ARANA GULCH HABITAT MANAGEMENT PLAN

Prepared for the City of Santa Cruz Planning Department
and the Department of Parks and Recreation

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1.0 Introduction

Arana Gulch is an open space located on 67 acres at the eastern border of the City of Santa Cruz. The eastern half of the property features the riparian corridor of Arana Gulch Creek and a tidal wetland where the creek drains into Monterey Bay at the Santa Cruz Harbor. The western half is a remnant of coastal prairie grassland that supports the Santa Cruz tarplant (*Holocarpha macradenia*) (SCT), a federally Threatened and a CA State Endangered species. A steep and narrow intermittent drainage called Hagemann Gulch crosses the property on the western boundary.

The area that encompasses what is now Arana Gulch was part of a 92-acre rancho granted to Jose Arana in 1842. In 1878, Frederick Hagemann acquired the entire area for a farming and livestock operation. In the 1920s, the Kinzli family acquired the property and started the East Side Dairy. The dairy operation continued through the mid-1950s and cattle grazing continued until 1988. Surrounded by urban development, this unique property was designated a Greenbelt land in 1979 by voter approval of Measure O. The City of Santa Cruz subsequently acquired Arana Gulch in 1994 from the Kinzli family and shortly thereafter opened the property to the public.

Over the past two decades a variety of land uses have been proposed for the property including the development of recreational opportunities and natural resource protection. The Arana Gulch Master Plan is the result of this lengthy planning and public input process. This plan has a dual emphasis on natural resource protection and restoration and public access and education. The elements include construction of a multi-use trail system, installation of grazing fences to support the reintroduction of livestock to the coastal prairie, and development of public information kiosks and other educational materials.

Implementation of the Arana Gulch Master Plan requires the City to obtain a coastal development permit (CDP) from the California Coastal Commission (CCC) because a portion of the planning area lies within the designated Coastal Zone. The CDP (3-11-074) includes both standard and special conditions. The Arana Gulch Habitat Management Plan (HMP) has been developed to satisfy the special conditions of the CDP. The purpose of this HMP is to provide for the restoration, enhancement, and long-term management of the Arana Gulch habitat Management Areas as self-sustaining and functioning habitats in perpetuity. The Management Areas include: the Coastal Prairie/Tarplant Management Area, the Arana Gulch Riparian and Wetland Management Area, and the Hagemann Gulch Riparian Woodland Management Area (Figure 1-1).

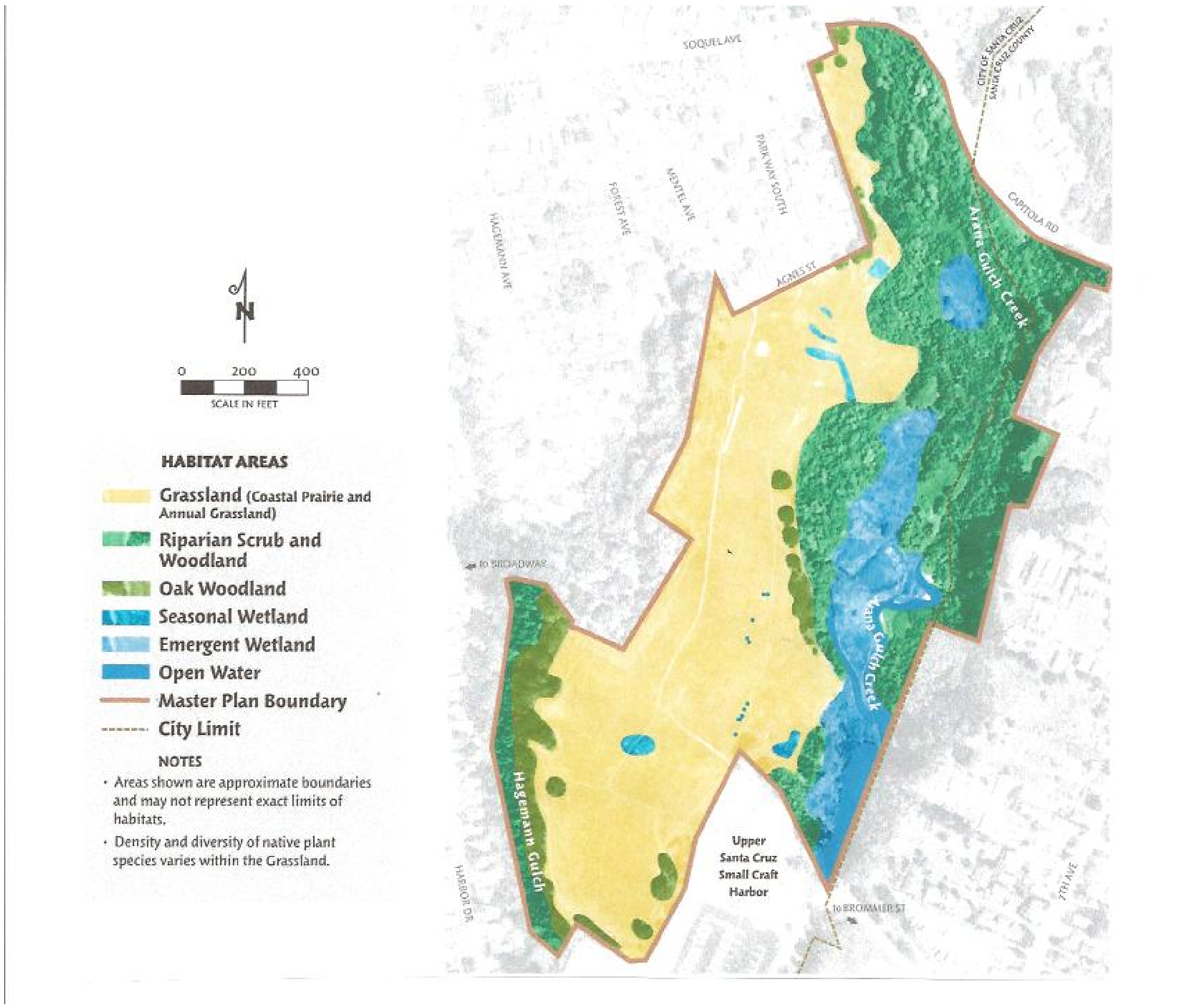

Figure 1-1. Map of Arana Gulch showing the locations of the Coastal Prairie/Tarplant Management Area, the Arana Gulch Riparian and Wetland Management Area, and the Hagemann Gulch Riparian Woodland Management Area.

Collectively, these habitats at Arana Gulch support a number of special-status plant and wildlife species. SCT is the only State or Federally listed plant species known from the property. However, potential habitat exists for other special-status plants including Artist's popcorn-flower (*Plagiobothrys chorisianus*), Santa Cruz clover (*Trifolium buckwestiorum*), and maple-leaved checkerbloom (*Sidalcea malachroides*). The highest priority wildlife species known to occur on the site is the federally Threatened steelhead trout (*Oncorhynchus mykiss*), which was last recorded in Arana Creek in 1999. Potential habitat occurs for special-status wildlife species including the tidewater goby (*Eucyclogobius newberryi)*, California red-legged frog (*Rana draytonii*), and southwestern pond turtle

(*Emys marmorata*), but the degraded conditions in the riparian zone and emergent wetland make the occurrence of these species unlikely. Potential habitat also occurs for several species of special status birds and bats. The San Francisco dusky-footed woodrat (*Neotoma fuscipes annectens)*, a CA Species of Concern, is present in Hagemannn Gulch.

In addition to special status species, a wide variety of wildlife species utilize the grassland community for foraging and breeding, including many birds, different types of lizards, a variety of snakes, California ground squirrel, gopher, California vole, and striped skunk. A number of predatory birds rely on the insects, smaller mammals, and birds of the grasslands as an important source of prey. Various bat species also catch insects rising from the open grasslands. Black-tailed deer have been observed browsing on the grassland slopes. Larger predatory mammal species, including the bobcat and gray fox, have been infrequently observed in the grassland areas.

The riparian scrub and woodland communities along the Hagemann Gulch and Arana Gulch Creek corridors provide important potential nesting and foraging habitat for numerous species of birds, and protective cover for larger wildlife such as black tailed deer, raccoon, striped skunk, and opossum. Bat species may utilize oaks for roosting. The emergent wetland community provides important estuary habitat for fish, amphibians, aquatic reptiles, and birds. The emergent vegetation provides essential reproductive habitat for invertebrates.

While there is no doubt that Arana Gulch provides an important refuge for plants, animals, and humans alike, the habitats are severely degraded. The coastal prairie grassland is almost exclusively comprised of non-native plants, including some noxious invaders. Non-native species have displaced most of the native understory in Hagemann Gulch with the exception of native poison oak, which is thriving. While these non-native species may provide cover for wildlife or food sources, they are a poor functional replacement for a diverse native riparian forest. The development of the Harbor, culverts, and development within the watershed has decreased habitat values for fisheries and other aquatic species within Arana Gulch Creek. Streambank erosion is prevalent along the entire length of Arana Creek as it crosses the greenbelt property. Within the southern tidal reach, the stream banks have collapsed and there is substantial channel head cutting. Pools within the channel are generally shallow and filled with fine sediment.

Restoring conditions at Arana Gulch will require a long-term coordinated effort. This HMP has a primary focus on the coastal prairie and the recovery of the SCT population as a first priority. A watershed approach is recommended for addressing conditions in Arana Creek. Targeted invasive plant removal is initially recommended for Hagemann Gulch. The Master

Plan provides a vision for future conditions at Arana Gulch focused on natural resources protection and passive recreation as follows:

- Sensitive habitat areas, including coastal prairie, riparian woodland and scrub, and wetlands are protected and enhanced.
- An active adaptive management program ensures the long-term viability of the Santa Cruz tarplant within Arana Gulch.
- Interpretive displays and programs educate the public about natural resource protection and enhancement.
- Best Management Practices are employed to improve trails, stabilize and restore eroded areas and reduce sediment transport to Arana Creek.

This HMP describes an Adaptive Management framework to begin the process of achieving this vision. Resources and land management agencies have widely embraced adaptive management as their approach to improving the condition of their natural resources. The adaptive management framework recognizes that effective resource management and land-use decision-making requires sound scientific information and provides the mechanism to link science directly to management. An Adaptive Management Working Group (AMWG) is the central component of an effective adaptive management framework. The working group serves at the pleasure of the City with the approval of the Executive Director of the California Coastal Commission. The central role of the AMWG is to guide the City on the implementation of HMP activities.

Establishment of the Arana Gulch AMWG has been conducted by the City of Santa Cruz to meet the first requirement of the CDP special conditions. It is comprised of a group of cooperative and committed stakeholders interested in the outcomes of decision-making and in the technical process of managing target conservation resources. The initial composition has been approved by the CCC Executive Director independently from this HMP. The City of Santa Cruz has allocated funding to support implementation of this HMP.

1.1 Habitat Management Plan special conditions

Implementation of the Arana Gulch Master Plan requires the City to obtain a coastal development permit (CDP) from the California Coastal Commission (CCC) because a portion of the planning area lies within the designated Coastal Zone. The CDP (3-11-074) includes both standard and special conditions. The standard conditions address execution of the permit and specify that the terms and conditions are perpetual and bind all future owners. The special conditions address five areas: 1) Approved Project; 2) Final Project Plans; 3) Arana Gulch Habitat Management Plan; 4) Public Access Plan; and 5) Construction Plan.

The CDP Conditions of Approval for Sections 1-3 are included here as follows:

3-11-074 (Arana Gulch Master Plan)

Conditions of Approval

A. Standard Conditions

1. Notice of Receipt and Acknowledgment. The permit is not valid and development shall not commence until a copy of the permit, signed by the permittee or authorized agent, acknowledging receipt of the permit and acceptance of the terms and conditions, is returned to the Commission office.

2. Expiration. If development has not commenced, the permit will expire two years from the date on which the Commission voted on the application. Development shall be pursued in a diligent manner and completed in a reasonable period of time. Application for extension of the permit must be made prior to the expiration date.

3. Interpretation. Any questions of intent or interpretation of any condition will be resolved by the Executive Director or the Commission.

4. Assignment. The permit may be assigned to any qualified person, provided assignee files with the Commission an affidavit accepting all terms and conditions of the permit.

5. Terms and Conditions Run with the Land. These terms and conditions shall be perpetual, and it is the intention of the Commission and the permittee to bind all future owners and possessors of the subject property to the terms and conditions.

B. Special Conditions

1. Approved Project. Subject to these standard and special conditions (including modifications to the project and/or the project plans required by them), this coastal development permit authorizes implementation of the Arana Gulch Master Plan and related trail and other improvements extending from Frederick Street to 7th Avenue, including: management and restoration of habitat areas; improvements to the existing trail system, including new paved and unpaved paths, improvement and realignment of existing unpaved paths, and removal and restoration of existing paths to be abandoned; construction of a new bridge over Hagemann Gulch; installation of interpretive displays and trail signage; installation of fencing, including to allow limited cattle grazing, all as more specifically described in the proposed project materials (see Exhibits C, D, E, F, and P).

2. Final Project Plans. PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the Permittee shall submit two copies of Final Project Plans to the Executive Director for review and approval. The Final Project Plans shall be substantially in conformance with the proposed project materials (see Exhibits C, D, E, F, and P) except that they shall be revised and supplemented to comply with the following requirements:

(a) Path Modifications.

1. Arana Meadow Trail. The paved Arana Meadow Trail that leads into Arana Gulch from the Agnes Street entrance shall be relocated to the west of its proposed location to the area of the existing unpaved portion of the Coastal Prairie Loop Trail.

2. Unpaved Paths. The Final Project Plans shall include specific details, including representative cross sections, clearly identifying all measures to be taken to create the new unpaved path segments as well as to modify the existing unpaved path segments. All unpaved path segments shall be made to match as much as possible in appearance.

3. Abandoned/Restored Paths. All paths that are not part of the designated path system shall be abandoned, and the area restored as part of the habitat in which it is located. All such paths shall be clearly identified on the Final Project Plans, and all measures to be taken to effectuate the abandonment/restoration shall be clearly identified.

4. All Paths Clearly Shown. All path segments, including those extending to the Broadway/Frederick Street intersection from the Hagemann Gulch bridge and including those extending from near Arana Creek to the Brommer Street/7th Avenue intersection, shall be clearly identified. These extending path segments shall be sited and designed to match the aesthetics of the rest of the path system as much as possible in siting, design, and flow, including being constructed in as curvilinear a manner as possible, and including native and non-invasive landscaping areas adjacent to them to help separate them visually and physically from adjacent uses and development, including vehicular use areas.

5. Path Maintenance. All measures to be taken to ensure that the path system is maintained in its approved state in perpetuity shall be clearly identified.

(b) Grazing/Fencing Detail. All meadow grassland areas within Arana Gulch that are located within the paved and unpaved trail loop (except the "dog free" Marsh Vista Trail) extending around the periphery of the main meadow area shall be included in the grazing area except for: areas of steep slopes; areas within 5 feet of trails; areas within 5 feet of benches/interpretive sites; areas within 100 feet of the Hagemann Gulch riparian corridor and related tree canopy; areas within 50 feet of oak trees/oak woodland canopy along the Coastal Prairie Loop Trail; and the area near Agnes Street where the Meadow Overlook interpretive facility is to be located as well as a 25 foot area surrounding the facility. The grazing area shall be demarcated by a wood post (round and approximately 4-inch diameter) and wire fence where the following shall be limited as much as is feasible to limit visual impacts: the number of fence posts, the height of fence posts, the area of post footing, the gauge of wire, the number of wires, and the number of wires that are barbed wires. All gates shall be steel and shall be designed so that they are complementary to, and seamlessly integrated with, the wood post and wire fence. The cattle corral near Agnes Street (as distinct from the grazing area) shall be limited in area as much as possible. All fencing and gates shall be sited and designed in the manner most protective of coastal resources.

(c) Other Fencing/Barrier Detail. All other fencing and barriers (i.e., other than the grazing and corral fencing) shall be clearly identified in site plan and elevation views. All such fencing and barriers shall be limited to that that is conclusively shown to be necessary to protect habitat and direct path system users, and shall be sited and designed to minimize to the maximum degree possible visual impacts, including through use of a consistent fencing and barrier design throughout the project. All fencing/barriers along that portion of the Creek View Trail adjacent to the Upper Harbor area shall be eliminated with the exception of a railing near Arana Creek if conclusively shown to be required to adequately ensure public safety, and if it is designed to limit view blockage (e.g., limited rails, cable-rails, etc).

(d) Lighting Detail. Lighting shall be prohibited with the exception of low-level lighting at the entrance locations into the path system, and with the exception of low-level lighting otherwise conclusively shown to be required to adequately ensure public safety associated with authorized trail use, where such public safety lighting is limited to the greatest degree feasible. Any lighting shown on the Final Project Plans shall be accompanied by justification for it, and clear identification of its parameters (i.e., luminosity, glare field, expected times when it would be on, etc.). All approved lighting shall be sited, designed, and operated to minimize impacts on habitat areas to the maximum degree possible.

(e) Entrance Detail. All improvements associated with entrance locations into the path system, including at Agnes Street and at the northern end of the Upper Harbor, shall be clearly identified in cross section and elevation views. All associated development (e.g., fencing, signs, benches, trash cans, recycling cans, bike racks, etc.) shall be clearly identified.

(f) Design. The Final Project Plans shall clearly identify all measures that will be applied to ensure that the project design, including all structures and including all other project elements (e.g., bridge, paved paths, unpaved paths, fencing and barriers, retaining walls, railings, benches, lighting, signs, water troughs, landscaping, etc.) clearly reflects a rural open space theme and aesthetic (i.e., simple, spare, and utilitarian lines and materials; natural materials (wood, stone, brick, etc.); corten (weathered) steel or equivalent; earth tone colors; etc.) with a pedestrian-oriented form and scale. At a minimum, the plans shall clearly identify all structural elements, materials, and finishes (including through site plans and elevations, materials palettes and representative photos, product brochures, etc.).

(g) Minor Adjustments. The Final Plans shall provide that minor adjustments to final plans may be allowed by the Executive Director if such adjustments: (1) are deemed reasonable and necessary; and (2) do not adversely impact coastal resources.

The Permittee shall undertake development in accordance with the approved Final Project Plans.

3. **Arana Gulch Habitat Management Plan.** PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the Permittee shall submit for Executive Director review and approval three copies of a final Arana Gulch Habitat Management Plan (HMP). The HMP shall provide for the restoration, enhancement, and long-term management of all Arana Gulch habitat areas (including, as referenced by the Arana Gulch Master Plan, the Coastal Prairie/Tarplant Management Area, the Arana Gulch Riparian and Wetland Management Area, and the Hagemann Gulch Riparian Woodland Management Area) as self sustaining and functioning habitats in perpetuity. The HMP shall be prepared by a qualified expert in restoration ecology for each of the habitat types, and shall take into account the specific conditions of the site as well as restoration, enhancement, and management goals. The HMP shall be substantially in conformance with the Master Plan documents submitted to the Coastal Commission, including the August 1, 2005 document entitled "A Management Program for Santa Cruz Tarplant (*Holocarpha macradenia*) at Arana Gulch"), including that it can be submitted in a package that includes relevant Master Plan documentation with an addendum that addresses this condition, provided all language is modified to be directive (e.g., "shall" rather than "should") and it complies with the following requirements and includes:

(a) A baseline assessment, including photographs, of the current physical and ecological condition of the restoration and enhancement areas. All existing topography, wet features, and vegetation shall be depicted on a map.

(b) A description of the goals of the plan, including in terms of topography, hydrology, vegetation, sensitive species, and wildlife usage.

(c) A description of planned site area preparation and invasive plant removal.

(d) Any planting either of seeds or container plants shall be made up exclusively of native taxa that are appropriate to the habitat and Arana Gulch region. Seed and/or vegetative propagules shall be obtained from local natural habitats so as to protect the genetic makeup of natural populations. Horticultural varieties shall not be used.

(e) A plan for monitoring and maintenance of habitat areas in perpetuity, including:

- A schedule.
- A description of field activities, including monitoring studies.
- Monitoring study design for each habitat type, including, as appropriate: goals and objectives of the study; field sampling design; study sites, including experimental/revegetation sites and reference sites; field methods, including specific field sampling techniques to be employed (photo monitoring of experimental/re-vegetation sites and reference sites shall be included); data analysis methods; presentation of results; assessment of progress toward meeting success criteria; recommendations; and monitoring study report content and schedule.
- Adaptive management procedures, including provisions to allow for modifications designed to better restore, enhance, manage, and protect habitat areas.
- Provision for submission of reports of monitoring results to the Executive Director for review and approval in perpetuity, beginning the first year after initiation of implementation of the plan. Such Monitoring Reports shall be submitted annually until success criteria are met, and then shall be submitted on an every 3-year basis after that. Each Monitoring Report (annual and 3-year) shall be cumulative and shall summarize all previous results. Each report shall clearly document the condition of the habitat areas, including in narrative (and supporting monitoring data) and with photographs taken from the same fixed points in the same directions as the baseline assessment and prior Monitoring Reports. Each report shall include a performance evaluation section where information and results from the monitoring program are used to evaluate the status of the restoration, enhancement, and long-term management in relation to the interim performance standards and final success criteria. To allow for an adaptive approach, each report shall also include a recommendations section to address changes that may be necessary in light of monitoring results and/or other information, including with respect to current restoration information and data related to the habitat areas in question, and to ensure progress toward and achievement of success criteria. Actions necessary to implement the recommendations shall be implemented within 30 days of Executive Director approval of each Monitoring Report, unless the Executive Director identifies a different time frame for implementation.

(f) Interim success criteria to be achieved in the first year of implementation, tied directly to the annual reporting requirement. Also, measureable goals to achieve habitat improvement over time, subject to modification by the Adaptive Management Working Group.

(g) Implementation procedures, cost estimates, identification and allotment of funding for all HMP activities, and related reporting procedures.

(h) Provisions for minor adjustments to the HMP by the Executive Director if such adjustments: (1) are deemed reasonable and necessary; and (2) do not adversely impact coastal resources.

(i) Identification of the membership of the Adaptive Management Working Group, which initial composition and any future changes shall be subject to Executive Director approval. The Adaptive Management Working Group shall guide all HMP activities under the plan.

(j) All details associated with the grazing program, subject to Adaptive Management Working Group and Executive Director approval, in substantial conformance with the proposed cattle grazing program (see Exhibit P Tab 4).

PRIOR TO COMMENCEMENT OF CONSTRUCTION, the HMP shall be implemented by establishing the Adaptive Management Working Group (AMWG), receiving prioritized first-year management recommendations from the AMWG, and initiating implementation of the highest priority recommendations in the field.

The Permittee shall undertake development in accordance with the approved Arana Gulch Habitat Management Plan.

This Habitat Management Plan (HMP) has been developed to satisfy the special conditions of the CDP. The purpose of this HMP is to provide for the restoration, enhancement, and long-term management of the Arana Gulch habitat Management Areas as self-sustaining and functioning habitats in perpetuity.

1.2 Habitat Management Plan organization and overview

This HMP presents the Adaptive Management Framework (2.0) first because it forms the foundation of the entire HMP. The adaptive management framework recognizes that effective resource management and land-use decision-making requires sound scientific information and describes a process that links scientific monitoring directly to management. Next, a conceptual model is presented for the whole of Arana Gulch (2.1) that illustrates some of the cause-and effect relationships that are assumed to exist within the project area. Separate conceptual models for each of the three Management Areas were also developed. Within an adaptive management framework, such conceptual models can help stakeholders document their understanding of a conservation system in a way that can be examined and agreed upon within the group as a way to prioritize planning and monitoring and as a guide to decision-making.

