and the crew should be paid to conduct the census and to submit the products as specified in #7.

APPENDIX 2

Suggestions for Implementation of the Santa Cruz Tarplant Adaptive Management Program

Formal and complete implementation of this Adaptive Management Program depends on coordination by the City of Santa Cruz, commitment of the participants, and acquisition of long-term funding. Until those components are in place, selected elements of this management program should be implemented to ensure persistence of Santa Cruz Tarplant at Arana Gulch. Such interim implementation focuses on taking actions in consultation with a "proto-Technical Advisory Group." Formal implementation involves establishing the entire adaptive management framework presented in this Program.

Interim Implementation

1) The City of Santa Cruz should establish the proto-Technical Advisory Group by inviting one regulatory scientist (from U.S. Fish and Wildlife Service, the California Department of Fish and Game, or the California Coastal Commission) and at least one academic or consulting scientist to serve. This group of two or three members must have expertise in conservation of rare plants and/or restoration of coastal grasslands.
2) The proto-Technical Advisory Group will work with representatives of the City of Santa Cruz to enact appropriate management actions that benefit Santa Cruz tarplant as reviewed in this program. Those actions could be mowing with phytomass removal, grazing, or other habitat manipulations that decrease the deleterious effects of annual grasses. Other actions that are more catastrophic in scale and intensity, such as soil scraping and controlled burning should only be conducted in consultation with a larger array of experts.
3) All actions taken must be properly documented and monitored as reviewed in the Adaptive Management Program with a written summary of results submitted to the City of Santa Cruz before the end of the current management year (December 31).
4) The yearly census of reproductive plants should be conducted every year using conventions and data formatting presented in Appendix A of this program. The results of the census submitted to the City of Santa Cruz before the end of the current management year (December 31).
5) Ongoing research on Santa Cruz Tarplant and Arana Gulch should be facilitated by the proto-Technical Advisory Group and the City of Santa Cruz during this interim period.

Formal Implementation

1) Establishment of the Adaptive Management Working Group should be conducted by the City of Santa Cruz with advice from the U.S. Fish and Wildlife Service, the California Department of Fish and Game, and the California Coastal Commission.
2) The three principal federal and state agencies charged with plant conservation and coastal zone management (U.S. Fish and Wildlife Service, the California Department of Fish and Game, and the California Coastal Commission) should each have a single representative on the Adaptive Management Working Group. In addition, at least two scientists with conservation and restoration experience in coastal grasslands and/or rare plant conservation should be invited to serve. The City of Santa Cruz, as the landowner and as the party responsible for implementation and funding of this program, could have up to two representatives on the Adaptive Management Working Group. These seven representatives constitute the core Working Group. Other parties with a direct interest in plant conservation and/or ecosystem restoration could be added with the approval of the core Working Group, but the total number should not exceed ten representatives for logistic purposes.
3) Funding for implementation of this program should rest in part with the City of Santa Cruz and in part with the agencies

represented on the Adaptive Management Working Group. Details on the origin, timing, and amount of that funding should be determined as soon as possible. Funding should be available to conduct the management program and convene the Working Group. Part of that funding should be used to provide support staffing for the chair of the Working Group as well as to pay expenses of the Working Group incurred for travel to meetings, if feasible.

4) The initial meeting of the Adaptive Management Working Group should include the accomplishment of the following tasks:
   a. Election of a chair to develop agenda, convenes the AMWG, and assigns tasks to others on the group (including appointment to the Technical Advisory Group. The chair should serve for three years.
   b. Election of a recorder to take and distribute minutes. The recorder should serve for two years.
   c. Development of basic operating "rules", especially the issue of quorum, and schedule of meetings and management events.
   d. Discussion of funding sources and acquisition.
   e. Discussion of the adaptive management process with respect to Santa Cruz tarplant and Arana Gulch, as outlined in this program (copies supplied to Working Group well in advance of the meeting). Construction of goals and objectives and key management questions will be postponed for the agenda other meetings to follow.
   f. Discussion of the two-tracked habitat management and research program and how to implement each track for the upcoming year and for the longer time framework of the program. Make a list of ongoing research projects at Arana Gulch.
   g. Achieve consensus on the "Management Track" actions for the upcoming year, including who will conduct them, when, and with what funding. Care should be taken so that these actions do not interfere with ongoing research projects. Determine the monitoring and reporting requirements for these actions and the timing of delivery of the final reports. Determine the permit requirements for these actions. The Technical Advisory Group may be asked to finalize protocols/requirements outside of the meeting and make them available to the party responsible for conducting the actions. Development of a schedule of surgical and catastrophic actions will be postponed for the agenda of other meetings to follow.
   h. Determine how a census of Santa Cruz tarplant at Arana Gulch will be conducted during the upcoming year (Appendix B), including who will conduct it, when and with what funding. Determine the reporting requirements for the census, and the timing of delivery of the final report. Determine the permit requirements for this census. The Technical Advisory Group may be asked to finalize protocols/requirements outside of the meeting and make them available to the party responsible for the census.
   i. Development of public educational opportunities will be postponed for the agenda of other meetings in the future.
   j. Schedule the next Adaptive Management Working Group meeting later in the same year. Assign subcommittees of 2 representatives each to prepare draft versions of the following: 1) goals and objectives, 2) key management questions, and the 3) schedule of surgical and catastrophic actions for discussion at the next meeting.
5) The Adaptive Management Working Group Chairperson should set the next meetings agenda and ensure that it and the minutes of the first meeting are distributed by the recorder. The Chairperson begins working with the City of Santa Cruz and other agencies to ensure funding will be available for the management actions, census, and Adaptive Management Working Group meetings.