Section 2.2 Establishment of the Adaptive Management Working Group (AMWG) is the first step in the implementation of this HMP. The composition of the initial AMWG is presented first in the section describing Membership (2.2.1) and then the Roles and Responsibilities (2.2.2) of member and non-member entities are described. A hallmark of an adaptive management framework is a structured flow of information (2.2.3) that further illustrates stakeholder roles and responsibilities. The development of an Arana Gulch website and public participation is described in section 2.2.4 as one of the important component of the adaptive management program. Finally, an Implementation Schedule (2.3) presents target completion dates for a variety of tasks (2.3.1) and the specific reporting requirements for the CDP (2.3.2).

A separate section is then devoted to each of the three Management Areas that includes the following required elements; a Baseline Assessment, a conceptual model (not required), a Monitoring Plan with specific Goals and Interim Success Criteria and a Schedule for implementation.

The most extensive section of this HMP is devoted to the Coastal Prairie/Tarplant Management Area. An overview of SCT biology and coastal prairie habitat (3.1) is adapted from the previous Management Program for SCT (Pavlik and Espeland 2005). The spectrum of management tools that can be used to help restore the coastal prairie habitat at Arana Gulch are presented in section 3.2. The next section provides the background and historic census data for the SCT population at Arana Gulch (3.3.1) and then details the management efforts to implement each of the five directives from the SCT Management Program during 2006 to 2012 (3.3.2). The Baseline Conditions across the coastal prairie Management Area (3.4) are qualitatively described. Then details of the Grazing Program are presented (3.5). Subsequent sections presenting the Monitoring plan (3.6) including the Conceptual model (3.6.1), Goals and Interim Success Criteria (3.6.2), and Schedule 3.6. 2 are common to all the Management Areas. Separate Management Goals and Objectives (3.6.3) and Management Schedule (3.6.4) related to the activities of the AMWG are presented. Finally, details of the first year vegetation monitoring are described in the 2013 Summer Baseline Assessment (3.7).

Section 4.0 of this HMP is devoted to the Hagemann Gulch Riparian Woodland, the smallest of the three Management Areas. The Baseline Conditions (4.1) includes a qualitative description of current conditions including the physical conditions (4.1.1), the existing riparian vegetation (4.1.2), wildlife habitat (4.1.3), non-native invasive plants (4.1.4), accessibility (4.1.5) and cultural resources (4.1.6) including the Rose of Castille shrubs. The conceptual model (4.2) and Monitoring Plan Goals and Interim Success Criteria (4.3.1) highlight the need to first address the non-native plant infestation in the area. The use of photo monitoring (4.3.2) is discussed as the primary monitoring tool to measure success toward reaching the specified goals.

The Baseline Conditions (5.1) for the Arana Gulch Creek Riparian and Wetland Management Area includes a qualitative description of current conditions within the Arana Gulch watershed (5.1.1), Arana Gulch Creek (5.1.2), the riparian vegetation (5.1.3), the emergent wetland (5.1.4), wildlife habitat (5.1.5), and accessibility (5.1.6). As the baseline assessment makes clear, only a watershed approach will adequately address the pervasive erosion and sedimentation that is degrading the riparian and tidal system in Arana Gulch. Therefore, a separate section (5.2) is devoted to the Arana Gulch Watershed Enhancement Plan that was developed in 2002 by Balance Hydrologics. A simple conceptual model follows (5.3) and then the Monitoring Plan Goals and Objectives (5.4) are largely derived from the watershed enhancement plan and the Arana Gulch Master Plan.

Finally, the City of Santa Cruz assumed primary responsibility for identifying Funding and Cost Estimates (6.0) for select activities for each of the Management Areas. The commitment of the Santa Cruz City Council to long-term funding of the SCT adaptive management plan is what will enable the initial implementation of this HMP. The site photos for each of the Management Areas are included as Appendix A.

2.0 Adaptive Management Framework

Resources and land management agencies have widely embraced adaptive management as their approach to improving the condition of their natural resources. The adaptive management framework recognizes that effective resource management and land-use decision-making requires sound scientific information and provides the mechanism to link science directly to management. Adaptive management further recognizes the complexity and uncertainty inherent in biological systems with a "learn by doing" approach (Walters and Holling 1990). The process is iterative, usually portrayed as a cycle of conceptualization, planning, implementation, monitoring, evaluation and adjusting management (Figure 2.1).

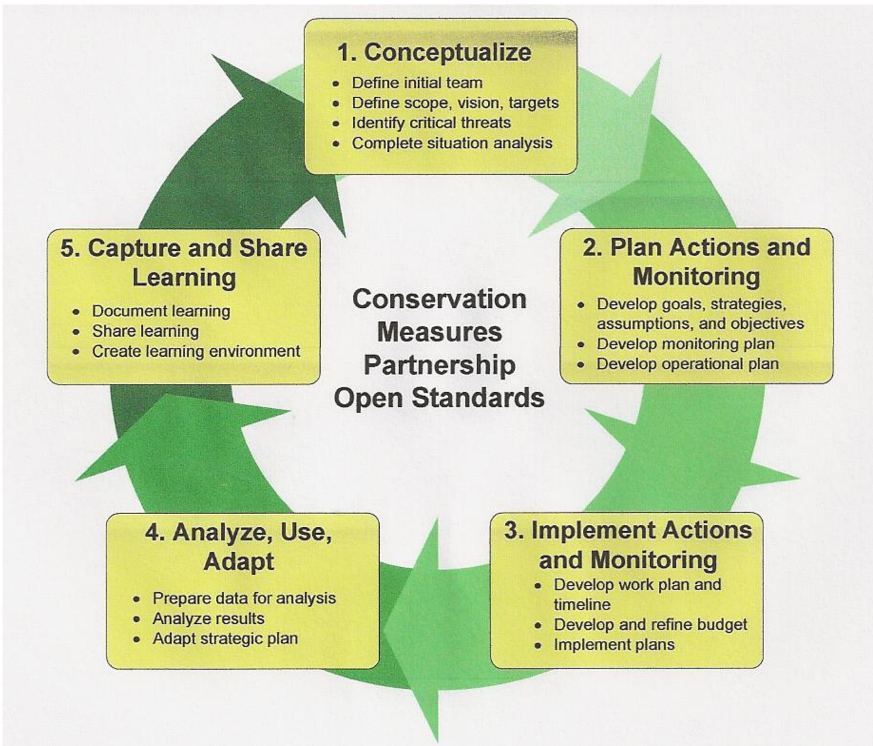

Figure 2.1. The Project Management Cycle as presented in the Conservation Measures Partnership Open Standards for Conservation.

The Management Program for SCT (Pavlik and Espeland 2005) presented a slightly different model of adaptive management. In this HMP, we adopt the more recently developed Open Standards for Conservation developed by the Conservation Measure Partnership (CMP) (www.conservationmeasures.org). An additional reason to adopt this model is that it is accompanied by a software tool called Miradi, which provides an easy way to develop conceptual diagrams and results chains.

The adaptive management cycle presents the basic structure for the following steps: 1) Conceptualize what you will achieve in the context of where you are working; 2) Plan both your actions and monitoring; 3) Implement your actions and monitoring; 4) Analyze your data and use your results to adapt your planning to maximize resource outcomes; and 5) Capture and share your results among stakeholders to promote learning. With each turn of the cycle, active learning through monitoring and evaluation reduces management uncertainties by developing tools that prove beneficial to the target resource. Thus, the adaptive management process is logical, can deal with uncertainty and data gaps, and is similar to the scientific process of hypothesis testing.

An adaptive management approach can bring the most updated scientific research on management directly into the decision-making process, resulting in an outcome that is more likely to improve the target resources. At Arana Gulch, the implementation of this HMP will depend on motivated stakeholders who participate in the decision-making process and work cooperatively 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 research. The best way to combine science with a stakeholder-controlled decision-making process is through an adaptive management framework.

As depicted in the CMP Project Management Cycle (Figure 2.1), the first task in the adaptive management process is to specify basic project parameters including the initial project team, the geographic scope, a vision for future conditions, and identify the conservation targets. The process of articulating these components began back in 2003, when the City of Santa Cruz began the planning process for the Arana Gulch Master Plan. The initial project team was comprised of City staff, consultants, and technical advisors (see Table 2.1 in section 2.2).The Master Plan limited the geographic scope of the project to the greenbelt at Arana Gulch. Areas outside of the property are not addressed. The three Management Areas were identified as the primary conservation targets. Conservation of SCT and its Coastal prairie habitat are combined. The Master Plan also provided the vision that is intended to guide the adaptive management process.

The vision for Arana Gulch, as presented in the Master Plan, is focused on natural resources protection and passive recreation as follows:

- Sensitive habitat areas, including coastal prairie, riparian woodland and scrub, and wetlands are protected and enhanced.
- An active adaptive management program ensures the long-term viability of the

Santa Cruz tarplant within Arana Gulch.

- Interpretive displays and programs educate the public about natural resource protection and enhancement.
- Best Management Practices are employed to improve trails, stabilize and restore eroded areas and reduce sediment transport to Arana Creek.

Once the project scope, vision, and targets are known, the next step in the adaptive management process involves identifying the key factors that influence the conservation targets and completing a situation analysis (see Figure 2.1).The Open Standards for Conservation recommend using a conceptual model to do this.

2.1 A Conceptual model for Arana Gulch

A good conceptual model illustrates the cause-and effect relationships that are assumed to exist within the project area and can also highlight data gaps and assist in the formulation of hypotheses that can be tested through monitoring. However, developing a model that links natural processes, threats, and management is difficult and often requires multiple rounds of iteration. Here, we present a first attempt at a basic conceptual model for Arana Gulch that will benefit from further refinement within the AMWG (Figure 2.2).

The conceptual model in Figure 2.2 visually illustrates the relationships between direct threats to the three Management Areas, the important indirect factors that influence those direct effects, and it identifies four basic strategies that have been identified as high priority in the Master Plan and other documents. Likewise, the indirect threats have been recognized in the previous planning process. These strategies were selected because they are linked directly to the outcomes in the vision for Arana Gulch and each has been determined to be feasible to some extent. In addition, they meet the criteria specified in the CMP Open Standards of being linked, focused, feasible, and appropriate. More detailed conceptual models are presented for each Management Area in the appropriate section.

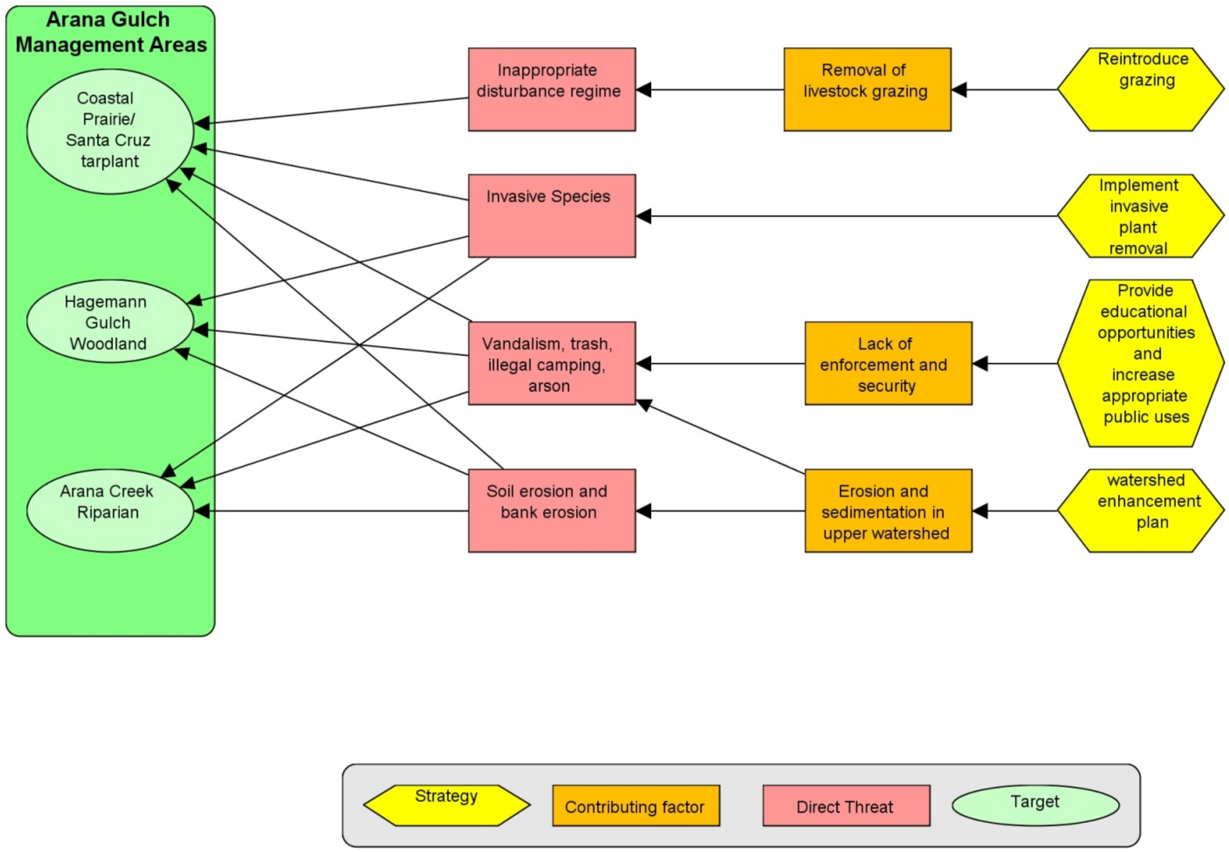

Figure 2.2. Conceptual model of conservation targets, key factors, and strategies for natural resource improvement and public education at Arana Gulch.

Ideally, the conceptual model is built by a team so that it accurately represents what is happening at the site and team members are in agreement that the model reflects their understanding of the situation. However, when multiple stakeholders and experts come to the table with different experiences and perspectives there can be a tendency to create highly complex conceptual models. This is particularly the case when dealing with ecological systems that are inherently complex, variable, and contingent on a multitude of inter-connecting factors. However, in designing conceptual models for monitoring ecological systems, less is more (Hierl 2007). Complex models are generally unjustified and unwarranted in ecological systems for two main reasons. The first is uncertainty. As more components and detail are added to the model, more data is required to faithfully represent those components and their role in the ecological system. Often this data is lacking. The second argument for opting for less complex models is that, given constraints on resources, it will be impossible to monitor everything. Constructing highly complex conceptual models makes the task of selecting monitoring components overly onerous—it obscures the forest for the trees. Rather than obscure the issues, a realistic and simple conceptual model can help identify what to monitor and lead directly to the development of a monitoring program for conservation targets.

Ultimately, the simple conceptual models presented here can help AMWG members document their understanding of the system in a way that can be examined and agreed upon by the group. One important factor that is not included in this initial model and not addressed in this HMP is climate change. As the AMWG makes progress on addressing the four identified strategies and successfully improving the SCT population, the group may wish to tackle the contingencies posed by a changing climate and particularly the threat of rising sea level.

2.2 Establishing the Adaptive Management Working Group

An Adaptive Management Working Group (AMWG) is the central component of an effective adaptive management framework. It is intentionally comprised of a group of cooperative and committed stakeholders interested in the outcomes of decision-making and in the technical process of managing target conservation resources Establishment of the Arana Gulch AMWG has been conducted by the City of Santa Cruz. The initial composition has been approved by the CCC Executive Director independently from this HMP.

2.2.1 Membership

The process of identifying the stakeholders that will participate in the AMWG began back in 2003 when the City of Santa Cruz began the planning process for the Arana Gulch Master Plan. Consulting staff from six firms participated in the plan development and the extended team of technical advisors included resource agency staff and scientists with expertise in coastal prairie and SCT biology and management (Table 2.1). In cooperation with City staff, these individuals made important contributions to the development of the Arana Gulch Master Plan and influenced the direction of the project.

Table 2.1 Arana Gulch Master Plan (2006) consulting and technical advisory staff to the City of Santa Cruz

Consulting staff	Title	Affiliation
Bruce Pavlik	Project Ecologist	BMP Ecosciences
Erin Espeland	Project Ecologist	BMP Ecosciences
William Davilla	Project Biologist	Ecosystems West
Kathleen Lyons	Project Botanist	Biotic Resources Group
Michael Sherrod	Landscape Architect	RRM Design
Chris Dufour	Landscape Architect	RRM Design
David Williams	Project Geologist	Cleath-Harris Geologists Inc.
Peter Haase	Project Hydrologist	Fall Creek Engineering – Hydrology

Technical advisory staff		
Dr. Susan Bainbridge		UC Jepson Herbarium
Dr. Grey Hayes		Elkhorn Slough National Reserve
Deborah Hillyard		California Department of Fish and Game
Connie Rutherford		US Fish and Wildlife Service
Douglas Cooper		US Fish and Wildlife Service
Lena Chang		US Fish and Wildlife Service
Gary Ruggerone		Caltrans Environmental Stewardship Branch
Don Miyahara		Caltrans Local Assistance

The first Management Program for SCT (Pavlik and Espeland 2005) suggested that the initial composition of the Arana Gulch AMWG include a single representative from each of the three principal federal and state agencies charged with plant conservation and coastal zone management (U.S. Fish and Wildlife Service, California Department of Fish and Game, and the California Coastal Commission); scientists with conservation and restoration experience in coastal grasslands and/or rare plant conservation; up to two representatives from the City of Santa Cruz; and a paid Chairperson, for a total of nine AMWG representatives. In 2011, the City moved forward with establishing an AMWG with the recommended composition and hired Alison E. Stanton, an independent research botanist, to both prepare this HMP and to Chair AMWG meetings in the first year. Such a professional Chairperson with expertise in conservation ecology and a lengthy history of participation in an adaptive management process can foster initial cooperation and provide leadership to the AMWG. In the long term, maintaining a professional Chairperson can provide continuity needed to counteract turnover among AMWG members.

The first meeting of the AMWG was held in April 2013, and the initial composition of the Arana Gulch AMWG was approved by the CCC Executive Director independently from this HMP in May 2013. .Table 2.2 lists the current agency staff representatives and scientists that were approved as initial AMWG members. At the request of the AMWG, other parties with a direct interest in plant conservation and/or ecosystem restoration could be added by the City with the approval of the CCC Executive Director.

Table 2.2. Initial Arana Gulch Adaptive Management Working Group (AMWG) Members.

Member	**Affiliation**
Lena Chang	Biologist, US Fish and Wildlife Service
Melissa Farinha	Env. Scientist, CA Dept of Fish and Game
Dr. Kate Huckelbridge or Dr. John Dixon	Ecologist, CA Coastal Commission
Dr. Grey Hayes or Suzanne Schettler	Consulting biologist, California Native Plant Society Greening Associates
Dr. Susan Bainbridge	UC Jepson Herbarium
Kathleen Lyons	Principal, Biological Resources Group
Michael Ferry	Associate Planner, City of SC Planning and Community Development
Mauro Garcia	Superintendent, City of SC Parks and Recreation
Alison Stanton, Facilitator	Principal, Alison E Stanton Consulting

2.2.2 Roles and Responsibilities

With respect to the implementation of this HMP, the three central entities are the City of Santa Cruz, the CA Coastal Commission, and the Arana Gulch AMWG. As the landowner and project applicant for a Coastal Development Permit (CDP), the City of Santa Cruz is responsible for implementing this HMP as a requirement of the CDP. The CCC is responsible for issuing the CDP and overseeing its implementation in perpetuity. The special Conditions of Approval (included in section 1.1) of the CDP specify certain tasks that require the City to 1) establish and participate in the AMWG, 2) receive prioritized annual management recommendations from the AMWG, and 3) provide funding and implement the highest priority AMWG management recommendations. To provide funding, the City of Santa Cruz has internal procedures that require the City Council to approve the annual HMP budget and the City has tasked the Parks and Recreation Executive Director (or designee) with developing that annual budget in consideration of AMWG recommendations. The central role of the AMWG is to guide the City on the implementation of HMP activities. Specified tasks of the CDP are to 1) recommend adjustments to the HMP to the CCC Executive Director that are deemed necessary and reasonable and do not adversely impact coastal resources, 2) approve details of the Grazing Program, and 3) prioritize annual HMP management recommendations. These roles and tasks are summarized in Table 2.3.

The AMWG is an advisory body and not a legislative body. In the City of Santa Cruz, formal legislative bodies can only be established by City Council Ordinance, Resolution, or as a Task Force appointed by the City Council. The Arana Gulch AMWG does not fall into any of these categories. Rather, the AMWG is a voluntary entity and each member is subject to their own organizational constraints and regulations. While an effective AMWG creates and maintains openness in order to have access to the fullest spectrum of management options that benefit the target resources, participation must be limited to managers, resource agency staff, scientists, and knowledgeable conservation practitioners. Although feedback from the public and/or outside scientific should be considered, the scientific, technical, and regulatory emphasis of the group at Arana Gulch requires a specialized composition.

In exchange for access, AWMG members must focus on improving resource quality by cooperating in an open, non-adversarial forum. It is the job of the AWMG to advise the City on implementation of the HMP in a way that protects and enhances the resources on site. While it is true that each member brings a distinct perspective to the process, all members must be united in the common cause to improve habitat conditions at Arana Gulch and improve SCT. This allows the AMWG to address all members concerns and objections directly, seek necessary permissions, and demonstrate the objective nature of scientific inquiry. Most importantly, a standard of straightforward communication builds trust among members.

Of the 9 AMWG members, the City representatives and the facilitator will abstain from voting but the other 6 members can vote. The regulatory agencies may have to abstain from voting in certain instances or gain supervisory approval in advance. Initially, the facilitator will judge the sense of the group as demonstrated by support from four voting members to develop recommendations. Every effort will be made to obtain advance input from all members via email on any issues requiring a decision on a recommendation. If this approach leads to conflict or inaction then it can be modified within the group, as necessary, without CCC Executive Director approval.

The AMWG first convened in April, 2013 and held a second meeting in July. An annual meeting in November is recommended to receive the annual Monitoring Report and prioritize management recommendations for the Grazing Program and the upcoming year. A quorum of members include 6 of the 9 members: one representative from the City, the Facilitator, two representatives from the 3 regulatory agencies (CCC, USFWS, CDFW), and 2 technical advisors.

Table 2.3. The roles of the City of Santa Cruz, the CA Coastal Commission, and the Arana Gulch AMWG in the implementation of the HMP and the associated tasks specified in the CDP Conditions of Approval.

Entity	Role	Tasks specified in CDP Conditions of Approval
City of Santa Cruz	**Implement AG HMP**	Establish (and participate in) AG AMWG
		Receive prioritized annual management recommendations from AMWG
		Provide funding and implement highest priority AMWG management recommendations
City of SC Parks and Recreation Executive Director (or designee)	Develop annual budget for prioritized HMP actitivies	*Role- unspecified in CDP conditions of approval*
City of Santa Cruz City Council	Approve annual HMP budget	*Role- unspecified in CDP conditions of approval*
California Coastal Commission	**Issue Coastal Development Permit and oversee implementation**	
CCC Executive Director		Approve final HMP and future modifications
		Approve initial AMWG compostion and future modifications
		Approve annual or tri-annual reports
AG AMWG	**Guide City of Santa Cruz on implementation of HMP activities**	
		Recommend adjustments to the HMP to the City and the CCC Executive Director that are 1) deemed necessary and reasonable and 2) do not adversely impact coastal resources
		Approve details of the Grazing Program
		Prioritize annual HMP management recommendations

2.2.3 AMWG Structured Information Flow

A hall mark of an adaptive management framework is a structured flow of information with the AMWG at the center (Figure 2.3). The AMWG is the workhorse of the process and is the entity responsible for developing management recommendation and coordinating monitoring and research activities. The AMWG works within regulatory and bureaucratic constraints to develop solutions to technical issues using a science-based approach. The central role of science in the process requires that the AMWG work closely with qualified consultants and/or academic researchers to design and implement research projects and to analyze monitoring data.

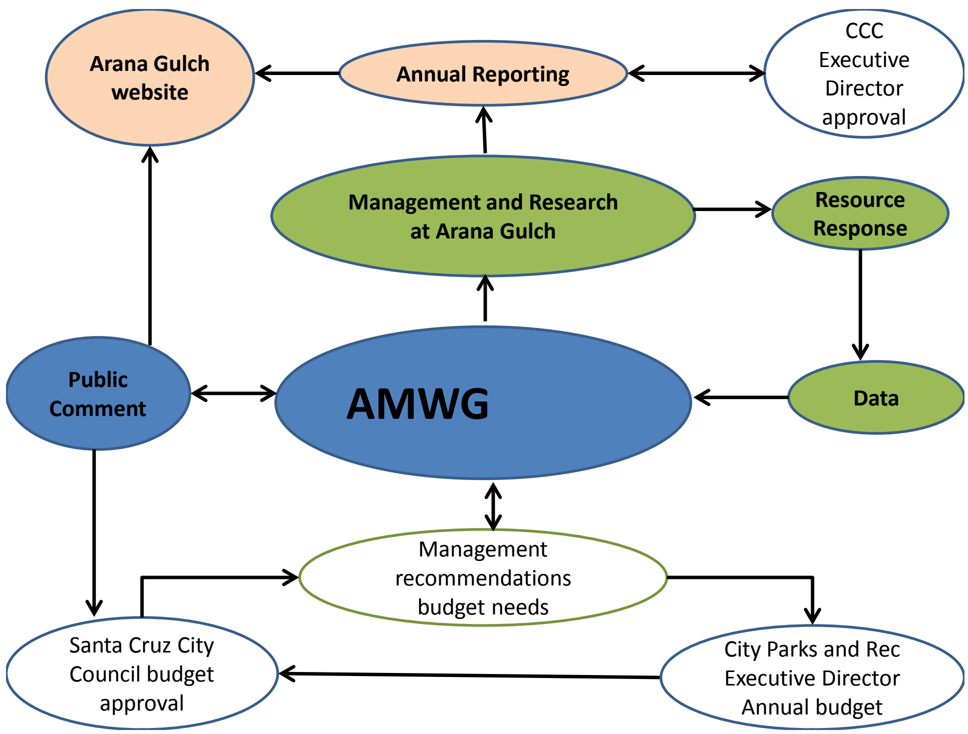

Figure 2.3 The structured flow of information of the Arana Gulch Adaptive Management Working Group (AMWG).

The structured information flow of the Arana Gulch AMWG is designed to bring issues from the public to the table, develop science-based solutions, and provide objective feedback from monitoring and research. It is through the AMWG that adaptive management becomes a collaborative learning process, imbedded within a regulatory and bureaucratic environment with its logistical, economic and political constraints.

The Santa Cruz City Council has set aside funds for implementing the Habitat Management Plan at Arana Gulch, specifically including adaptive management of the Santa Cruz tarplant.

In the course of operations, the AMWG will make management recommendations to the City. The Director of Parks and Recreation will develop an annual budget based on those recommendations for all activities at Arana Gulch related to this Habitat Management Plan. The Director of Parks and Recreation and his or her designee is the entity that presents the budget, recommends it for approval by the City Council, and administers the approved budget. Any substantive change to an approved budget requires additional approval by the City Council. Because the budget will be derived from public funds it is a focal point for transparency.

Another focal point of transparency will be the creation of a website or page on the City of Santa Cruz Parks website that is devoted to communicating the efforts to conserve and restore Arana Gulch and to receive feedback from the public. The AMWG will insure that management actions are posted and that monitoring and research results are presented on the webpage as they become available. Thus, the webpage will provide the direct communication conduit between the AMWG and the public. Further details on the development of the website are in the next section.

2.2.4 Arana Gulch website and public participation

One component of the vision for Arana Gulch presented in the Master Plan is to "provide interpretive displays and programs to educate the public about natural resource protection and enhancement at Arana Gulch". This will be mostly addressed within the full-scale Public Access Management Plan the City of Santa Cruz has developed as a condition of the Coastal Development Permit. That plan describes all aspects of public access including interpretative displays, facilities, and programs.

Obtaining broad public support for the management and restoration of habitat conditions across Arana Gulch and especially the protection and improvement of the SCT population is both necessary and desirable. A website is the most effective and economical way to communicate with the public. It will be the responsibility of the City of Santa Cruz Parks to oversee creation of a website or page on the City website that is devoted to communicating the efforts to conserve and restore Arana Gulch and to receive feedback from the public. The AMWG may provide recommendations to the City on website content, especially with language pertaining to direct management activities and conservation objectives. In turn the City will share comments from the public with the AMWG. Thus, the webpage will provide the direct communication conduit between the AMWG and the public and could powerfully demonstrate that endangered species protection, habitat restoration, recreational access, and local governance can cooperatively work to protect the public trust.

The AMWG will need to decide what information to share and how to deal with public comment. All documents submitted to the CCC are public including this HMP and all annual monitoring reports, and therefore will be posted on the website as they become available. AMWG meeting minutes could also be posted. A template outlining what information will be provided and a schedule will simplify the process of regularly updating the website. Public comment could be extensive at various points and anticipating and addressing the information needs of the public upfront will expedite the process of dealing with these comments. It is further anticipated that there may be regular streams of comment from various community groups and a standardized information template could moderate communications with these groups.

2.3 HMP implementation schedule

The AMWG convened at a first meeting in April, 2013. The initial membership was formally approved by the CCC Executive Director in May 2013. A second meeting was held in July 2013. As the Chairperson, Ms. Stanton develops draft meeting agendas, solicits additional agenda items from other members, secures meeting locations, ensures that agendas and meeting minutes are distributed in a timely manner, and facilitates the meetings. The Chairperson works closely with the City of Santa Cruz to ensure that the adaptive management process moves forward by anticipating logistical problems and seeking to identify solutions and build consensus among AMWG members. A professional Chairperson with expertise in conservation ecology and a lengthy history of participation in an adaptive management process can foster initial cooperation and provide leadership to the AMWG. In the long term, maintaining a professional Chairperson can provide continuity needed to counteract turnover among AMWG members.

Implementation of this HMP will occur within the adaptive management framework described in the sections above through the establishment of the Arana Gulch AMWG. The initial tasks and schedule for the first year of implementation are presented and the reporting requirements for the CDP described.

2.3.1 Schedule

Table 2.3 lists the necessary tasks for the implementation of this HMP. Further details about the baseline assessment data collection timeline are provided in the appropriate section for each of the three management areas.

Table 2-3. A proposed schedule of the tasks required for implementation of the Arana Gulch Habitat Management Plan with potential completion dates.

TASK	TARGET COMPLETION DATE
Habitat Management Plan (HMP) accepted by California Coastal Commission (CCC)	September 2013
First meeting of the Adaptive Management Working Group (AMWG)	April 2013
Construction begins of multi-use trails and grazing infrastructure	Target date October 2013
Baseline assessment- Vegetation cover and heights in the coastal prairie	June2013
Baseline assessment- photo point monitoring in all three management areas	Before, during, after construction in 2013
Baseline assessment- Residual dry matter (RDM) sampling and plot photos in the coastal prairie	After grazing initiation attend of season before it rains Sept/ Oct 2014
Monitoring Report: Baseline Assessment draft	Reviewed by AMWG in Nov 2013
Monitoring Report Baseline Assessment to CCC	Dec 2013
Implementation of the Grazing Program in the coastal prairie	Winter of 2013/2014
Year One monitoring data collection	March 2014-Oct 2014
Monitoring Report Year One draft	Reviewed by AMWG in Nov 2014
Monitoring Report Year One to CCC	Dec 2014

2.3.2 CCC Reporting procedures

Monitoring Reports will be submitted to the CCC Executive Director for review and approval in perpetuity, beginning the first year after initiation of implementation of this Habitat Management Plan. Such Monitoring Reports shall be submitted annually until success criteria are met, and then shall be submitted on an every 3-year basis after that. Each Monitoring Report (annual and 3-year) shall be cumulative and shall summarize all previous results. Each report shall clearly document the condition of the habitat areas, including in narrative (and supporting monitoring data) and with photographs taken from the same fixed points in the same directions as the baseline assessment and prior Monitoring Reports. Each report shall include a performance evaluation section where information and results from the monitoring program are used to evaluate the status of the restoration, enhancement, and long-term management in relation to the interim and final success criteria. To allow for an adaptive approach, each report shall also include a recommendations section to address changes that may be necessary in light of monitoring results and/or other information, and to ensure progress toward and achievement of success criteria. Actions necessary to implement the recommendations shall be implemented within 30 days of Executive Director approval of each Monitoring Report, unless the Executive Director identifies a different time frame for implementation.

3.0 Coastal Prairie/Tarplant Management Area

The Coastal Prairie/Tarplant Management Area occupies 30.2 acres in the central portion of Arana Gulch. The coastal prairie vegetation of Arana Gulch supports the Santa Cruz tarplant *(Holocarpha macradenia)*, a member of the sunflower family (Asteraceaeconsidered Threatened under the Endangered Species Act (USFWS, 2000) and Endangered by the State of California. The population of SCT at Arana Gulch has declined precipitously over the last two decades and it is clear that restoring habitat conditions on the coastal prairie and improving the Santa Cruz tarplant population on the site will require a long-term commitment by the City of Santa Cruz and other stakeholders.

This section of the HMP is organized into eight sub- sections. Section 3.1, An Overview of Santa Cruz tarplant Biology and Coastal Prairie Habitat, is adapted from the first Management Program SCT (Pavlik and Espeland 2005). The overview first describes the species' reproduction with a focus on seed bank dynamics. It then describes intact California coastal prairie, how the habitat is maintained through natural disturbance, how the habitat has been altered and how the distribution of SCT has declined. Section 3.1 ends with the same set of emergent biological principles that may drive management, first proposed by Pavlik and Espeland (2005). The next section (3.2) describes the spectrum of management tools that can be used to help restore the coastal prairie habitat at Arana Gulch. Section 3.3 provides the background and historic census data for the SCT population at Arana Gulch (3.3.1) and then details the management efforts to implement each of the five directives of the Management Program for SCT during 2006 to 2012 (3.3.2).

Next, the Baseline Conditions (3.4) describes the qualitative conditions of the physical environment (3.4.1), the upland vegetation (3.4.2), the season wetlands (3.4.3), and summarizes the current status of the SCT population at Arana Gulch (3.4.4). The Grazing Program (3.5) was designed during the Master Plan development but has been modified and reformatted to better present new information and additional details. The Monitoring Plan (3.6) includes a Conceptual Model for Arana Gulch (3.6.1) that narrows the general model presented in Section 2.0. The Goals and Interim Success Criteria (3.6.2) for the first year of implementation are presented separately for biological resources and management. Finally, vegetation monitoring began in 2013 and Section 3.7 describes the field sample design (3.7.2) and data analysis and reporting (3.7.3).

3.1 An Overview of Santa Cruz Tarplant Biology and Coast Prairie Habitat

3.1.1 Species Description

The Santa Cruz tarplant *(Holocarpha macradenia),* or SCT, is an aromatic annual plant in the sunflower family (Asteraceae). DeCandolle first described the species in 1836 (Munz 1959).The genus *Holocarpha*, commonly called tarplants or tarweeds, is only found in California. The first known collection of SCT is from an 1833 herbarium specimen from an unknown location, currently at the University of California Jepson Herbarium (UC292699).

SCT has yellow flowers and resinous, linear, toothed leaves (Photo 1). Flowering individuals can grow up to 1 meter tall, but are more often less than one half meter (Keil 1993). Basal leaves form a rosette and plants may produce a single ascending stem or spreading branches that produce multiple inflorescence heads (Hayes 2002) (Photo 2).

The composite yellow flower heads contain both ray and disk flowers. Ray flowers have showy, long petals that form the outermost ring of flowers on the head. Disk flowers pack the central part of the head with their minute petals and protruding black stamens. Each flower produces a dry fruit, called an achene, which contains one seed.

3.1.2 Reproduction and Seed Bank Dynamics

SCT germinates after the first significant rainfall event, usually in the late fall. The basal rosette increases in size throughout the growing season until bolting in late June (Hayes 2002) although ascending stems can appear much earlier with flower production as early as April (Bainbridge memo 7/20/05). Plants produce anywhere from one to more than 120 flower heads (Bainbridge 2003). Flowering may continue as late as November (Bainbridge 7/20/05). SCT is self-incompatible and requires pollen from another individual to produce viable seed. (Baldwin 2003). A wide variety of potential pollinating insects have been observed on SCT flowers including solitary bees, bee flies, and butterflies (Hayes 2003).

Like all annual plants, SCT is completely dependent upon successful seed production for persistence. Plants die following seed dispersal and the presence of a population the next growing season depends entirely on germination of seed stored in the soil. Seeds reside in the soil until favorable conditions (moisture, light, and temperature) allow for germination. Those conditions occur when the soil surface is exposed and there is ample winter rainfall. Natural periodic disturbance or active management with grazing, mowing, scraping, or controlled fire is needed to reduce grass accumulation and expose the soil surface.

The reservoir of dormant seeds that reside at or below the soil surface is called a seed bank. Seed bank studies on SCT found the persistent soil seed bank is comprised of ray achenes (Palmer 1982, Bainbridge 2003). Ray seeds are larger than disk seeds, have a tougher seed wall that may be less vulnerable to predation, and have a strong dormancy mechanism (Palmer 1982, Hayes 2002). In contrast, disk seeds have more delicate seed coats, which means that they are more likely to germinate with the first rains, but also more likely to get eaten. Predation experiments conducted on Santa Cruz tarplant disk seeds found predation rates of well over 90% in a 1-month interval (Hayes 2002).

Seed bank densities can be highly variable within a site due to spatial aggregation from and among sites due to different environmental conditions and different management practices. Palmer (1982) estimated seed bank densities were from .10 to .56 seeds per m^2 in the top 2.5 cm of soil, and .01 to .09 seeds per m^2 in the 2.5 to 5.0 cm soil depth at Arana Gulch. Maximum seed density was .66 seeds per m^2 within experimental plots at Porter Ranch. In contrast, Dr. Susan Bainbridge assessed the SCT seed bank density of the Porter Ranch population in 1999 to be 40,000 seeds per m^2 (Bainbridge 2003). Unfortunately, no seed bank density estimate was obtained for Arana Gulch. However, average SCT seed bank density was 240 seeds per m^2 at Twin Lakes and 887 seeds per m^2 at the Watsonville Airport.

Seeds of SCT have germinated after 6 to 9 years in room temperature storage and in one instance, seedlings emerged from a soil pile on a construction site 8 years after adults had been present (CDFG 1995) leading Pavlik and Espland (2005) to estimate SCT seed bank longevity at 5 to10 years. However, seeds at least 15 years old have also germinated after dry storage (Barber 2002).

The only quantitative seed bank decay data available are unpublished results recently obtained from Susan Bainbridge (pers. comm. 2012). In 2000, she took seed from one SCT site in the East Bay and one in Monterey County and placed them in mesh bags and buried multiple bags at a depth of 5cm in the soil. She exhumed seed bags every year for five years and examined the seed embryo viability. Prior to burial, about 70% of the seed were viable and viability steadily declined over the five years (Figure 3.1). By year 5, the average seed viability over both sites was 37%, significantly lower than the pre-burial average. This study method may seriously underestimate seed mortality because buried seed are protected to a certain degree from predation. In the soil, predation and infection contribute to the loss of seeds from plant seed banks. Other studies have found less than 1% carryover from seed produced one year to the germinable seed bank the following year (Young and Evans 1989). And seed bank persistence of less than 10% over a year has been found in other annual grassland forbs in the Asteraceae (Lunt 1995, Yu et al. 2003).

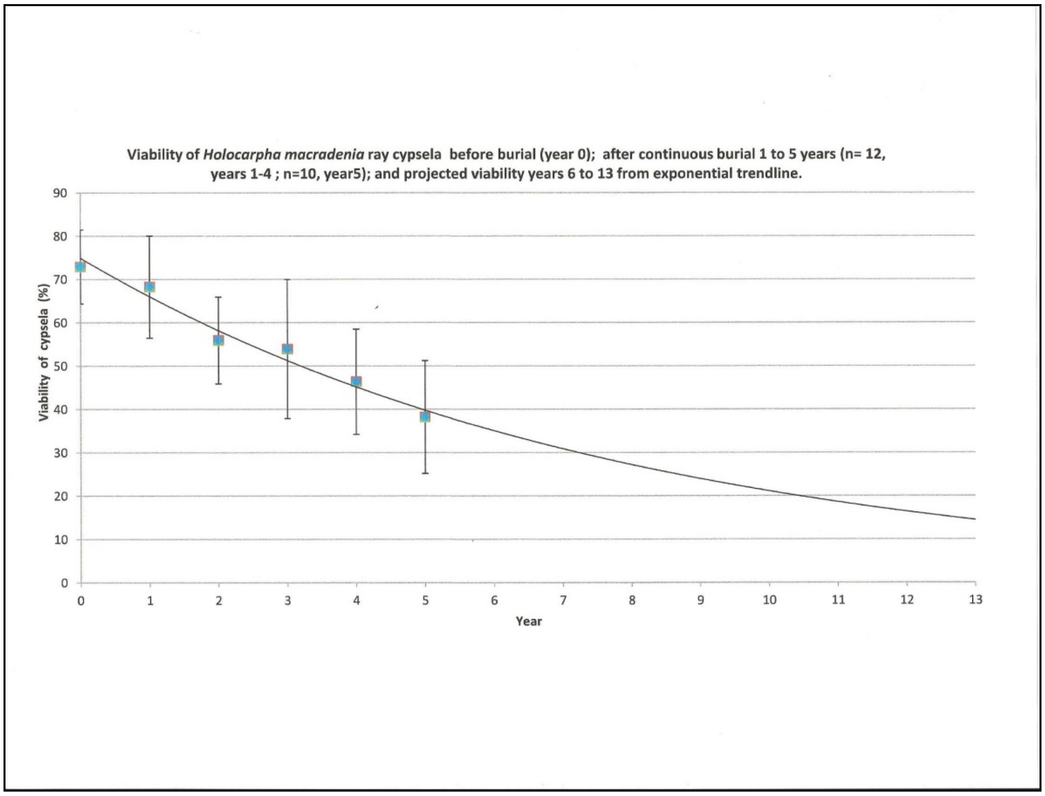

Figure 3.1 Assessment of the viability if buried SCT seed over a 5 year period (unpublished data, Bainbridge).

More recently, Satterwaithe et al. (2007) developed demographic models of population growth rate for SCT using vital rates measured in experimental plots under different management regimes. For un-managed control plots, the models predicted population decline and extinction regardless of seed bank dynamics, or environmental variation. In clipped plots, the simulations suggested that an intermediate level of first year germination of ray seeds minimized extinction risk to a greatest degree. Put another way, the study indicated that increased adult fecundity lead to greater increases in population growth rates. When catastrophic variations in survival were included in the model, the efficacy of intermediate germination in buffering against extinction depended strongly on seed bank survival. Overall, the study recommends focusing on improving the performance of above ground plants over actions that stimulate germination of the seed bank.

The proper approach to managing the SCT seed bank has been contentious. Some managers have favored approaches that stimulation expression of the seed bank to boost small populations, while others have raised concerns about depleting the soil seed bank and losing its buffering capacity to protect against extreme environmental or other variation (CDFG 1995). Satterwaithe et al. (2007) acknowledge that in instances where population vital growth rates would predict decline without input from the seed bank, that germination should be stimulated. While they caution about the buffering role of the seed bank, the capacity of a seed bank to buffer is reduced if the seed are short-lived.

Applying the limited knowledge of SCT seed bank dynamics at Arana Gulch is a challenge. Population size at Arana Gulch has been very low for 6 years and seed bank densities could be very low. If the longevity of the SCT seed bank is as short as 10 years, the best strategy to increase population persistence is one that stimulates germination but does not entirely deplete the seed bank.

3.1.3 Coastal Prairie Habitat and Natural Disturbance Processes

Intact California coastal prairie is considered one of the most species-rich grasslands on the continent (Stromberg 2001). Historically, a rich mixture of annual and perennial forbs was imbedded in a productive matrix of mostly perennial grasses such as California oatgrass (*Danthonia californica*) and purple needlegrass (*Stipa pulchra*). The grassland was structurally open, forming a clumped overstory less than 3 feet tall with a great deal of space in between perennial grass clumps that allowed annual spring- and summer-flowering forbs to grow. Small depressions in the surface of the coastal prairie terrace allowed the formation of seasonal wetlands. The open structure and biological diversity of California coastal prairie is maintained by disturbance processes especially grazing and burrowing by small mammals.

Grazing by elk and more recently, by cattle and sheep, play an important role in the maintenance of California grasslands. Grazers remove above ground biomass, decrease vegetation height, and lower litter depth in coastal prairies (Hayes and Holl 2003a, Noy-Meir et al. 1989). Native forb and grass species in coastal prairie habitat evolved with this pressure and adapted to the open habitat structure. In addition, grazers likely helped disperse seeds that would stick in their coats and this movement facilitated gene flow among populations throughout the coastal prairie (Palmer 1982, Baldwin et.al 2002).

Fossorial mammals can be another source of disturbance in coastal prairie. Like cattle, gopher burrowing creates open spaces and can slow the aboveground accumulation of phytomass (Stromberg and Griffin 1996). However, while gophers have the positive effect of reducing thatch accumulation, the disturbance they create can inhibit plant establishment by creating an inhospitable germination environment (soil of gopher mounds, while open, has lower water-holding capacity then surrounding areas) or by simply burying developing seedlings (Stromberg and Griffin 1996). Santa Cruz tarplant appears to respond poorly to conditions on mounds (low germination, seedling death due to burial) (Bainbridge memo 7/20/05). Across a given site, the small scale of gopher disturbance may not significantly enhance light levels or deter herbivory by slugs and other microherbivores to have a net positive effect (Hayes memo 8/8/05, Maze unpublished ms. 2005).

3.1.4 Habitat Alteration

Over the course of the last century, non-native weeds, agricultural practices, and domestic livestock have fundamentally altered the composition, structure and processes of the remaining California coastal prairie habitats (Stromberg et al. 2001). An influx of Mediterranean annual grasses and non-native forbs has substantially increased canopy height and litter accumulation in coastal grasslands throughout California (Biswell 1956, Noy-Meir et al. 1989). The resulting combination of depleted light and water availability forms a negative feedback loop for native forbs including SCT, preventing further germination, seed production and seed bank development (Bainbridge 2003, Hayes and Holl 2003a). At the Arana Gulch property, the coastal prairie is now comprised primarily of non-native annual grasses and forbs with very few native species apparent.

3.1.5 Species Distribution, Conservation Status, and Genetics

All species in the genus *Holocarpha* are only found in California. Historically, Santa Cruz tarplant was found at low elevations (below 1,000 feet) in coastal prairies and coastal range grasslands between Marin and Monterey counties. Numerous herbarium specimens from the late 1800's through 1936 document this limited distribution (California Consortium of Herbarium). The destruction and alteration of coastal prairie habitat that came with the white settlement of California has severely reduced the species distribution. By 1959, the first California Flora (Munz 1959) indicated that the species could be extinct. However, publication of that volume prompted naturalists to search for the species, and there were nearly one dozen collections made of SCT later that same year (California Consortium of Herbarium).

Continued development and habitat destruction lead to the state of California listing SCT as Endangered in 1979 and the listing of the species as Threatened under the Endangered Species Act (ESA) in 2000 (US Fish and Wildlife Service 2000). Currently, SCT is known from a total of 20 populations; 11 natural populations in Santa Cruz County, one in northern Monterey County, and eight populations that were reintroduced in the East Bay Wildcat Regional Parkin Contra Costa County (USFWS 2008).

In 2002, the USFWS developed a Critical Habitat Designation for 11 of the occupied locations (Figure 3-2, USFWS 2002). The entire coastal prairie terrace at Arana Gulch is considered Critical Habitat for SCT (Figure 3-3, USFWS 2002). The Arana Gulch Unit is essential because it has supported the third largest standing native SCT population. It therefore has the potential to contribute significantly to the seed bank reserve for the entire species. In addition, the site is publically owned, protected from future development, and the site is large enough to support large scale management activities. The proximity of Arana Gulch to the SCT population at Twin Lakes could allow for connectivity between them. Together, they are the lowest elevation of the native populations in the northern Monterey Bay area (40 to 60 ft) and are closest to the influence of the coastal climate.

The Arana Gulch SCT population is not recognized as being genetically distinct under the ESA listing rule (USFWS 2000), but there is some evidence that this population is unique. To investigate genetic variation within SCT, Palmer (1982) crossed plants from six different natural populations. While viable F_1 seeds were readily produced, a few breeding incompatibilities were detected in crosses between plants from Arana Gulch and those from other populations, including reduced pollen fertility and a reduced seed set. In a cluster analysis of many leaf, flower, inflorescence, and seed morphological characters collected from field-grown plants, Palmer (1982) found that the Arana Gulch population differed from populations from “Pajaro” or Porter Ranch (Monterey County) and Pinole (Contra Costa County) which were indistinguishable from one another. However, other nearby populations were not included in the study (i.e Twin Lakes) that could have genetic similarities. Newer genetic methods could be used to test Palmer’s results.

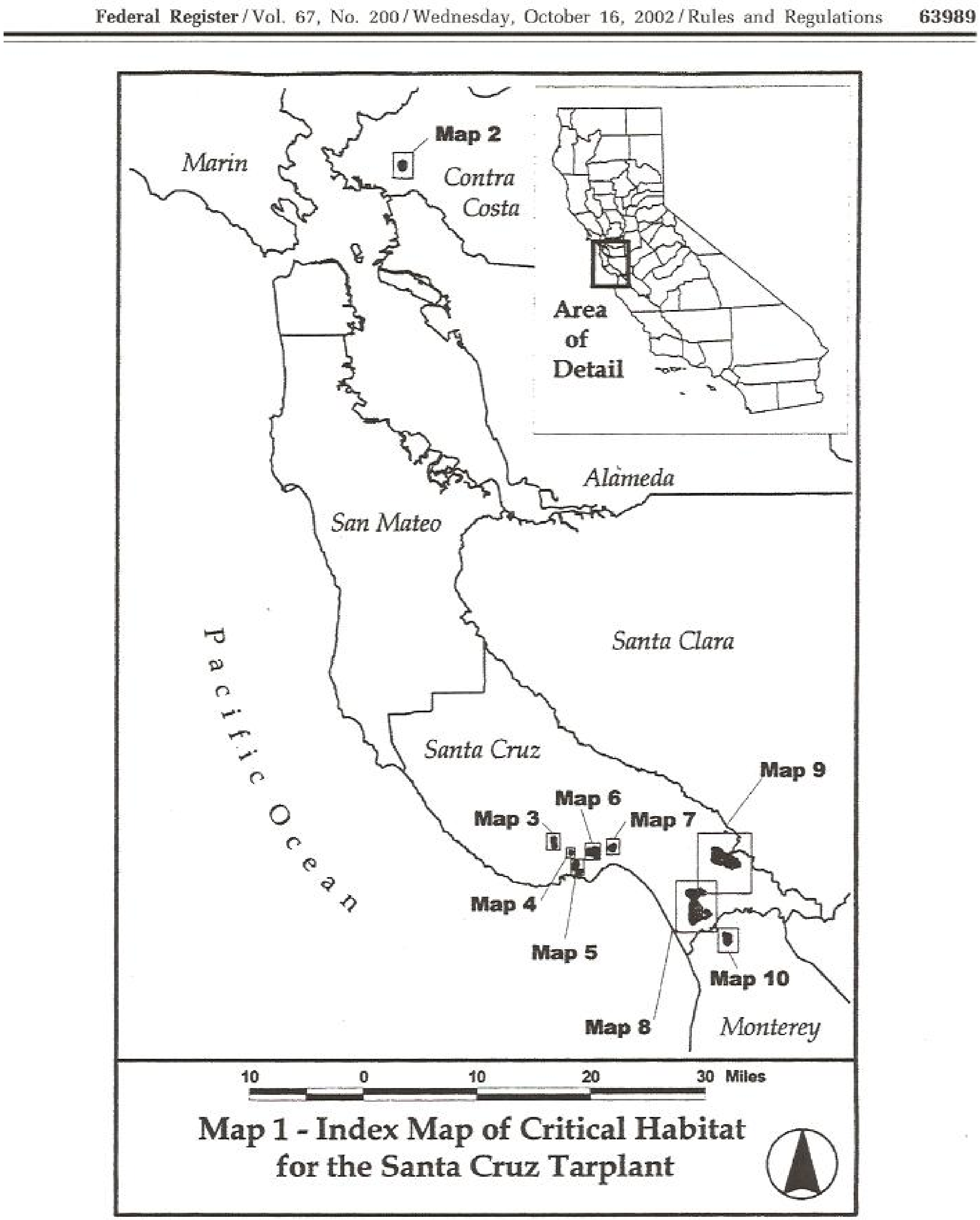

Figure 3.2. Overview of Critical Habitat for SCT. The Arana Gulch population is on Map 5 (from USFWS federal register 2002).

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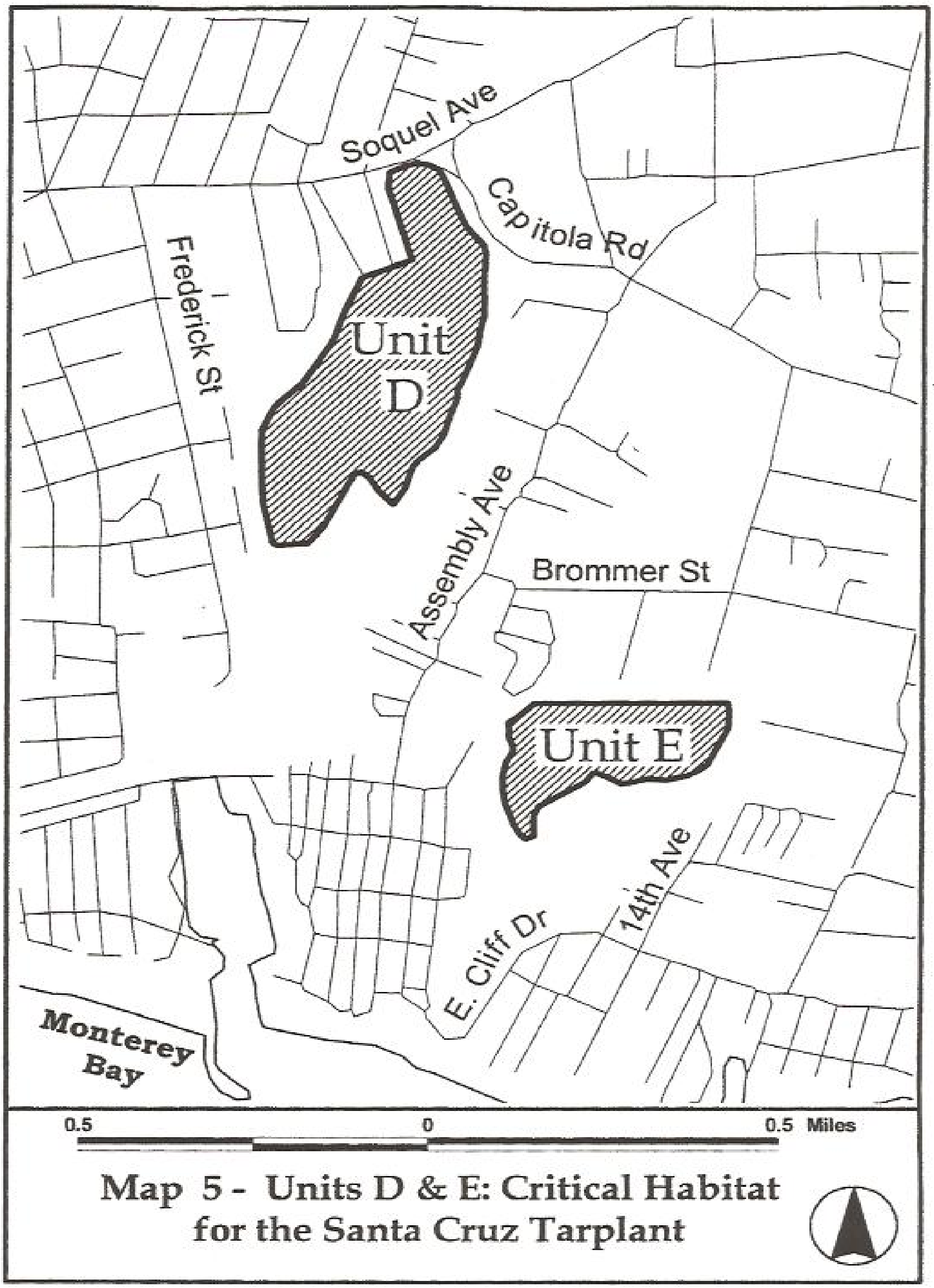

Figure 3.3. Critical Habitat for SCT. Arana Gulch is Unit D and Twin Lakes, a CA State Parks property, is Unit E (from USFWS federal register 2002).

3.1.6 Emergent Biological Principles

Given our present understanding of SCT biology and the natural disturbance processes in coastal prairie detailed in the sections above, the following emergent biological principles adapted from Pavlik and Espeland (2005) remain relevant and timely guidelines for the management of this endangered plant.

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 dynamics are primarily determined by habitat quality of the coastal prairie, and size of the soil seed bank is primarily determined by the demographic history of the population.
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.

3.2 Coastal prairie management tools

The open structure and biological diversity of a healthy coastal prairie is maintained by disturbance processes including grazing and burrowing by small mammals. At Arana Gulch, SCT evolved with these disturbances and its continued persistence depends on the maintenance of a disturbance regime.

It is extremely difficult to directly manage an annual species like SCT because of the ephemeral expression of juvenile and mature plants. Rather, the habitat must be managed in a way that allows for successful reproduction and input into the seed bank. For SCT, quality habitat is characterized as an open coastal prairie with a variety of native forbs and grasses interspersed with bare ground. Since grazing was removed from Arana Gulch in 1988, the habitat has been fairly quickly transformed to a non-native annual grassland with very high vegetation cover, a tall canopy height, and high loads of accumulated thatch. During the same time the population of SCT has precipitously declined. Restoring a proper disturbance regime will reduce non-native annual grass cover and thatch and facilitate the recovery of SCT. No single tool will restore the habitat at Arana Gulch and in the sections below we discuss the spectrum of management tools that can be used to help restore the coastal prairie habitat at Arana Gulch.

3.2.1 Grazing

Grazing is currently used as a viable and effective management tool in California coastal prairie grasslands. Grazers remove above ground biomass, decrease vegetation height, and lower litter depth in coastal prairies when compared to those without grazers (Hayes and Holl 2003a, Noy-Meir et al. 1989). The resulting decrease in annual grass cover/canopy allows more light to penetrate through the grasslands. This leads to an increase in the number of canopy layers within the coastal prairie habitat, and in turn leads to more favorable habitat conditions for native forbs including SCT (Hayes and Holl 2003b, Noy-Meir et al. 1989). The number (of species) and abundance of native annual forbs has been found to be higher in grazed coastal prairies of similar geographic location than their non-grazed counterparts (Hayes and Holl 2003a). Grazing (or clipping of annual grasses to simulate grazing) can enhance germination of SCT, and has been shown to increase survival of SCT to reproduction, though results were site and year dependent (Holl and Hayes 2006). While grazing increases native annual forbs it often increases exotic annual forbs as well, and can decrease native perennial forbs because of a lack of native seed bank (Hayes and Holl 2003b, Hayes and Holl 2011).Grazing can also result in an increase of certain damaging non-native annual grasses like medusa head (*Taenatherum caput-medusae)* and goat grass (*Aegilops sp.).*

Reintroduction of the native Tule elk to coastal prairies in northern California were shown to increase the biomass and abundance of both native and exotic annual species (grasses and forbs), and to decrease the biomass but not the abundance of native and exotic perennial species, including the invasive grass *Holcus lanatus* (Johnson and Cushman 2007). *Holcus lanatus* (velvet grass) is currently invading the outer areas of the Arana Gulch coastal prairie. Hayes and Holl (2003a) also found cattle grazing controlled velvet grass in some of their experimental treatments and it would be greatly advantageous to all native species at Arana Gulch if this invasive perennial grass were reduced or eliminated.

Native perennial grass responses to grazing are species specific. The response is of interest because the remaining patches of SCT at Arana Gulch in Area A are near, but not in, patches of California oatgrass (*Danthonia californica)* and it is thought that perennial grasses provide suitable habitat if there is sufficient bare ground between clumps to allow for recruitment. Species such as California oatgrass generally increase with grazing, while purple needlegrass *(Stipa pulchra* formerly *Nassella)* has shown differential responses to grazing depending on timing and intensity (Hayes and Holl 2003a). Intense grazing decreased reproductive output of *S. pulchra* but did not increase mortality. Rotational grazing decreased culm production in mature plants but it also increased *Stipa* seedling survival likely because of the decrease in annual grasses (Marty et al. 2005).

3.2.2 Mowing

In some cases, mowing with biomass removal in coastal grasslands has been shown to shift dominance from an annual grasses to a more species rich, forb dominated community composed of a greater proportion of native species (Maron and Jeffries 2001). However, the timing of mowing is a very important consideration in restoration and weed control efforts (DiTomaso et al 2007). Mowing too early in spring can significantly increase light penetration without removing a significant amount of biomass. Mowing too late allows seed production to occur and may serve to disperse seeds or work them into the soil where they persist. To reduce the annual grasses, the optimal time to mow is when they are in flower, prior to seed set. However, if conditions are too moist it can stimulate compensatory growth and even greater seed production (Maron and Jeffries 2001).

At Arana Gulch, mowing alone and with raking has occurred in most years in May/June or bi-yearly (with an additional mowing in October/November) in areas A-D of the coastal prairie since the City of Santa Cruz acquired it in1994. No mowing occurred in 2002-2005. Despite this mowing regime, the population of SCT has continued to decline precipitously. Mowing and removal of material in experimental plots in 2001 did not result in any SCT recruitment or shifts in community composition in areas A or D (Bainbridge, 2003). Section 3.3.2 provides more details on the mowing implemented from 2006 to 2012.

In contrast, mowing has been used very successfully at the Watsonville Airport to maintain a very large SCT population. From 1993 to 2001 the number of estimated SCT plants fluctuated from a low of nearly one half million to over 28 million (Kiguichi 2003). However, the conditions at Watsonville are quite different than at Arana Gulch and the mowing regime has been very different. Productivity in most SCT habitat at Watsonville is much lower than at Arana Gulch, possibly due to greater clay content in the soil, and seed bank density and average numbers of flower heads per plant are also lower (Bainbridge, pers. comm., 2013). The airport historically performed maintenance mowing and/or cattle grazing on its grasslands on a year-round basis in order to maintain visual clearance for Airport safety and reduce risk of fire (Kiguchi 2003). In 1993, after the presence of SCT was brought to its attention, the Airport modified its mowing regime by adjusting mower height to avoid damage to plants during the growing season. Spring/summer mowings were also timed to reduce annual grasses and fall mowings were delayed until after seed set. Selected areas were also occasionally disked, but this practice was banned in SCT areas when negative impacts were observed.

3.2.3 Soil Scraping

One of the greatest deterrents to the growth and reproduction of SCT at Arana Gulch is the high cover of exotic annual grasses and the heavy thatch accumulations currently found in the grasslands. Under these conditions, SCT must compete for light, space and water. Soil scraping entails removing the aboveground vegetation, thatch and upper organic layer of the soil surface and is generally done mechanically with a bulldozer or backhoe, although it can also be done by hand. The intent behind soil scraping is to expose bare ground and increase light penetration to stimulate germination of desirable plants.

Of all the different management tools that have been applied at Arana Gulch, soil scraping has produced the most positive response in the SCT population. The City cooperated with the Santa Cruz chapter of the CA Native Plant Society and the CA Department of Fish and Game (now Wildlife) to bring a bulldozer to the site in June of 1995 and scrape 3 acres in the middle of the historic SCT area A. No plants were present in 1994 or 1995. The following summer, over 7,000 SCT were found within the scraped area. During October of 1996, a high intensity arson fire occurred that burned about half of the scraped area. The following summer, around 35,000 SCT individuals were found in a "field that was neatly defined by the area that had been bulldozed two years before" with the most dense occurrence in the area that had been both scraped and burned (Hayes 1998).

A subsequent controlled experiment in 2001 demonstrated a significant increase in SCT surviving to reproduction in all of the scraped plots (Bainbridge 2003). No survival or recruitment occurred in the mow or control plots. Furthermore, exotic annual grasses decreased significantly in scraped plots and scraping successfully stimulated germination of native annual forbs including *Lupinus nanus, Plagiobothrys undulates, Trifolium barbigerum, Juncus bufonius,* and *Deinandra corymbosa*.

3.2.4 Prescribed Burning

Prescribed fire can be used as a management tool to both remove the aboveground biomass and thatch and to attempt to kill or decrease the seed bank of the target non-native species (DiTomaso et al. 2006, Meyer and Schiffman 1999). However, fire has a variable effect on grasslands.

Fire has occurred in the Arana Gulch coastal prairie as both a management tool and as an accidental occurrence. As previously mentioned, SCT responded very positively to an arson fire that occurred within an area that had been scraped area in October of 1996. However, the scraping had already successfully removed the accumulated thatch so it is impossible to know how the SCT would have responded to fire alone. Following this positive response, in the fall of 1997 a low intensity prescribed burn was performed in area A in a portion which did not burn the previous year, but did overlap somewhat with the bulldozer treatment. The next year around 65,000 plants were found in and around area A in areas that had been scraped and/or burned. For a second year in a row, the response of the SCT population to the combination of fire and soil scraping appeared to be very positive.

In fall of 1998, a prescribed burn was again performed in area A, although the burn area likely did not overlap the previous year's burn (Bainbridge, personal communication). Prescribed fire was also applied in area D at the same time. The following year, the population of SCT at Arana dropped substantially. The variable response of the SCT population at Arana Gulch to fire may have been influenced by strong weather patterns during the same period, as the winter of 1997-98 was an extraordinarily wet year.

An arson fire in 2012 burned approximately 3 acres in the very central portion of the prairie at Arana Gulch. The fire was patchy and did not occur within the boundaries of any recent SCT occurrences (Photo 3). It will be necessary to account for the fire when conducting the baseline assessment in 2013 as it would be important to document a flush of SCT that could potentially occur as a result of the fire.

Bainbridge (unpublished meta-analysis data) found that on a landscape scale, the combination of prescribed fire and grazing may help shift the community from grass to a more forb dominated community that favors native forbs more than occurs in un-grazed areas. However, increases in native species abundance are dependent on the presence of an intact seed bank of native species.

In other grasslands throughout California, prescribed burns have been used to successfully remove accumulated aboveground biomass (DiTomaso et al. 2006, Ogden and Rejmánek 2005, Fall burns usually move rapidly with low intensity and successfully remove biomass without destroying the seed bank. If a fire does burn extremely hot, it can have negative consequences on the soil seed bank for all species including desirable native species such as SCT (DiTomaso et al. 2006, Kiguchi 2003). Spring burns are most successful at reducing non-native annual grasses if they still have immature seeds on the stems, and desirable native forbs (such as SCT) are still at the rosette stage (DiTomaso et al. 2006). Successful elimination of the fire year's non-native annual grass seed production has occurred with well-timed spring prescribed burns followed by seeding, causing a guild shift from non-native grasses to native and non-native annual forbs (MacDougall and Turkington 2007, Moyes et al. 2005, Parsons and Stohlgren 1989). However, the replacement of exotic annual grasses by native and non-native forbs is temporary and generally does not lead to the recovery of native perennials, especially where these have been entirely displaced for many years(Moyes et al. 2005

3.2.5 Out-planting/seeding

If the native forb seed bank (including is SCT) and potentially the native grass seed bank at Arana Gulch has been thoroughly depleted then native species recovery may require seeding and/or out-planting of native species. Seabloom et al. (2003) found that the biomass of annual grasses decreased and the biomass of native perennial grasses increased significantly in Southern California grasslands when native grass seed was added to the community. If seeding experiments are implemented to increase other components of the coastal prairie vegetative community, the following guidelines specified in the CDP conditions of approval shall be followed:

> Any planting either of seeds or container plants shall be made up exclusively of native taxa that are appropriate to the habitat and Arana Gulch region. Seed and/or vegetative propagules shall be obtained from local natural habitats so as to protect the genetic makeup of natural populations. Horticultural varieties shall not be used.

No outplanting or seeding of SCT or other native species has occurred at Arana Gulch. However, beginning in 1999, seed from the Twin Lakes CA State Park SCT population was propagated at the UC Jepson Herbarium in order to increase seed stock for outplanting and restoration efforts (Bainbridge 2003). The Twin Lakes population is only a half mile from Arana Gulch. (see Figure 3-3). A concurrent controlled pollination study was also initiated to assess the number of breeding types represented in the seed stock, but the subsequent germination and viability testing of the crosses was never completed.

A series of outplantings were installed at Twin Lakes beginning February, 2002 with 15 propagated SCT (Table3.1). Table 3.1 was developed from data collected by Tim Hyland from 2001- 2010 and contained in yearly internal CA State Park status reports. In the previous two years before the planting there were only 7 and 19 SCT observed. After adequate survivorship and reproductive output of the first small outplanting was observed, a second outplanting of two macro plots of 300 SCT plants each was planted by Sue Bainbridge in late February 2003. That planting was fairly successful with 57% of SCT surviving to reproduction producing an estimated 6,400 seeds. Heavy herbivory of planted seedlings was observed and the number of SCT in the unplanted area dwindled to only 5 SCT despite mowing and using a chain harrow that produced some bare ground.

Table 3.1 SCT census data and outplanting at Twin Lakes CA State Parks from 2000 to 2010. SCT[1] is the number of plants found in unplanted areas and SCT[2] is the number of plants in areas that were previously planted. If the numbers are the same then plants were found across the site.

year	# SCT[1]	treatments applied	Avg flower heads/ plant or total	# SCT[2]	# SCT outplant	# SCT repro	# total flwr head	# seeds
2000	7	Oct scrape spring mow 2x	2					
2001	19	March mow/rake	2					
2002	7	April mow	2		15	12 (80%)	215	
2003	5	Oct chain harrow Apr/May mow	1		600	344 (57%)	989	6,400
2004	0	Mow 3x	0		234 Sluggo applied	174 (74%)	17/plant	29,580
2005	?			500-700				
2006	?				occurred			
2007	0	accidental fire Oct 2006 (south)		1212				
		no fire (north)		355				
2008	?							
2009	924	March/ June mow		924*				
2010	55	March Sluggo May mow	88 total	55*				
2013	40		87 total					

A third outplanting was conducted in 2004 along with an application of an iron based snail and slug bait ' Sluggo' to try and combat the herbivory. This planting was very successful with 74% reproduction and an estimated seed production of 29, 580. In 2005, 500-700 SCT were counted within the areas that were outplanted the prior year. A final outplanting was conducted in 2006. Since then, an accidental fire occurred on the south side of the road in October 2006 at the site. In 2007, there were 1212 SCT the next year and only 355 SCT on the north side of the road where no fire occurred. In 2009, there were 924 SCT scattered across planted and unplanted areas. Only 2010 SCT were present in 2010, a very dry year.

The results from Twin Lakes indicate that outplanting SCT can be successful because propagated SCT plants will establish, grow, and reproduce. However, the long term benefit of this high level of effort is not clear. The low numbers of plants present in 2012 and 2013 suggest that without continued inputs, the high cost of propagation and outplanting do not lead to a sustainable SCT population. Holl and Hayes (2006) attempted out-planting and seeding of SCT at three coastal prairie sites in Santa Cruz and Monterey Counties, but none of the populations were viable through time. They believed the negative results could have been caused by unusually hot and dry climate conditions the year of introduction, the lack of seed banks at the sites, unusual microsite conditions that prevented establishment, and/or planting too few individuals.

Successful seeding of SCT has been performed at the Watsonville airport using seeds from different locations on the site beginning in fall of 1995 (Kiguchi 2003). Mature seed heads were collected from viable populations in late fall through mowing, as it allowed some seeds to spread in the current population and other seed heads to be collected, and collected seed heads were dried. Most sites at Watsonville airport are frequently mowed to keep plant height down, although a detailed description of the seeded site is not given (Kiguchi 2003). Seeds were dispersed in areas, and in 2001 over 24,000 plants were growing in seeded sites. Out-planting of seedlings was also attempted at Watsonville airport, but was not successful.

Out-planting or seeding experiments would not be recommended in the near future at Arana Gulch. If and when habitat conditions are substantially improved at Arana Gulch and the site becomes conducive to substantial SCT growth and reproduction, an out-planting or seeding program could be considered. SCT is an obligate out-crossing species (Hayes 2003), so if restoration through seeding and/or out-planting is attempted, the genetics of the seeds/seedling used will have to be tracked so that less closely related individuals are planted close enough together for successful cross-pollination by insect pollinators and to avoid a population bottleneck and inbreeding depression.

3.3 Managing the Santa Cruz Tarplant Population at Arana Gulch

3.3.1 Background and Historic Census

The area that encompasses what is now Arana Gulch was part of a 92-acre rancho granted to Jose Arana in 1842. In 1878, Frederick Hagemann acquired the entire area for a farming and livestock operation. In the 1920s, the Kinzli family acquired the property and started the East Side Dairy. The dairy operation continued through the mid-1950s and cattle grazing continued until 1988. The Kinzli family maintained ownership of the property until the City of Santa Cruz acquired Arana Gulch in 1994.

The population of SCT at Arana Gulch has fluctuated greatly in size and spatial extent. Records in the California Natural Diversity Database (CNDDB) indicate that field surveys for SCT at Arana Gulch were first conducted in 1977 by Randy Morgan but plant counts are not provided (accessed July 2012). A dissertation on the species included observations from Arana Gulch and suggested that SCT population density at Arana Gulch in the late 1970's was moderate to low, plants were small and un-branched, and the coastal prairie community was already dominated by non-native grasses and heavily impacted by livestock (Palmer 1980). At that time, the dairy was still in operation and 35-40 head were routinely kept on the property.

Cattle were removed from Arana Gulch in 1988. Two years earlier, Randy Morgan estimated in 1986 that there were over 100,000 plants on the property. In 1989, R. Doug Stone at EA Engineering Science and Technology Inc. confirmed Randy Morgan's observation and identified SCT in what appeared to be four distinct areas in the southern half of the property and called them subpopulations A, B, C, and D (Figure 3.4). A CNDDB record from 1989 indicates that Stone may have found <1,000 plants across the site that year but there is no information about which areas the plants may have occupied (CNDDB 2012). According to another CNDDB record, there were only 65 plants on site by 1992, but again, they were not assigned to a particular site. Although the methodology behind the subpopulation designation is unclear, the four areas have been the focus of all management activities and census efforts since they were first described (Bainbridge 2003).

Figure 3.4 Map of Arana Gulch showing the locations of Santa Cruz tarplant areas A-D, the seasonal wetlands, and the approved multi-use trail alignment and grazing fencing.

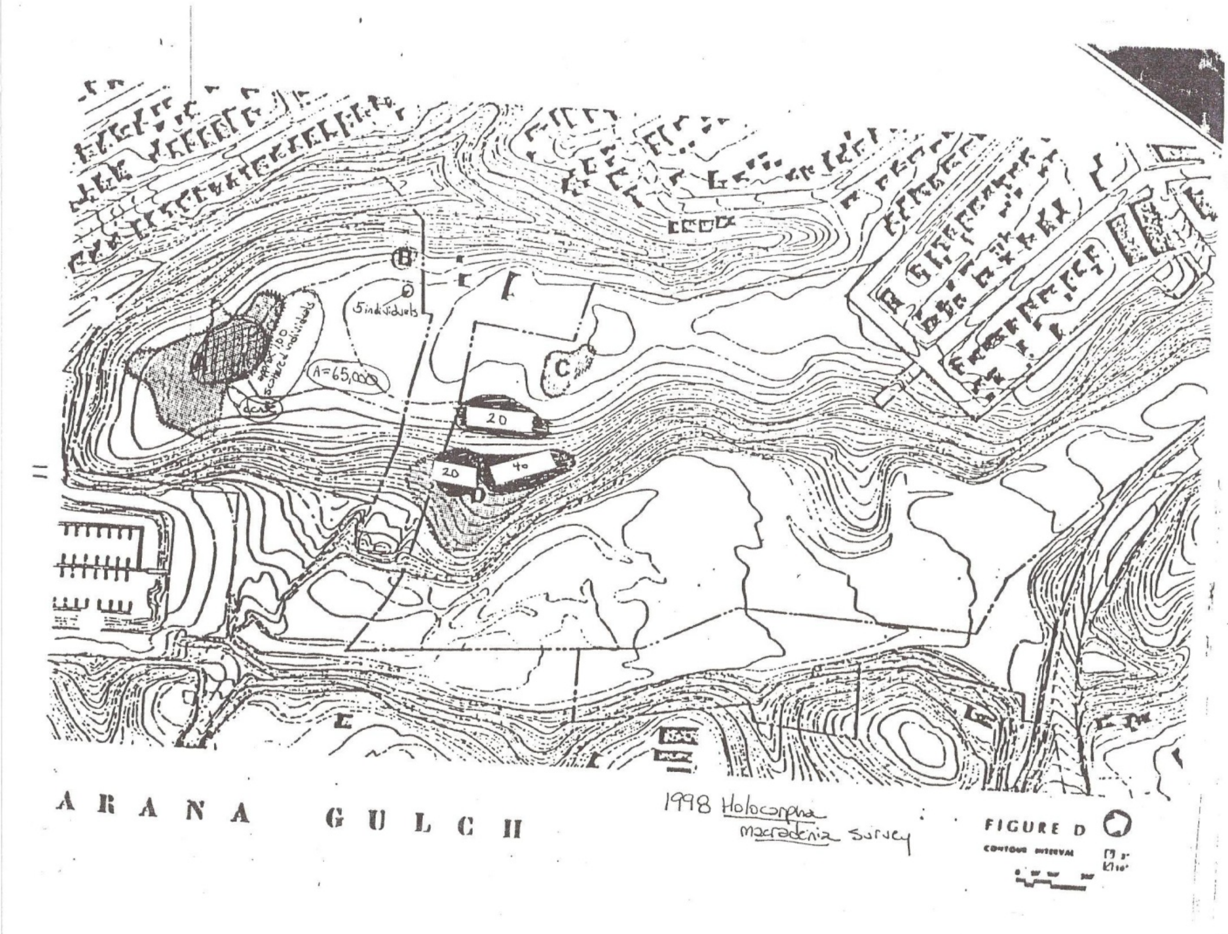

Figure 3.5 Map of the distribution and abundance of SCT on the coastal prairie at Arana Gulch in 1998.

The City of Santa Cruz acquired Arana Gulch in 1994, a year when no SCT plants were found on the property. Since 1994, the number of SCT plants counted has fluctuated from 0 to a high of 65,000 in 1998 (Table 3.2).The survey in 1998 was conducted by members of the Santa Cruz Chapter of CNPS (Figure 3.5- see note “A = 65,000”). Management actions at Arana Gulch including mowing, soil scraping, both prescribed and accidental fire, and experimental actions are also listed in Table 3.2.

Table 3.2. Santa Cruz tarplant total plant counts and management actions applied at four management areas in Arana Gulch. U = indicates mowing type (scythe-type or chopped mulch), unknown M = indicates chopped mulch type mowing

Year	Area A		Area B		Area C		Area D	
	Total Plants	Management	Total Plants	Management	Total Plants	Management	Total Plants	Management
2012	16	Mow /Rake (early June)	0	Mow (June)	0	Mow (June)	0	Mow/Rake (early June)
2011	32	Mow/Rake (May) Mow (Oct) 3 scrape plots (Oct)	0	Mow (June) Mow/Rake (Oct)	0	Mow (June) Mow/Rake (Oct)	0	Mow/Rake (May) Mow (Oct)
2010	0	Mow/Rake (May) Mow/Rake/ 2 Scrape Plots (Oct.)	0	Mow (June)	0	Mow (June)	0	Mow/Rake (May) Mow/Rake/ 1 Scrape Plot (Oct.)
2009	68	Mow/Rake (May) Mow/Rake (Dec)	0	Mow (May)	0	Mow (May)	0	Mow /Rake (May) Mow/Rake (Dec)
2008	44	Mow (April) Mow/Rake (Nov)	0	Mow (April, June)	0	Mow (April, June)	0	Mow (April) Mow/Rake (Nov)
2007	27	Mow^{M}/Rake (April) Mow ^{M} /Rake (Nov)	0	Mow^{M} /Rake (April) Mow ^{M} /Rake (Nov)	0	Mow^{M}/Rake (April) Mow ^{M} /Rake (Nov)	0	Mow^{M}/Rake (April) Mow ^{M} /Rake (Nov)
2006	348	None	0	None	0	None	0	Mow ^{M} /Rake (Oct)
2005	1,552	None	0	None	0	None	0	None
2004	797	None	0	None	0	None	2	None
2003	2,536	None	0	None	0	None	57	None
2002	10,230	None	0	None	0	None	156	None
2001	619	Experimental actions: (Bainbridge)	N/A	None	0	None?	N/A	Experimental actions: (Bainbridge)
2000	1,053	Mow^{U} (May-June)	0	Mow^{U} (May-June)	0	Mow^{U}(May-June)	1	None
1999	1,228	None	0	None	0	Mow^{U}(May-June)	1	None
1998	65,000	Mow^{M}, Prescribed fire north of A(Oct)	5	Mow^{U}(May-June) Prescribed fire (Oct)	20	Mow^{U}(May-June)	60	Prescribed fire (Oct)
1997	35,000	Prescribed fire (Oct)	0	Mow^{U}(May-June)	0	Mow^{U}(May-June)	21	Mow^{U}/Rake (May) Scrape (plots) (Oct)
1996	7,420	Mow^{U} /Rake (May) Arson fire (Oct)	0	Mow^{U} (May) Scrape (plots) (Oct)	0	Mow^{U} (May)	0	Mow^{U}/Rake (May) Scrape (plots) (Oct)
1995	0	Mechanical/Hand Scrape of 3 acres Mow ^{M}/Rake (June)	0	Mow(May) Mow (June)	0	Mow (May) Mow (June)	0	Mow (May) Mow/Rake (June)
1994	0	None	0	None	0	None	0	None

The last peaks in the SCT population at Arana Gulch occurred in 2002 when over 10,000 plants were present in area A following experimental actions conducted in 2001. Since 2002, SCT numbers have fallen precipitously and no individuals have been found in areas B or C since 1998, and none found inarea D since 2004 (Table 3-2).

3.3.2 Implementation of the Management Program for Santa Cruz tarplant 2006-2012

In 2006, the city of Santa Cruz implemented "A Management Program for Santa Cruz Tarplant (*Holocarpha macradenia*) to help direct the recovery of SCT at Arana Gulch (Pavlik and Espeland 2005). This management program was incorporated into the Arana Gulch Master Plan as an appendix and specified the following five directives:

1) Install an adaptive management framework allowing stakeholders to scientifically conduct and evaluate actions.
2) Conduct a two-tracked program for improving overall habitat quality during the first seven years with both:
    a. Semi-annual mowing with phytomass removal to reduce annual grass reproduction and cover over large portions of the Coastal Prairie/Tarplant Management Area (CPTMA).
    b. Ongoing experimental manipulations in reserved portions of the CPTMA 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.
5) Develop public educational opportunities associated with the coastal prairie of Arana Gulch and efforts to conserve and restore its rare resources.

Sections 1-3 below describe how these directives were implemented from 2006 through 2012. Section 4 presents the monitoring data and describes the response of the SCT population to these recent management actions. Section 5 briefly addresses efforts to develop educational opportunities.

1) Install an adaptive management framework allowing stakeholders to scientifically conduct and evaluate actions.

Establishment of the Adaptive Management Working Group (AMWG) is the first step in the implementation of this HMP since the AMWG is a central component of an effective adaptive management framework. In 2011, the City hired Alison E. Stanton an independent research botanist, to both prepare this HMP and to Chair AMWG meetings in the first year. This constituted the first step in installing an adaptive management framework. However, the first AMWG meeting was not held until April 2013. During 2006 to 2012, the City implemented aspects of the first SCT Management Program with help from consultants but without benefit of a stakeholder- driven AMWG and an associated adaptive management framework.

2a) Improve overall habitat quality during the first seven years with semi-annual mowing with phytomass removal to reduce annual grass reproduction and cover

The city of Santa Cruz hired various environmental consulting groups during 2006 to 2012 to implement a semi-annual mowing regime, accompanied by raking (phytomass removal), as specified in the Management Program for SCT (Pavlik and Espeland 2005). All management has been directed at the four areas (A, B, C, D) of the coastal prairie thought to represent subpopulations.

While all areas were mowed annually beginning in 1995 after the City acquired the property, raking was first added in the fall of 2006 (see Table 3.1). The semi-annual regime was implemented in 2007 when all subpopulations were mowed and raked in both April and November following the management directives. Beginning with the 2007 treatment, areas A and D have received semi-annual mowing "to a 4-6 inch grass height, with raking/removal of the mowed material along with a portion of the built-up thatch" through spring 2010 (Lyons, 2010). The first of the semi-annual mowing/raking treatments was generally performed between April and May, prior to tarplant bolting. The second mowing/raking occurred between October and December, after tarplant senescence, but prior to major rain events. Areas B and C received only the late spring mow from 2007 through 2009, coordinated with fuel break mowing on the western perimeter of the grassland.

The treatment protocol changed slightly in 2010 (Lyons 2010). Previous mowing was conducted by a horse drawn mower and rake and the raked material was baled and removed from the site. In the first new treatment protocol, tractor-mounted mowing was performed in areas A and D to a reduced height of 2-3 inches (instead of 4-6 inches) followed by raking (Lyons 2010). This lower level raking created site conditions with approximately 60% plant cover and 40% open ground in area A (Photo 4, Lyons 2010). The raked thatch was shaken to reduce the removal of soil and potential SCT seeds, and was removed from the site. In the fall treatment, areas B and C were mowed and raked, but area D was mowed without raking. The entire terrace and gentle slopes surrounding area A were also mowed, but only the portions of area A with extant tarplant received raking. No plant or soil materials were removed from the site in the fall 2011 treatment, but were instead spread among adjacent mowed and not-raked areas. A buffer of 10 ft around extant SCT individuals was flagged for avoidance during mowing and spreading of dried plant material.

Since 2002, the SCT population has decreased dramatically and it seems clear that mowing treatments have not been an effective way to stimulate SCT germination and recruitment of SCT at Arana Gulch. One reason mowing may have been ineffective is that grasses have intercalary meristems, meaning their growing points are located at the base of the plant. The tractor mowings that have occurred at Arana Gulch cut the grass at 4 to 6 inches above ground which does not injure the meristems and the grasses continue to grow.

In addition, many of the exotic grasses found at Arana Gulch, including the *Avena* spp., *Bromus* spp. and *Festuca* (*Vulpia)* spp. have inflorescences that either drop seeds as they ripen, and/or the inflorescences shatter. When these exotic grasses are mowed in May and June, most have fully developed seeds and therefore the mowing is not decreasing reproduction and is instead dispersing the seeds throughout the area.

The mowing in the Arana Gulch coastal prairie is also likely facilitating the spread of velvet grass, *Holcus lanatus*, a non-native invasive perennial grass. Velvet grass was found in only a few small isolated locations at Arana Gulch in the early 2000's (Bainbridge, personal communication) and now has well-established stands in areas C and the seasonal wetland between areas A and D. Perennial grasses generally germinate more quickly than native forb species with the onset of fall rains (Deering and Young 2006) and clearing the thatch a second time out at Arana Gulch with a fall mow/rake would facilitate their germination. Seabloom et al. (2003) found that the biomass of annual grasses decreased and the biomass of native perennial grasses increased significantly with the cessation of mowing in Southern California grasslands when native grass seed was added to the community.

2b) Improve overall habitat quality during the first seven years with experimental manipulations in reserved portions of the CPTMA to improve existing, and to develop new, management actions

Manipulations in small plots in the coastal prairie have investigated the effect of mowing, raking, soil scraping, and prescribed fire either alone or in combination on SCT. However, a true experiment utilizes a replicated plot design with "controls" or untreated areas to test whether the treatment results in a significantly different outcome than a comparable untreated area. Bainbridge (2003) installed the only replicated experiment at Arana Gulch to examine the individual effects of burning, scraping, mowing, and no treatment on the recruitment of SCT. In 2001, she established 20 x 50 m plots that each contained 10 treatment plots: three control, two mow, two scrape, and three burn. Treatments were applied as follows: mowing on May 24-25 and August 2; scraping on June 6 or August 7;

and burning on June 19 or October 18, 2001. While there was not a significant difference on SCT stimulation between early and late season scraping, there was overall a substantial increase in SCT surviving to reproduction in all of the scraped areas and none occurred in the mow or control plots(Figure 3-6). The differences between burn and scrape treatments was significant ($p<0.05$). Treatment was more important than timing but explained but only 18% of the variability in density. There was no difference between the two burns. Regression of seed bank density and recruitment showed no significant correlation suggesting a treatment effect rather than a seed bank effect. Exotic annual grasses decreased significantly in both scraping treatments and successfully stimulated germination of native annual forbs including *Lupinus nanus, Plagiobothrys undulates, Trifolium barbigerum, Juncus bufonius,* and *Deinandra corymbosa*.

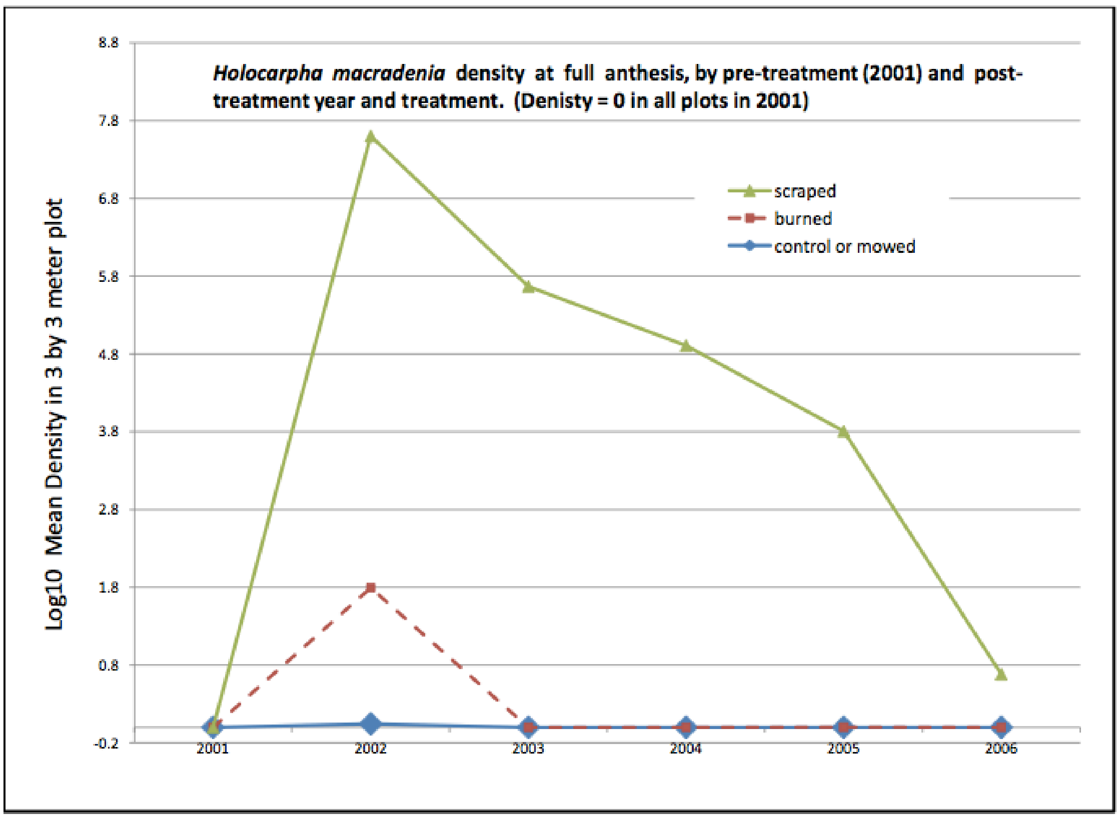

Figure 3.6 SCT population density after experimental burn, scrape, mow, and no (control) treatments from 2001 to 2006 (Bainbridge unpublished data). No seedlings were detected in the mowing and control plots..Treatments occurred in 2001. Y axis is log10 scale.

3) Implement "surgical" and "catastrophic" actions

A total absence of plants at Arana Gulch in 2010 indicated the semi-annual mowing and raking protocol was not successfully improving the habitat quality at Arana Gulch for SCT growth and reproduction (Lyons 2010). Therefore, small-scale scraping plots were created in September, 2010 as a "catastrophic" measure. A tractor was used to scrape two plots of approximately 40 x 50 ft within flat portions of area A and one plot of approximately 30 x 60 ft within area D (Photo 5). Above-ground SCT had not been seen in plot areas for at least 15 years. Plant matter and soil were removed to an average depth of 1 inch, with a range of disturbance of 0.5-3.0 inches. Soil was shaken loose from the plant matter and was lightly distributed on adjacent areas. All plant matter was removed from the site (Lyons 2010). Soil was lightly compacted from the tractor.

A "surgical" weeding treatment was also performed in 2010 to evaluate trends in plant cover (Lyons 2011). Five adjacent un-weeded and weeded plots were established in the western edge of area A where tarplant was present in 2009. Non-native species were removed from the "weeded" plots in spring 2010, and plots were re-evaluated a month later. Un-weeded plots were dominated by the exotic forbs subterranean clover (*Trifolium subterraneum*) and filaree (*Erodium botrys*) with lesser amounts of the native perennial grass California oatgrass (*Danthonia californica*), exotic annual grasses, and other exotic annual forbs. SCT seedlings were not found in the un-weeded or weeded plots of area A, but they were found within the vicinity/adjacent to the plots. Within a month after weeding, the weeded plots were re-invaded by exotic species, predominantly cat's ear (*Hypochaeris* sp.), filaree, subterranean clover, English plantain (*Plantago lanceolata*), and rattail fescue (*Festuca myuros* formerly *Vulpia*).

A second "surgical" weeding treatment was performed in 2010 after Medusa head (*Taeniatherum caput-medusae*) was detected in the eastern portion of area A. This highly invasive annual grass was hand pulled, bagged, and removed from the site to prevent further infestation. Rosettes of cat's ear, radish (*Raphanus sativa*), and bull thistle (*Cirsium vulgare*) were also weed-whipped and removed from Areas A and D by city maintenance crews in August 2010. Figure 3.7 shows the locations of the 2010 management actions.

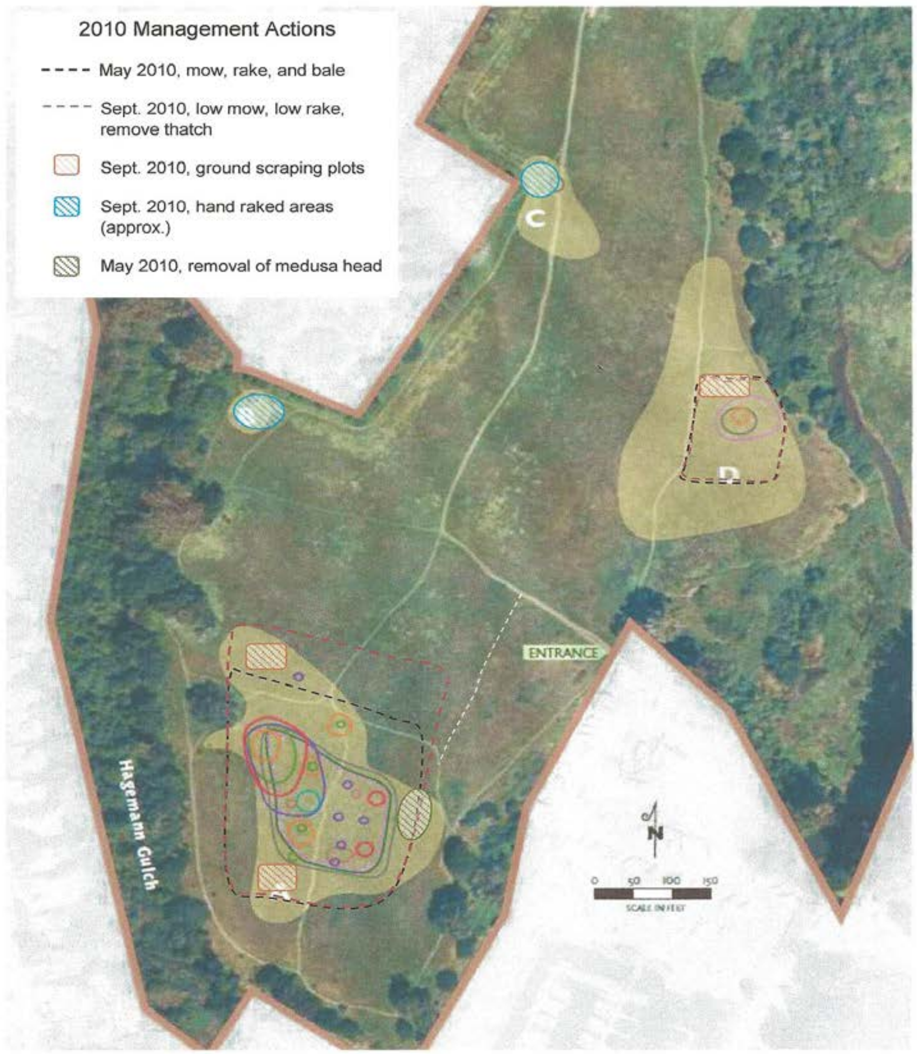

Figure 2. Areas Subject to Habitat Management in 2010

Figure 3.7 Locations of management actions conducted in 2010 including large scale mowing with raking, small scale soil scraping plots, a hand raking plot, and hand weed pulling plot (from Lyons, 2010).

In 2011, a second “catastrophic” treatment was applied in the fall (Lyons, 2011). Scraping occurred in three approximately 30 x 30 ft scraped plots located in area A following the same protocol as 2010 (Photo 6). The plots were in an area where SCT had not been observed during the previous 5 years.

4) **Evaluate every management action and research effort: tarplant response to recent management**

SCT has been monitored in Areas A-D in late spring through mid-summer every year since the City first acquired the property in 1994. Areas B, C have not supported SCT since 1998 and area D has not had SCT since 2004, despite a combination of mowing, raking, and scraping treatments in these areas. Since 2005, individuals in area A have been mapped with a GPS and the number of individuals recorded. Fecundity was only measured from 2010-2012 by documenting the number of inflorescences/plant.

The last time there was a significant number of SCT individuals at Arana Gulch was in 2005 in a very high rainfall year (42.6 inches) when 1,552 plants were found in area A (see Figure 3-6. The following year there was also above normal rainfall (43.6 inches), but there were only 348 plants. From 2007 through 2012 the population has ranged from a low of 0 in 2010 to a high of only 68 plants in 2009. The precipitous decline in the population over the last five years does not show any correlation with rainfall. Average rainfall in the recent period from 2005 to 2011 has been right at the long term normal (30.3 inches).

Recent management actions have also had little effect on population size. The scrapings performed in fall of 2010 in areas A and D did not lead to any tarplant germination. The scrape plots were located in an area where plants had not been seen for at least 15 years and it may be that the seed bank is depleted in that part of the coastal prairie. However, the three plots scraped in fall 2011 within the mowed/raked portion of area A had supported SCT more recently. The 16 plants counted in spring of 2012 were all located in two of these scrape plots (Figure 3.8).

In 2012, the mowing occurred In June, apparently after Santa Cruz tarplant had bolted. Of the 16 individual plants that were found, 12 were branched and had cut stems at 4-12” with most branching occurring below the clipped point of the stem (Photo 7). The mowing apparently caused plants to branch and the total inflorescence production of 293 was much higher than the 84 inflorescences produced by a higher number of plants the previous year. We do not know if the increase in inflorescence number has also increased seed output, because the size of inflorescences has not been evaluated.

The limited response of the SCT population to recent management actions may be a result of a depleted seed bank or of declining habitat quality, since there does not appear to be any strong correlation with rainfall. The data strongly suggest that the semi- annual mowing regime has failed to reduce annual grass cover and promote conditions that favor SCT germination and survival. Data on the SCT seed bank and coastal prairie vegetation conditions at Arana Gulch are needed to quantify the nature of the SCT population decline and identify the possible causes.

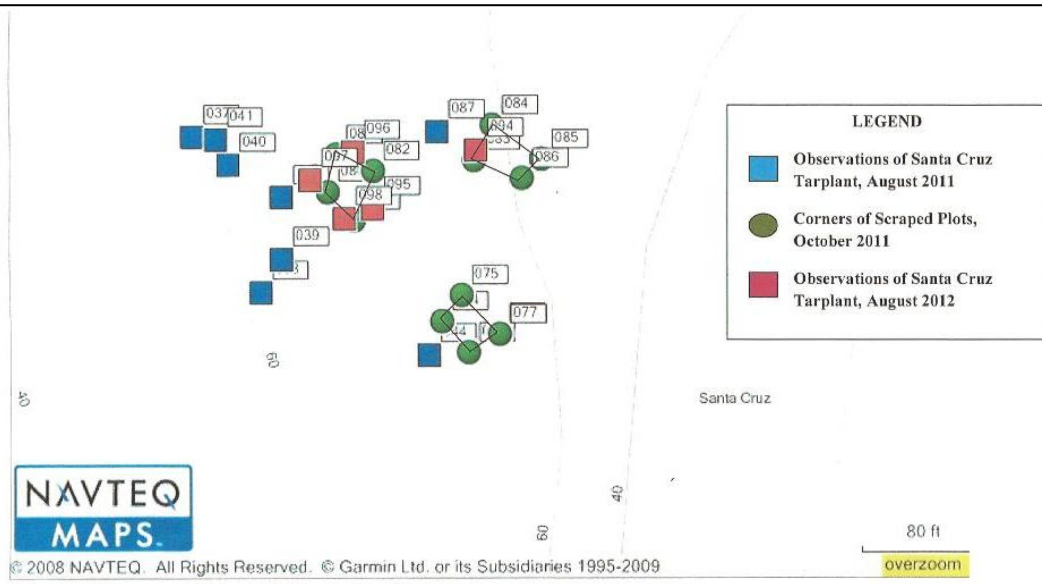

Figure 1. Distribution of Santa Cruz Tarplant, Area A – Arana Gulch Greenbelt, August 2012

Figure 3.8 Location of SCT plants observed in August 2012 relative to three plots scraped in October, 2011 and SCT plants observed in 2011 (from Lyons memo to the City August 16, 2012).

5) **Develop public educational opportunities associated with the coastal prairie of Arana Gulch and efforts to conserve and restore its rare resources.**

Educational opportunities have been identified in the Arana Gulch Master Plan and a condition of the Coastal Commission Coastal Development Permit (CDP) is to develop a Public Access Management Plan which clearly describes how public access will be provided and managed. The City of Santa Cruz assumes responsibility for this condition and will develop all interpretative materials about the coastal prairie and efforts to conserve and restore its rare resources, with a particular emphasis on SCT recovery.

3.4 Baseline Conditions across the Coastal Prairie Management Area

The Coastal Prairie/Tarplant Management Area occupies 30.2 acres in the central portion of Arana Gulch. The following qualitative descriptions of the physical conditions of the area, upland prairie vegetation, and the seasonal wetlands are largely derived from environmental assessment documents based on past surveys including; Habitat Restoration Group (1996); Biotic Resources Group (1999, and Bland and Associates (1999). The status of SCT on the site from 1994 to the present is largely based on data provided by the City and Kathy Lyons. Qualitative descriptions of site conditions are also based on field observation in 2012. Appendix B includes general photos of site conditions.

The purpose of these qualitative descriptions is to provide a picture of general site conditions as of 2012. They are not intended to establish any sort of reference point for evaluating changes in resources condition over time nor in assessing the outcome of any management actions. Carefully designed, quantitative monitoring programs are needed for those purposes. Funding for conducting a quantitative baseline assessment at Arana Gulch was not included in the contract to develop this HMP. The City and the CCC came to an informal agreement that a baseline assessment could happen with the input of the AMWG once the group had convened and had an opportunity to review the Draft management goals and objectives for the Coastal Prairie Management Area.

A qualitative baseline assessment was completed in July 2013 after Alison Stanton received additional funding from the City at the behest of the AMWG. Although the results are not presented here, the monitoring variables are described in Section 3.8.1 that are tied directly to the Goals and Objectives presented for the Coastal Prairie and SCT in 3.6.1.

3.4.1 Physical conditions

The coastal prairie and annual grassland habitat in this management area is located on an upper marine terrace comprised of the sandstones and siltstones of the Purisima Formation and unconsolidated terrace deposits that weather to sand and silt with very little gravel or cobble sized debris. Based on the Soil Survey of Santa Cruz County (USDA, 1979) the slopes in the upper grassland area are generally moderate, ranging from 4 degrees to 17degrees and the predominant soil type is the Elkhorn sandy loam. This soil is very deep and well-drained. Although permeability and runoff is moderately slow on gentle slopes, on the steeper slopes (over 9 percent), runoff potential is rapid and erosion hazard is high. However, soil conditions on the terrace are not homogeneous. While processing seed bank samples in 2003, Sue Bainbridge observed less clay content in the soil from Areas B,C, and D compared to area A (Bainbridge pers.comm. 2013).

The grassland vegetation intercepts rainfall and fog and approximately 15 to 20 percent of precipitation infiltrates into underlying soils. Excess rainfall is shed off of these areas as dispersed sheet flow to the downslope areas. Deep infiltration of runoff recharges shallow groundwater of the Santa Cruz and Soquel aquifers. Surface hydrology and drainage of the coastal prairie have been altered by the compacted earthen trails that crisscross the site. Improvement of this trail system and associated erosion is the major component of the Arana Gulch Master Plan and multi-use trail development.

Potential impacts of the multi-use trails in the coastal prairie on the SCT population were addressed in a geologic report that analyzed subsurface drainage in the vicinity of SCT area D and surrounding bike trails (Cleath Harris Geologists, 2010). That report concluded that the groundwater depth is sufficiently deep that it will not be impacted by bike trail construction and that flows to area D will remain unaffected. However, the AMWG may wish to further investigate hydrologic dynamics on the site in the future, especially if the prairie fails to response positively to the reintroduction of grazing.

3.4.2 Upland Vegetation

A non-native annual grassland presently dominates the coastal prairie habitat at Arana Gulch. Prevalent non-native grasses include wild oat *(Avena fatua),* slender wild oat *(Avena barbata),* ripgut brome *(Bromus diandrus),* soft chess *(Bromus hordaceus)* rattlesnake grass *(Briza maxima),* and ryegrass *(Festuca perennis (*formerly *Lolium multiflorum).* During the peak growing season in 2012, grass height averaged over 4 feet in un-mowed areas in the central terrace (Photo 8). Localized patches of the native perennial grasses purple needlegrass and California oatgrass occur on the terrace. Large tufts of spreading rush (*Juncus patens*) are also scattered through the grassland.

Native forbs are very sparsely distributed and may include: California poppy *(Eschscholzia californica),* yarrow *(Achillea millefolium),* owl's clover *(Castilleja densiflora ssp. densiflora),* Indian soap root *(Chlorogalum pomeridianum var. divaricatum),* yellow Mariposa lily *(Calochortus luteus),* and golden brodiaea *(Triteleia ixioides ssp. ixioides)* (DEIR 2006). In addition to SCT, two other tarplant species are present: a cluster of hayfield tarweed (*Deindandra corymbosa formerly Hemizonia*) occurs in the central terrace, while the coast tarplant (*Madia sativa*) is more scattered. Characteristic non-native forbs include hairy cat's ear (*Hypochaeris radicata*), prickly lettuce (*Lactuca serriola*), vetch (*Vicia sativa*), wild radish (*Raphanus sativus*), fiddle dock (*Rumex pulcher*), sheep sorrel (*Rumex acetosella*), English plantain (*Plantago lanceolata*), bindweed (*Convolvulus arvensis*), pennyroyal (*Mentha pulegium*), narrow-leaved clover (*Trifolium angustifolium*).

There are no emergent trees in the grassland with the exception of four plum (*Prunus spp.)* trees in the southern portion of the site that were planted in the distant past. Some coast live oak saplings have also been observed. There is also a single small patch of the native coyote bush (*Baccharis pilularis*) at the far south end.

Several noxious invasive species are present in the grassland. As described in section 3.3.4, velvet grass (*Holcus lanatus*), a non-native invasive perennial grass, has expanded from a few small isolated locations at in the early 2000's (Bainbridge, personal communication) to well-established stands around SCT area C and the seasonal wetland between areas A and D. This species is rated Moderate by the California Invasive Plant Council (Cal-IPC). A very dense and large stand of Italian thistle (*Carduus pycnocephalus*) with emergent shortpod mustard (*Hirschfeldia incana*) occupies the steep eastern slope near the northern entrance to the greenbelt. Both species are rated Moderate by Cal-IPC and in 2012 this stand averaged 5 feet high. The only forb species with a High rating that is present in the grassland is Scotch thistle (*Onopordum acanthium*). A small patch is on the southwestern edge of the terrace near Hagemann Gulch along with a limited amount of poison hemlock (*Conium maculatum*), a Moderate species.

3.4.3 Seasonal wetland vegetation

A small amount of seasonal wetland is mapped in three areas on the coastal terrace (see Figure 3.4). Of the three polygons the most distinct wetland is located near the margin of the riparian scrub and woodland adjacent to Arana Gulch Creek in the eastern portion of the project site. That wetland is a well-defined depression with dense, tall vegetation cover dominated by velvet grass. Other species include rye grass, spreading rush, curly dock (*Rumex crispus*), cocklebur (*Xanthium strumarium*), pennyroyal, annual beard grass (*Polypogon monspeliensis*), prickly lettuce. An infestation of bull thistle (*Cirsium vulgare*), a Moderate CalIPC species, is present and a dense thicket of the invasive non-native woody vine Himalayan blackberry (*Rubus armeniacus* formerly *R. discolor*), a High Cal-IPC species, is penetrating the wetland from all sides. The other two mapped seasonal wetlands do not contain vegetation that is very distinct from that of the surrounding grassland. The wetland just north of area A is

3.4.4 Santa Cruz tarplant status

The census data listing the number of SCT individuals in areas A-D is the main tool we have to assess the baseline status of the SCT population at Arana Gulch (Table 3.1). The census data indicate that the current status of the SCT population at Arana Gulch is in a perilous decline. SCT habitat has been severely degraded as this photo of a sign to protect "sensitive tarplant habitat" that is engulfed in wild oat clearly shows (Photo 8). In the 2012 census only 16 SCT individuals were mapped.

The current appearance of the four habitat areas is similar. Area A is located on the southern end of Arana Gulch and is the only area that still supports SCT (Photo 9). The difference between the mowed and un-mowed perimeter of area A is striking (Photo 10). Area B is on the central west edge of the coastal prairie where the proposed Hagemann

Gulch bridge will cross (Photo 11). It is adjacent to the fence line of the neighborhood to the west and is so small that it is always completed mowed as part of the fuel break. Area C is located further north on the western edge of the prairie and is also mowed as part of the fuel break mowing (Photo 12). Area D is located down slope from the central terrace adjacent to the Arana Creek riparian corridor (Photo 13).

The last significant number of SCT was seven years ago in 2005 when 1,552 plants were counted. Seeds of SCT have germinated after 6 to 9 years in room temperature storage, and therefore SCT seed bank longevity has been estimated at 5 to 10 years (Pavlik and Espland 2005). However, the census record from Arana Gulch suggests that seed may have persisted for 10 years from 1986 to 1996. During that period there are only have 4 census estimates of <1,000 SCT in 1989, 133 in 1993 (from area D), and no plants in 1994 or 1995. While we do not know the conditions in the intervening years, there was a severe drought in place from 1987 until 1993 and it is highly likely that there were in fact few to no plants present on the site over that time. With the reappearance of over 7,000 plants in 1996 it seems quite likely that they were derived from seed that had persisted since the last major presence of SCT in 1986. Currently, there have not been more than 1,000 SCT since 2005 and there has not been a substantial recruitment event in 10 years when there were 10,000 SCT in 2002. It may be that a properly implemented scraping or fire or other disturbance this fall would stimulate a large flush of SCT, similar to what happened in 1996 after a bulldozer scraped 3 acres in fall of 1995. Climatic conditions could make big difference in the response this time. The decade from 1986 to 1996 was drier than the decade from 2002 to the present and wetter soil conditions could have caused greater seed decay over the recent decade than the previous one. Also, 1995 was an extremely wet winter and the greater moisture availability in the spring likely increased the magnitude of the response to the scrape.

There is a dearth of information available on the longevity of seeds in the soil seed bank in general. There are a few examples of seed germinating after burial for 100 years, but these are often seeds with heavy seed coats such as many leguminous species e.g. *Lotus*. Seed from the Aster family are not known to be especially long-lived. If the seeds of SCT are in fact long-lived and persistent, there is less pressure and more time available to restore favorable habitat conditions for the species at Arana Gulch. However, seed bank longevity studies require years of monitoring and there is no easy or quick way to find out the longevity of SCT seed in the soil. In any case, what is clear from the census record at Arana Gulch is that no management, as well as the wrong kind of management puts the entire coastal prairie in peril.

3.5 Grazing Program

The Coastal Development Permit conditions of approval require this Habitat Management Plan to present "all details associated with the grazing program, subject to Adaptive Management Working Group and Executive Director approval, in substantial conformance with the proposed cattle grazing program" included as Exhibit P Tab 4 in the application package. That narrative describes the proposed cattle grazing program which is compatible with the multi-use east-west trail route as proposed in the *Arana Gulch Master Plan*. The sections below present a modification of that cattle grazing program that includes additional information and partitions the plan into separate sections to better highlight important elements.

3.5.1 Grazing area and fencing

The map of the approved Arana Gulch multi-use trail alignment including grazing structures, the locations of SCT areas A-D, and the seasonal wetlands is Figure 3-4, found on page 49 .

The proposed grazing area would be approximately 18 acres, nearly triple the acreage originally proposed. Rather than one contiguous grazing area, the proposed grazing program features three grazing areas as shown on the attached map to encompass SCT areas A, C and D. The grazing area does not include any riparian habitat.

These separately fenced areas are beneficial because they allow the grazing operator to adapt to regularly changing site conditions. Cattle can easily be moved between the grazing areas as needed to conduct more controlled and focused cattle grazing. For example, if SCT individuals emerge within areas A and D, cattle can be moved to the northernmost grazing area C. The grazing area encompassing SCT area D is located approximately 100 feet from Arana Gulch Creek and close to a seasonal wetland and the emergent wetlands of the riparian area. Gating this small area allows it to be closed off during periods of heavier rainfall to protect the soil from excessive hoof damage, prevent erosion, and protect water quality. Moving cattle between grazing areas within Arana Gulch on short notice is far more efficient and feasible than requiring the grazer to remove all of the cattle from the property and transport them to another grazing site.

3.5.2 Installation of fencing materials

The proposed grazing area will require approximately 5,600 linear feet of livestock fencing. The fencing includes round wood posts and wire designed to minimize visual impacts. Posts will be approximately 5 feet above ground and painted green. Metal livestock gates (green) will be installed as shown on the attached map and designed to integrate visually with the post and wire fencing. The gates will be 12-16 feet in width to create an opening for fire vehicle access during dry season.

The fence would be installed during the dry season to avoid rutting/erosion during saturated soil conditions. Installation will require a motorized pick-up truck to haul fencing materials. Hand tools will be used to install posts and footings where required. The SCT areas and an adequate buffer will be flagged to ensure no motorized vehicle disturbs those areas. The fencing contractor will access the site from the Agnes Street entrance. Once the fencing is installed, annual maintenance is relatively simple and cost effective.

3.5.3 Grazing regime and class of cattle

The minimum number of cattle necessary to reduce non-native grasses and stimulate SCT expression and growth will be utilized. It is anticipated that the grazing operator will use a water rotational regime with a range of approximately 2 to 6 cow/calf pairs. Cow/calf pairs may be a good choice for the high profile setting of Arana Gulch for several reasons. First, cows generally stay close to their calves and do not test the fences as much as stockers. Second, cows can also be selected that have no experience with dogs to lessen potentially negative across-the-fence interactions. And third, baby cows are cute and more accessible to a public that might be surprised by grazing in an urban setting and can be a boon to public outreach efforts.

Initially, three pairs may be brought to the site and grazed from approximately January through June, with the potential for longer periods as recommended by the AMWG. Supplemental alfalfa will be made available during the winter as needed along with portable water troughs. Portable water troughs and feed stations will be located within grazing areas as far back from the top of the steep slopes as possible and outside of sensitive areas. Cattle will be kept on site until SCT flowers in order to prevent cattle from crushing blooming plants. The exact grazing schedule each year will depend on specific weather conditions and the flowering period of SCT. Manure generated by cattle grazing will be allowed to remain on site and naturally decompose. This is consistent with grazing management implemented at other sites (i.e. High Ground Organics, Elkhorn Slough Foundation lands). No adverse impacts to surrounding areas or to SCT have been detected from this practice.

Depending on the response of the SCT and conditions of the coastal prairie, longer grazing periods may be recommended. In the future, permanent placement of water and feed troughs might be identified, but the surrounding area should be compacted first to minimize future erosion.

The City currently manages a successful grazing operation at the Moore Creek Preserve for the purpose of coastal terrace prairie habitat enhancement and improvement of the federally endangered Ohlone Tiger beetle and the state endangered San Francisco popcorn flower (*Plagiobothrus diffusus*). It is anticipated that the grazing will be contracted to the same operator who is local and has the capacity to assess site conditions on a weekly basis and within a day to respond to rain events, if necessary. The close proximity will allow the operator to move cows among the fenced areas quickly and respond to site conditions. Once the fencing is installed annual grazing is relatively simple and cost effective for the City to implement and maintain.

3.5.4 Cattle Transport

The cattle will be transported to the Agnes Street entrance, then offloaded from the cattle truck and released into a corral located to the west of the park entrance. The cattle will then be herded among grazing areas with horses, ATVs or a pick-up truck depending on the season. The exact timing of the cattle delivery will depend on climatic conditions and resulting soil saturation. The cattle will not be delivered during periods of heavy rainfall when soils are highly saturated. Removal of cattle will follow the same route.

3.5.5 Coastal Water Quality

Much of the grazing area is located on the coastal terrace, over 300 feet from the Arana Gulch Creek. The grazing areas are primarily situated on the level coastal terrace with gentle slopes ranging from two to nine percent. Grazing would not occur on steeper slopes to prevent erosion. The grazing fencing will be set back from the top of the steep slopes by a minimum of 50 feet, except where above-ground SCT have been observed. In those areas, the fence line will be adjusted to incorporate these plants/habitat within the grazing area. The southern grazing area would be located approximately 150 feet from the Hagemann Gulch drainage

The grazing area encompassing SCT area D is approximately 100 feet from Arana Gulch Creek. As previously mentioned, this area features a gate which allows the ability to close off the area from cattle during periods of heavier rainfall. Fencing will also be installed around the seasonal wetland (with a 50 foot buffer). The seasonal wetland fencing could be installed as temporary to allow grazing within this area during the drier months.

Given the mostly level topography and soil permeability of the grazing area, setback from steeper slopes, and distance from Arana Gulch Creek, no impacts on coastal water quality are expected from the proposed grazing operation. Nonetheless, water quality protection measures and site monitoring would be conducted to ensure no impacts to coastal water quality occur.

3.5.6 Best Management Practices (BMPs)

Specific Best Management Practices (BMPs) and site monitoring requirements will be implemented to ensure there are no negative impacts on coastal water quality from cattle grazing at Arana Gulch. The BMPs and monitoring will be incorporated in the final grazing plan and implemented in the field and include:

- Install grazing area fencing a minimum distance of 50 feet from the top of the steep slopes. If there are areas where above-ground SCT have been observed within 50 feet of the top of the terrace slope, the location of the fencing will be adjusted to include these plants/habitat within the fenced grazing area.
- Install temporary fencing around the seasonal wetland within the southern grazing area to include 50-foot buffer. Allow grazing in the seasonal wetland area during dry conditions as recommended by the botanist.
- Locate water trough and any supplemental feed within grazing areas as far back from the top of the steep slopes as possible. Locate the trough and feed outside of sensitive areas (occupied tarplant areas/seasonal wetland)
- During months of highest rainfall and storm events, keep minimum number of cow/calf pairs on site to avoid erosion and minimize volume of cattle waste.
- Conduct regular visual inspections of fence line to ensure cattle remain within designated grazing area.
- During rainfall events, conduct visual inspections (by foot) to ensure no rilling or other erosion within and from the grazing area. Appropriate erosion control measures, such as straw wattles, will be installed, if necessary, to prevent any accelerated or channelized runoff toward steep slopes.
- Avoid motorized vehicle use during rainy season/soil saturation to maximum extent feasible

3.6 Monitoring Plan

3.6.1 A conceptual model for the Arana Gulch coastal prairie and SCT

Here, we present a first attempt at a basic conceptual model for the Coastal Prairie/Tarplant Management Area (CPTMA) that will benefit from further refinement within the AMWG (Figure 3.9). One of the most important functions of a conceptual model is that it helps identify what to monitor and leads directly to the development of a monitoring program for conservation targets. . Developing a simple and realistic conceptual model for the conservation targets can make the process easier because it visually portrays the interactions among important factors and specifies strategies that can be translated in goals and objectives. The two main conservation targets identified in the Master Plan are the SCT population and the coastal prairie habitat. The set of six direct threats includes the main factors identified in the Arana Gulch Master Plan and the SCT Management Plan; low population size, seedbank depletion of both SCT and other native species, seed predation, pollinator loss, competition from high cover of non-native species, and illegal activities.

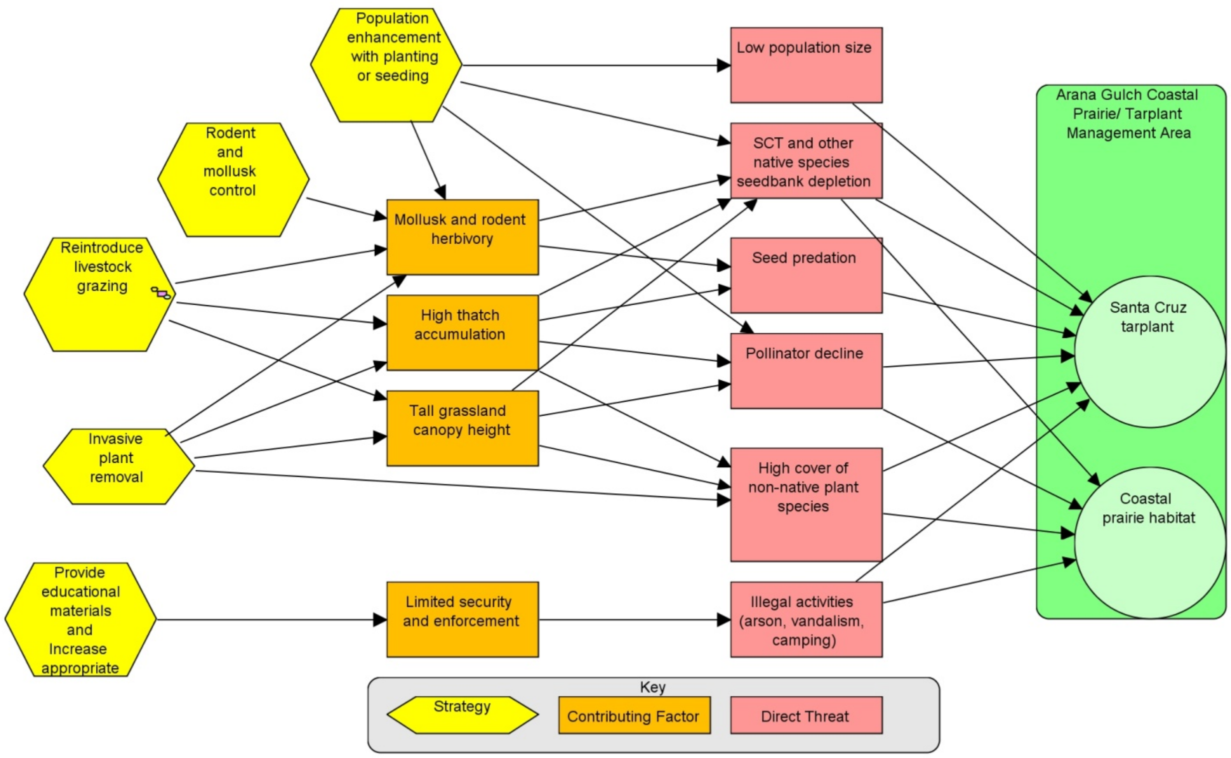

Figure 3.9 Conceptual model for the Coastal Priaire/Tarplant Management Area at Arana Gulch.

The set of four contributing factors to the direct threats have also been previously identified in the planning process and in the scientific literature. High thatch accumulation, tall grassland canopy height, and mollusk and rodent herbivory can all be linked to the direct threats. These factors are components of high invasive plant cover and they contribute to increased seed predation, seed bank depletion, and potential pollinator loss through the resulting shift in the composition of the vegetative community. Illegal activities such as vandalism, arson, or camping are other manageable factors that contribute to the further degradation of the prairie and the decline in the SCT population at Arana Gulch.

Other direct and indirect threats that impact SCT recruitment and growth including; drought, climate change, pathogens, alteration of soil nutrient status, shifts in hydrological dynamics were not included in this initial model focused primarily on the recovery of SCT the vegetative community.

A total of five strategies that address the direct and indirect threats were selected because these meet the criteria specified in the Open Standards for Conservation of being linked, focused, feasible, and appropriate. They are linked directly to the outcomes in the vision for Arana Gulch (section 2.3) and each has been determined to be feasible to some extent. The strategy to build fencing and reintroduce livestock grazing has already been approved as part of the multi-use trail alignment. The details of the Grazing Plan were presented in the previous section (3.5). The initial expectation is that grazing will reduce the high thatch load, decrease the canopy height, and expose bare ground so that SCT can germinate and complete its lifecycle. The strategy to conduct invasive plant removal may be employed on target weeds and the strategy to conduct population enhancement of SCT and other native species may be a necessary component of the restoration and recovery process. Rodent and mollusk control are included more as a secondary strategy that could be employed as part of other strategies.

The strategy to provide educational opportunities and increase appropriate public uses is a central part of the Arana Gulch Master Plan and was specified as an important component in the SCT Management Plan. As part of the Coastal Development Permit conditions, the City of Santa Cruz must develop a full-scale Public Access Management Plan that describes all aspects of public access including interpretative displays, facilities, and educational programs. The strategy is based on the assumption that an increase in the number of users at Arana Gulch that will occur as a result of the multi-use trail development will increase the number of opportunities to observe and report illegal activities. Thus, greater use of the site acts as a deterrent to unauthorized uses and the installation of education kiosks further promote appropriate uses. Trail maintenance is required into perpetuity and this decreases the likelihood that new user trails will emerge again. If user trails do emerge, it may become a concern of the AMWG.

3.6.2 Goals and Interim success criteria for SCT and the coastal prairie

Goals and objectives set the overall direction for a monitoring plan. Goals should be broad, but concise visionary statements that set an overall direction for monitoring and management. Objectives are concise statements that describe what will be achieved, specify a level or degree of achievement, when and where it will be conducted, and by whom. Good objectives meet the SMART criteria: specific, measureable, achievable, results-oriented, and time fixed (Lutes et al. 2006). Often multiple objectives are needed for a single goal.

For the coastal prairie and SCT population at Arana Gulch, the goals and objectives of this Habitat Monitoring Plan address both the conservation targets and the management regime. While the goals for the conservation targets are broad statements, the objectives are mostly very specific and limited in time to years 1 or 2 after treatment implementation. These measureable objectives are tied directly to the annual reporting requirements (section 2.3.2) and constitute the interim success criteria for implementation of this Habitat Management Plan in the near term. The development of such interim success criteria is a specific requirement of the Coastal Development Permit conditions of approval.

While these goals and objectives set an overall direction for monitoring and management, the response of the SCT population to management can be predicted with a high degree of confidence in some cases and with very little confidence in others. This means that some of the objectives may turn out to be overly optimistic, while others might be conservative. Therefore, the rationale behind each goal and objective presented below is briefly explained often with reference to additional supporting information found in sections 3.1 and 3.2. Through the process of monitoring and data evaluation, the AMWG will be able to better quantify the confidence intervals. As generated data becomes a central component of the adaptive management process, the AMWG will adjust the goals and objectives as necessary. These revisions can be received by the CCC at any time and can be incorporated into the annual reports.

Goal 1: Maintain a viable SCT population at Arana Gulch

Objective 1A: Increase the number of aboveground SCT to at least the 2006 level by 2015.

Fewer than 100 SCT have been present at Arana Gulch since 2006 when 348 plants were detected. The census data suggest that, given favorable conditions, the reintroduction of a proper disturbance to the site could quickly increase the number of expressed SCT by 1,000's of plants. However, if the seed bank is depleted that may not be realistic. It is expected that the Grazing Program (section 3.5) could be implemented over the winter of 2013/2014. A conservative goal for the response of the SCT population in the first year after the return of grazing is the 2006 population level. The objective can be adjusted after the first year response is observed.

Objective 1B: Expand the distribution of SCT beyond Area A within three years.

SCT has only been observed in Area A since 2004 when only 2 plants were found in Area D. Plants were only seen in Areas B and C once in 1998. While the designation of areas A-D have helped to focus management and the annual census, there is no apparent reason that SCT will remain restricted to area A when a disturbance regime of grazing is reintroduced. However, the last time there were more than 1,000 plants was 2005, so if the seed bank is depleted it could take several years for the expansion to occur.

Goal 2: Reintroduce grazing to restore a disturbance regime that maintains functioning coastal prairie.

Objective 2A: Implement the Grazing Program by 2014.

Details of the Grazing Program are presented in the next section (3.7) and it is expected that it will be implemented over the winter of 2013/2014. The potential benefits of grazing in coastal prairie restoration were discussed in section 3.2.2. However, poorly managed grazing can result in potentially negative impacts to water quality or sensitive habitats. Two objectives addressing these potential concerns are specified below.

Objective 2A.1: Locate grazing support features (e.g. portable water troughs, salt lick, fence posts) outside of occupied SCT habitat or seasonal wetlands where possible. Observe the condition of all features three times during each grazing season over the first three years.

Cows congregate near the troughs and can cause excessive trampling and erosion in the surrounding areas. The use of portable troughs means the issue might arise on an annual basis and therefore its implementation could be monitored at several points, timed at either regular intervals or to coincide with large rain events. In addition, monitoring the troughs affords an opportunity to be on the lookout for potential negative impacts to birds, bats, and other animals attracted by the water. If impacts are detected, the AMWG can develop a more quantitative monitoring approach.

Objective 2A.2: Implement Best Management Practices (BMPs) to minimize erosion, avoid impacts to the seasonal wetland, and to avoid impacts to water quality from cattle waste.

The BMPs are specified in detail in section 3.5.6.

Objective 2B: Maintain Residual Dry Matter (RDM) within a range that allows SCT to complete its lifecycle and protects the coastal prairie grasslands from erosion (between 700 to 1,500 lbs per acre.

Residual dry biomass (RDM) is a standard metric used by land management agencies for assessing the level of grazing use on annual rangelands and associated savannas and woodlands According to Bartolome et al. (2006) "Residual dry matter is the old plant material left standing or on the ground at the beginning of a new growing season. It indicates the combined effects of the previous season's forage production and its consumption by grazing animals of all types. The standard assumes that the amount of RDM remaining in the fall, subject to site conditions and variations in weather, will influence subsequent species composition and forage production. Properly managed RDM can be expected to provide protection from soil erosion and nutrient losses." At Arana Gulch, the beginning of the new growing season coincides with the first fall rains, usually in mid to late October. Observed levels of residual dry biomass (RDM) in 2012 at Arana Gulch were very high. RDM should be quantified at the end of the first growing season after grazing commences.

Goal 3: Minimize the detrimental effects of high non-native plant cover and restore coastal prairie species diversity and habitat function.

Dense stands of non-native plants provide poor quality habitat for SCT by directing competing for resources and indirectly by creating conditions that promote micro-herbivory. The mowing regime at Arana Gulch has been unsuccessful at minimizing the detrimental effect of the high non-native annual grass and forb cover at the site. It is expected that a grazing regime will be more successful.

Objective 3A: Reduce canopy height during the basal rosette stage for SCT (November-April) from the baseline level to a level that enables SCT plants to complete their lifecycle (0.5m or less) by 2015.

Objective 3B: Reduce the cover of non-native species in the coastal prairie from the baseline level to one more representative of a reference functioning coastal prairie system by 2020.

The canopy height of all vegetation will be measured during peak production in April/May as part of the baseline assessment in the initial year of monitoring at Arana Gulch (section 3.7). In 2012, canopy height in un-mowed parts of the central terrace appeared to exceed 5 feet (pers. ob), but the qualitative assessment will be conducted in 2013. Grazing would be expected to significantly decrease canopy height overall, ideally to a level that is less than the average stature of SCT (0.5m from Kiel 1993). Shifts in vegetation composition in response to grazing at Arana Gulch are difficult to predict.. In 2001 and 2002, Bainbridge (2003) found that native species comprised <10% cover in un-treated plots. At Arana Gulch, grazing was not one of the treatments she applied, so there is no estimate of vegetation response to grazing available for the site. It is difficult to define a realistic % reduction target since there is no data yet available and reducing non-native cover in grasslands is notoriously difficult and may take many years. A date of 2020 to meet these interim success criteria is somewhat arbitrary and should be revisited by the AMWG as more data becomes available.

Objective 3B: Cover of native perennial grasses increases from baseline levels to one more representative of a reference intact coastal prairie system.

Objective 3C: increases cover of native species from baseline levels to one more representative of a reference functioning coastal prairie system by 2020.

Objective 3D: Increase native species richness from baseline levels to one more representative of a reference functioning coastal prairie system by 2020

In the study mentioned above, Bainbridge (2003) found that native perennial forbs had <0.1% cover and did not find any native annuals at all, while native perennial grasses constituted almost all of the native vegetative cover in un-treated plots at Arana Gulch (<10%) In 2012, it appeared that natives may currently account for less than 1% of vegetation across the site, represented only by a few patches of California oatgrass and purple needle grass. Simply increasing the cover of these two species of native perennial grasses will not necessarily improve habitat for SCT and may even make conditions less favorable. Therefore, it is important to increase species richness of all guilds of natives. Again, the date of 2020 is somewhat arbitrary and should be adjusted as more data becomes available.

Objective 3E: Increase the cover of bare ground in the coastal prairie from the baseline level to a level that enables SCT plants to complete their lifecycle by 2015.

Opening up bare ground for SCT recruitment is an important component of both thatch and canopy height reductions. Because bare ground is simple to measure and easier to foster than shifts in vegetation composition, it is included as a separate objectives with a short term time frame.

Goal 4: Maintain a genetically and demographically viable soil seed bank in perpetuity.

SCT is an annual plant and therefore it is the size of the seed bank and its attendant dynamics that will determine the ability of the species to persist.

Objective 4A: Increase the density of viable ray achenes in the soil seed bank from baseline levels in the first three years and then assessed every five years.

Survivorship of seed in the seed bank is a result of many interacting factors including death from predation, pathogens, or drought stress. Persistence of the seed bank over time involves even more factors. Bainbridge (2003) was able to estimate the growth rate of the soil seed bank at select sample sites using demographic measurements of reproductive input, germination, survivorship, seed mortality, and seed bank density. Measuring these attributes of the soil seed bank is notoriously difficult and time consuming. While any or all of these could be addressed in a research project the most direct measurement of the condition of the soil seed bank is to estimate seed density from soil samples using a float and sieve method. While this metric still requires specialized expertise, it is comparatively simple and inexpensive to implement. The baseline value will be assessed in the initial monitoring in 2014.

3.6.3 Biological monitoring schedule

The set of biological variables that will be measured is fairly concentrated (Table 3.3). Data collection for the vegetation variables depends on the rate of phenological development over the growing season and must occur within the specified time frames. The data for SCT must be collected when the plant is in full flower at the end of the summer in August/September. The RDM data must be collected at the very end of the growing season just prior to the first rains which generally occur in mid to late October. In contrast, the cover, and guild composition data for the coastal prairie grassland must be collected during peak growth when species are fruiting and can be identified, usually in March/April. In most cases, the entity responsible for monitoring will be an AMWG recommended consulting biologist, who will monitor phenological development and collect data at the appropriate time. Photo monitoring related to vegetation variables also needs to occur within the proper window.

Table 3.3 The biological variables included in the baseline assessment and monitoring plan for the Coastal Prairie/ Tarplant Management Area.

Objective	Variable	measurement frequency	Desired direction of change	Interim target date
1A	# of aboveground SCT plants	yearly in Aug/Sept	increase	2014
1B	distribution of SCT plants	yearly in Aug/Sept	expansion	2017
2A.1	Observation of feed and water troughs	3x during grazing	stable	2015
2A.2	BMP implementation monitoring	3x during grazing	stable	2015
2B.	residual dry matter (RDM)	yearly in Sept/Oct	maintain within range	2017
3A	Average canopy height	3x during growing season	reduction	2015
3B	percent cover of non-native plants	Yearly at peak growth in April	reduction	2020
3C	percent cover of native plants	Yearly at peak growth in April	increase	2020
3D	Native species richness	Yearly at peak growth in April	increase	2020
3E	% bareground	3x during growing season	Increase	2015
Goal 3	Permanent photo points with GPS location and compass direction	Before, during and post construction and then yearly at peak growth	improving	2015
4	Seed bank density (# of viable ray achenes)	yearly	increase	2015

Timing is less important for the non-vegetative variables. Observation of the grazing program implementation can occur at any time during the grazing season, so long as there is sufficient frequency (3 times). Measurements of average vegetation height and bareground can be taken at the same time. If any negative impacts from the grazing operation are detected during the qualitative observations of feed and water trough locations, and further BMP implementation monitoring is required, the needed erosion and water quality measurements will be made by a qualified erosion control specialist. A specialist is also initially required to design an experimental sampling regime to measure the seed bank density. Sampling can occur at anytime during the year. After the design phase, one training session may be all that is required to transfer the responsibility to the biologist. However, assessing the viability of SCT seed requires the additional step of dissecting out the embryo of the seed in a lab and would likely be done at UC Berkeley.

3.6.4 Management goals, objectives, and schedule

The first SCT Management Plan included a set of 5 directives intended to guide the management program. Section 3.3.2 describes how the City implemented these directives during the period from 2006 to 2012. However, an adaptive management framework was not in place. In addition, the directive to conduct a "semi-annual mowing regime with phytomass removal" does not appear to have benefitted SCT or the coastal prairie as it was implemented over those 7 years. Likewise, it has proved difficult to interpret how to implement the directive to develop "surgical and catastrophic management actions". Both of those directives were based on a seven year cycle and the postulated longevity of SCT seed in the soil seed bank for 7 years. Since the longevity of SCT in the soil seed bank is in fact unknown and the ecological concepts behind those directives are not clear, those two directives have been dropped from inclusion in the Management Goals and Objectives. Elements from the other directives are presented here as management Goals and Objectives.

Goal 1: Maintain an adaptive management framework that allows stakeholders to scientifically conduct and evaluate actions.

An adaptive management framework allows the AMWG to address all members' concerns and objections directly, seek necessary permissions, and demonstrate the objective nature of scientific inquiry. Most importantly, a standard of straightforward communication builds trust among members as they cooperate to advise the City on implementation of the HMP in a way that protects and enhances the resources on site. As described in section 6.0, the City of Santa Cruz City has committed long-term funding to support the SCT adaptive management process.

Objective 1A: Conduct at least 3 AMWG meetings in 2013 with a quorum of members present each time. In subsequent years, the frequency of meetings beyond an annual November meeting can be determined by the needs of the AMWG.

The AMWG first convened in April, 2013 and held a second meeting in July. An annual meeting in November is recommended to receive the annual Monitoring Report and prioritize management recommendations for the Grazing Program and the upcoming year. A quorum of members include 6 of the 9 members: one representative from the City, the

Facilitator, two representatives from the 3 regulatory agencies (CCC, USFWS, CDFW), and 2 technical advisors.

Objective 1.B: Maintain funding levels to achieve a level of habitat management:

1) **that is indefinitely sustainable into the future, and**
2) **shows a stable or increasing trend in measured biological variables over a biologically appropriate timescale.**

The City of Santa Cruz City has committed long-term funding to support the SCT adaptive management process at Arana Gulch. The City will strive to maintain an appropriate level of funding to sustain a level of habitat management that achieves the biological goals discussed above.

Goal 2: Conduct a two-tracked program of management and research with built-in monitoring.

As the AMWG does its job providing recommendations to the City on the implementation of this HMP at Arana Gulch, it could choose one of two pathways to evaluate the effects of the resulting management action: a Management Track or a Research Track.

The Management Track uses some form of status and trend monitoring to assess success or failure in meeting HMP goals and objectives. The monitoring program is designed to gather data that will be subjected to trend analysis and evaluation to determine the direction of change in existing conditions over time. Status and trend monitoring does not establish cause and effect and its statistical power must be appropriately evaluated to give the AMWG a clear understanding of the degree of uncertainty associated with the measured parameters. The advantage of this type of monitoring is that usually the data can be collected quickly and with relatively low cost.

The Research Track requires an experimental design, with replication and controls, and generally utilizes cause and effect monitoring to test hypotheses. It attempts to fill very specific data gaps by measuring the response of a suite of variables to an experimental manipulation. While a research project could use status and trend monitoring methods, a well-designed experiment with appropriate controls, replications and statistical power can provide the best management guidance, but it is very specialized, time-consuming, and relatively expensive. Although the research track is usually a much more costly program, the benefit is delivered in the form of increased certainty regarding the response of the system to the applied treatments.

Initial implementation of the HMP at Arana Gulch will focus on implementation of the Grazing Program. If the grazing program does not result in the desired biological outcomes within an appropriate timescale then it may be necessary to develop a research program to address specific goals and objectives of this HMP. A 1

Objective 2A: Maintain a Management Track that leads to stable or increasing trend in measured biological variables over a biologically appropriate timescale.

The Management Track leads to faster feedback than a research track and at a lower cost. Although simpler to execute than the Research Track, the monitoring programs for this track still must be designed by qualified consultants or academics and evaluated by science-trained members of the AMWG to insure that the data will inform the goals and objectives of the HMP.

Objective 2B: Utilize a Key Management Question (KMQ) framework to guide the Research Track when research is needed to achieve the specific goals and objectives for SCT and the coastal prairie.

Because of the higher costs, it is especially important to keep research on a targeted track. At Arana Gulch this means conducting research that helps achieve the specific goals and objectives of this HMP. This is a challenge best met through the development of Key Management Questions (KMQs). Given the goals and objectives presented for each Management Area in this HMP, AWMG members will be asked to submit what they consider to be reasonable questions that could be addressed by a modest research program. Once a spectrum of questions is assembled it will be necessary to distill the academic questions down to a small number of KMQs (6 or fewer). The "acid-test" for selected KMQs is to assume the role of a manager and say: "If I knew the answer to that question, then I would know to take action X (or not take action X)". Therefore, KMQs are "need-to-know" research questions. Other "nice-to-know" research questions, however interesting, would not be included under the Habitat Management Plan. With a sound KMQ framework in place at Arana Gulch, no science will be done unless it can be related to achieving the specific goals and objectives of the HMP. When necessary, this type of research-oriented monitoring will be designed by qualified consultants or academics and evaluated by science-trained members of the AMWG.

Goal 3: Develop public educational opportunities associated with Arana Gulch and efforts to conserve and restore its rare resources.

The City of Santa Cruz is developing a full-scale Public Access Management Plan that describes all aspects of public access including interpretative displays, facilities, and educational programs. While the City will develop the necessary educational materials, the AMWG may provide recommendations to the City of Santa Cruz Parks on ways to effectively communicate its efforts to manage and restore the SCT population and its coastal prairie habitat at Arana Gulch to the public. Having a website available in advance of construction of grazing fences (and multi-use trails) will simplify and streamline public outreach. It will be necessary to communicate all aspects of the grazing program and make the public aware of the efforts to restore conditions at Arana Gulch

Objective 3A: Maintain a website to communicate restoration efforts to the public and provide a place for documents related to the requirements of the CDP, such as the Monitoring Reports.

The website is intended to be the information conduit between the AMWG and the public and therefore, the AMWG will need to decide what information to share and how to deal with public comment. A template outlining what information will be provided and on what schedule will simplify the process of regularly updating the website. The group could decide to provide information ranging from the entire annual report furnished to the CCC to bulleted lists of actions and results. Public comment could be extensive at various points in the construction process and especially in the initial phase of grazing, and anticipating and addressing the information needs of the public upfront will expedite the process of dealing with public comment. An interactive public reporting form similar to the Bike Hazard reporting form of the Santa Cruz County RTC could be used to report breaks in the fences or other issues. Signs and interpretative panels posted at the site with the web address would give the public access to information and alert them to the adaptive management process.

The AMWG will assess progress in meeting management objectives on a simple schedule. The number of yearly AMWG meetings, the level of participation, the funding level, and website maintenance will be assessed annually at the November AMWG meeting. Reporting requirements will also be assessed on a yearly basis along with the progress in developing Key Management Questions to guide the research track.

3.7 2013 Summer Baseline Assessment

This monitoring plan is designed to assess progress in the implementation of the Habitat Management Plan in the Coastal Prairie/Tarplant Management Area. More specifically, it is designed to address the specific goals, objectives, and interim success criteria described in section 3.6. The purpose and justification (3.7.1) are followed by the field sample design (3.7.2) and expected data analysis and reporting (3.7.3). The measured biological variables and management metrics that are tied directly to the Goals and Objectives are incorporated into a single table.

3.7.1 Purpose and justification

The purpose of the 2013 summer baseline assessment in the coastal prairie is to establish baseline vegetation and ground cover conditions in areas within the Coastal Prairie Management Area that will be grazed under guidance of the Grazing Program specified in the Arana Gulch Habitat Management Plan. This baseline will allow quantitative evaluation of the efficacy of grazing to improve habitat conditions for the Santa Cruz tarplant and restore coastal prairie function.

These objectives do not set specific levels for measured variables and instead refer to representative reference sites. Sampling of reference sites is not included as part of this study. However, we obtained an unpublished study from Dr. Karen Holl (UCSC) (per the suggestion of Tim Hyland at the first AMWG meeting) called "Reference And Baseline Vegetation Sampling For Younger Lagoon Natural Reserve – Spring 2010" that includes recent data on vegetation conditions at 6 reference coastal prairie sites situated between Point Lobos and Davenport. Arana Gulch was excluded from the study because of low native cover compared to the rest of the sites. The AMWG can use these and other data from the literature to establish more specific achievable targets for Arana Gulch.

Also, we recognize that 2013 was not the best year to conduct a baseline assessment Precipitation was higher than normal in Nov. and Dec., 2012 and then much lower than normal the rest of the spring in 2013 (Table 3.4).

Table 3.4 Monthly rainfall (inches) at the Santa Cruz NOAA weather station in 2012 and 2013, including the 111 year average.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
111 yr MEAN	6.14	5.42	4.33	1.92	0.8	0.22	0.06	0.07	0.42	1.39	3.31	5.24	30.04
S.D.	4.13	3.94	3.05	1.86	1.05	0.36	0.3	0.19	0.96	1.42	2.78	3.97	9.55
2012	3.68	0.94	7.38	3.1	0.06	0.19	0.03	0.00	0.02	0.53	5.56	7.95	29.44
2013	0.9	0.31	1.45	0.93	0.02	0.16	0.03	0.00					3.8

While precipitation may have been erratic this last water year, Mediterranean climates are extremely variable from year to year. Construction in slated to begin in fall 2013 and so it is necessary to get data from at least one baseline year before construction begins. If construction is delayed, a second year of baseline data can be obtained, more quickly and at a lower cost in 2014.

3.7.2 Field sample design

The map of the approved Arana Gulch multi-use trail alignment including grazing structures, the locations of Santa Cruz tarplant areas A-D, and the seasonal wetlands is Figure 3-4, found on page 49 . Total area within grazing enclosures is about 18.75 acres or 8.4 hectares divided among the grazing enclosures as follows:

Area A = 651,763 sq ft or 15 acres (6 ha)
Area C = 177,340 sq ft or 4.1 acres (1.6 ha)
Area D=92,269 sq ft or 2.1 acres (0.9 ha)

Satellite imagery and GPS were used to identify locations of 25m transect locations: 8 in A, 6 in C, and 4 in D (Figure 3.10). Once the starting point for each 25m transect was located with GPS, a compass was used to limit the range of possible bearings for the transect in order to stay within uniform habitats and insure that there is at least a 5m buffer with future fence lines, existing dirt trails, or other features that should be avoided. Rebar fitted with plastic caps was installed at both ends of each 25 m transect. Each transect was photographed according to a standard method.

The point intercept method was used to assess changes in plant species cover or ground cover for each grazing area. This method uses a narrow diameter sampling pole or sampling pins, placed at systematic intervals along line transects to sample within plot variation and quantify statistically valid changes in plant species cover and height over time. Plant species or ground cover classes that touch the pin are recorded as “hits” along a transect. Percent cover is calculated by dividing the number of hits for each plant species or ground cover class by the total number of points along a transect.

We recorded “hits” of each species encountered by the pole at every 0.5m for a total of 50 points per transect. The top species was identified at each point and every unique species was recorded once before we finally recorded a ground cover code (thatch, bare, gopher, basal vegetation, rock). The average height of the vegetation was measured along the transect at the 6, 12 and 18 and 22 m points. Thatch depth was not recorded because it was impossible to tell residue from the previous year’s growth from senescent material from earlier in the growing season. We also conducted a search within 5m of the transect line on both sides and recorded presence of any plant species that was not hit on the transects.

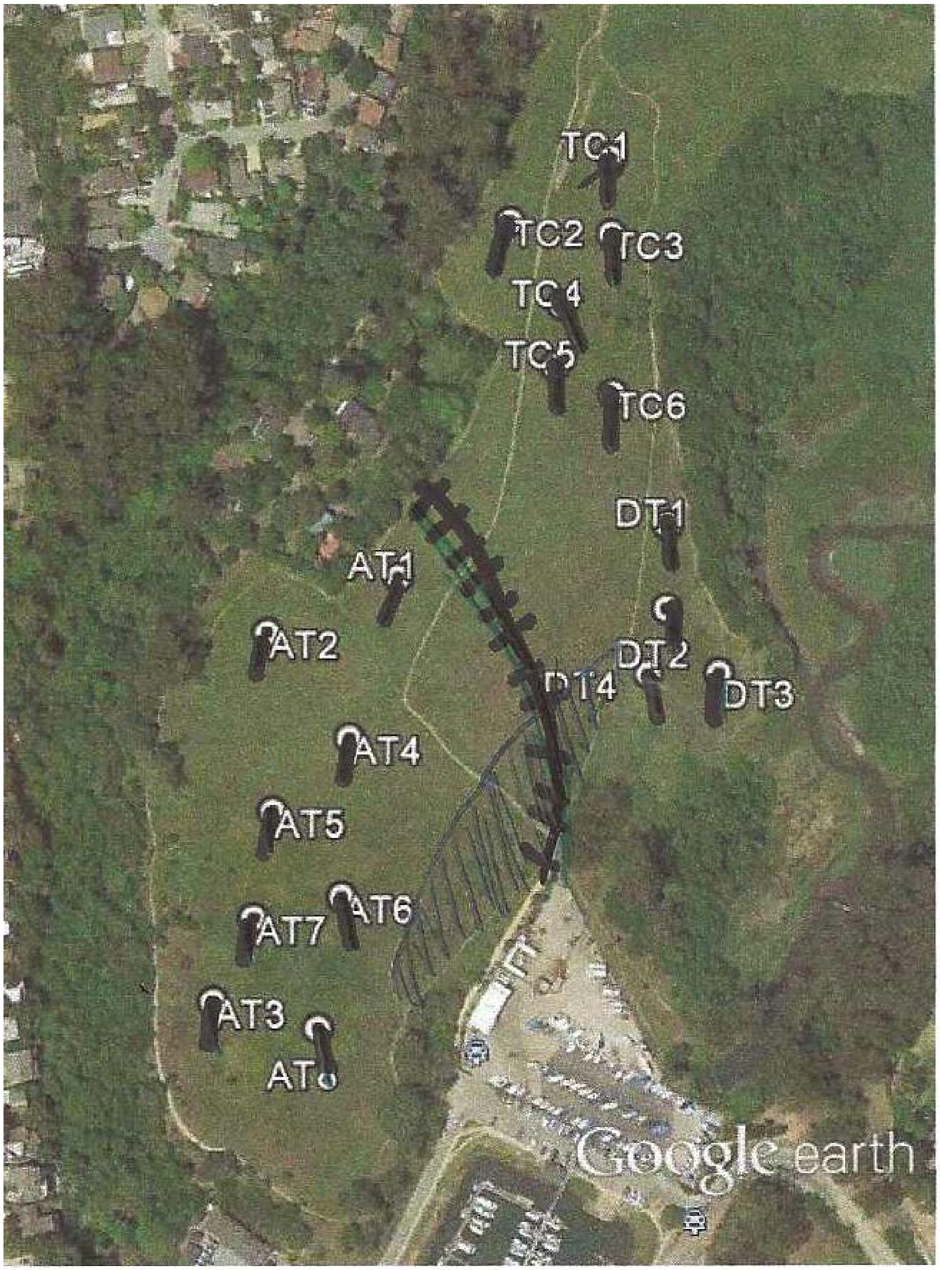

Figure 3.10 Map showing preliminary vegetation transects locations in Areas A, C, and D. The number of installed transects and the actual position is somewhat different.

3.7.3 Data analysis and reporting

The percent cover for each species on a transect is equal to the number of hits times 2. The transect is the sample unit and for each we will calculate % cover by species, total number of species, and the % ground cover of thatch, bare, gopher, basal vegetation, and rock. We will calculate average canopy height (cm) for each transect. We will report the means and standard deviation for each of these variables for each grazing enclosure.

In the field we conducted a power analysis using a statistical power calculator provided by DSS Research (http://www.dssresearch.com/toolkit/sscalc/size_a1.asp). This enabled us to test the power of our sample size and how much change we can detect. The tool allows one to enter the average cover and standard deviation values recorded in a macroplot to a fixed value that is 2.5 or 5% greater than that value. We assigned an 80% power level (β = 0.2) and α = 0.1. A power analysis on the first round of data collection indicated that three additional transects were needed in Area A, but that 5 transects in Area C and 4 transects in Area D If were sufficient.

A summary report with methods, site map, GPS coordinates, photos, datasheets, and summary data tables will be developed to be included in the Year 1 report for CCC. Results will also be grouped by guilds: (exotic/native, perennial/annual, forb/grass).

4.0 Hagemann Gulch Riparian Woodland Management Area

This section of the Habitat Management Plan is devoted to the Hagemann Gulch Riparian Woodland, the smallest of the three Management Areas. The steep 3-acre canyon features a mix of riparian trees and scrub extending along the southwestern boundary of Arana Gulch. This section includes the required elements of the Habitat Management Plan as directed in the Coastal Development Permit conditions that will allow for the restoration, enhancement, and management of the natural resources of Hagemann Gulch. The Baseline Assessment (4.1) includes a qualitative description of current conditions including the physical conditions (4.1.1), the existing riparian vegetation (4.1.2), wildlife habitat (4.1.3), non-native invasive plants (4.1.4), accessibility (4.1.5) and cultural resources (4.1.6). The conceptual model (4.2) for Hagemann Gulch visually illustrates the relationships between direct and indirect threats to the three main conservation targets for the management area and identifies strategies focused on elements that were identified as high priority in the Arana Gulch Master Plan. The Monitoring Plan (4.3) presents goals and objectives (4.3.1) and includes interim success criteria for the first year of implementation. Photo monitoring (4.3.2) is discussed as the primary monitoring tool to measure success toward reaching the specified goals.

4.1 Baseline Conditions

The Hagemann Gulch Riparian Woodland is the 3-acre wooded canyon that extends for approximately 1,200 feet along the southwestern boundary of Arana Gulch. A seasonal drainage is located at the bottom of the steep canyon which is covered by a dense canopy of trees and scrub. Riparian scrub and woodland occurs on the lower slopes while the upper slope is comprised primarily of coast live oak woodland. The upper slope is choked with poison oak *(Toxicodendron diversilobum),* Himalayan blackberry (*Rubus armeniacus* formerly *R. discolor*), and Englishy ivy (Hedera helix). At present, the combination of steep terrain and dense poisonous vegetation renders Hagemann Gulch largely inaccessible.

This inaccessibility limits our ability to conduct a quantitative baseline assessment. The descriptions of the physical conditions, riparian scrub and oak woodland, and potential wildlife habitat are largely derived from environmental assessment documents based on past surveys including; Habitat Restoration Group (1996a); Biotic Resources Group (1999) Bland and Associates (1999), and EcoSystems West (2005).

While a quantitative assessment might be desirable, a qualitative approach, particularly of the status of invasive plants (5.1.4), can provide a level of detail commensurate with the initial goals and objectives for the management area. Qualitative monitoring with photopoints, achieved through a series of photographs taken before, during, and after the multi-use trail development, can effectively document changes in vegetation and other site conditions over time. More detail on using photopoints is provided in the monitoring plan.

4.1.1 Physical conditions

Hagemann Gulch extends north of the Arana Gulch property boundary for approximately 600 feet. The canyon is situated within the Arana Gulch watershed and receives seasonal drainage from approximately 66-acres, including 50 acres of urbanized area (primarily of residential, commercial and light industrial uses) and approximately 16 acres of open space or undeveloped land. The runoff follows two separate drainage courses that converge on the Arana Gulch site. Both drainage courses receive intermittent flows from several of the City's storm drain outlets connected to the system in the adjacent neighborhoods. Stream flow is highly variable and dependent primarily on rainfall and groundwater conditions. Storm water from Hagemann Gulch flows into the Upper Santa Cruz Harbor.

Historic stream flow data is not available for Hagemann Gulch. In 1998, the Coastal Watershed Council conducted limited monitoring of the intermittent drainage (summarized by Balance Hydrologics 2002). Measurements were made throughout the year of water temperature, dissolved oxygen, turbidity, specific conductance, and pH. In general, the results indicated that water quality in Hagemann Gulch was within specified objectives. However, storm events can flush sediment and pollutants commonly found in urban runoff such as heavy metals, hydrocarbons, persistent pesticides, and pathogens. To date, no testing has been conducted to measure these specific parameters.

Based on the Soil Survey of Santa Cruz County (USDA, 1979) the predominant soil type encountered at Hagemann Gulch is the Elkhorn sandy loam. This soil is very deep and well-drained. Although permeability and runoff is moderately slow on gentle slopes, on the steeper slopes (over 9 percent) present along the gulch, runoff potential is rapid and erosion hazard is high.

4.1.2 Riparian Scrub and Oak Woodland

Riparian scrub occupies the narrow bottom of Hagemann Gulch and extends onto the lower slopes. This habitat type is dominated by willows, of which arroyo willow (*Salix lasiolepis*) is the most abundant. Other species include Pacific willow (*Salix lucida* ssp. *lasiandra*) and red willow (*Salix laevigata*). Box elder (*Acer negundo* var. *californicum*) is locally dominant and the large riparian shrub American dogwood (*Cornus sericea*) is also a common associate. Non-native trees such as poplar (*Poplar sp.*) and blue gum eucalyptus (*Eucalyptus globulus*) are also found in the canyon.

The riparian scrub in Hagemann Gulch may be classified as arroyo willow thicket (CDFG 2010 or the coast arroyo willow riparian forest of Holland (1986). This habitat type is recognized as a special status natural community (CDFG 2010). Most riparian and wetland communities are special status in California because of their limited distribution and potential vulnerability to impacts from projects. However, the riparian scrub in Hagemann Gulch is mostly very dense and impenetrable with an understory dominated by the invasive, non-native woody vine Himalayan blackberry (*Rubus armeniacus* formerly *R. discolor*) that has degraded the habitat quality (Photo 14).

Riparian oak woodland is found along the upper eastern slope of Hagemann Gulch where coast live oak *(Quercus agrifolia)* dominates the tree canopy. California bay *(Umbellularia californica)* and non-native trees such as blue gum eucalyptus and Monterey pine (*Pinus radiata*) have spread into the native oak woodland from nearby plantings. The native component of the understory is dominated by poison oak *(Toxicodendron diversilobum)* with some California blackberry *(Rubus ursinus). N*on-native invasive species like English ivy *(Hedera helix),* Himalaya blackberry, and French broom (Genista *monspessulana*) contribute the majority of cover. Other less prevalent components include the escaped ornamental Japanese honeysuckle (*Lonicera japonica*) and a sprawling ground cover of bedstraw (*Galium sp.).* Most of this habitat is dense and impenetrable and the infestation of non-native plants has degraded the habitat quality. In addition, an accumulated thatch of dead woody material increases fire hazard in the area.

4.1.3 Wildlife habitat

Factors affecting the value of riparian scrub and woodland habitat to wildlife include the extent of protective cover, complexity of vegetation, the proximity of existing development, the potential for disturbance by humans and their pets, and the degree of infestation of non-native species. Riparian drainages like Hagemann Gulch may serve as movement corridors for larger wildlife species, such as deer, raccoon, bobcat, and gray fox, particularly where dense growth provides protective cover. Riparian oak woodland habitat provides nourishment and shelter for many of the resident wildlife. Fox, squirrels, and other mammal and bird species, utilize the oak tree's acorns as a food source while mature oak trees contain natural cavities used by small animals for nesting. Snags (i.e. standing, dead trees) offer a place for woodpeckers to excavate roost and nest sites. Subsequently, those sites are then occupied by secondary cavity nesting birds such as tree swallows and owls. This riparian scrub/woodland may also be utilized for nesting by raptors.

A number of special-status wildlife species are known or suspected from Hagemann Gulch including the California red-legged frog, several species of birds and bats, and the San

Francisco dusky-footed woodrat. Most recently, EcoSystems West (2005) completed reconnaissance-level field visits focusing on evaluating the habitat conditions and potential for these species to occur at Arana Gulch.

That study determined that the California red-legged frog is not likely to occur in Hagemann Gulch or around the bridge alignment crossing, due to the absence of suitable breeding habitat and isolation from watersheds known to support the species. An active red-tailed hawk nest was observed in a grove of eucalyptus trees approximately 300 feet north of the proposed bridge crossing. Although the red-tailed hawk is not considered a special-status species, the destruction of active nests is prohibited without federal and/or State authorization.

In the same vicinity, in the drainage below the proposed bridge alignment, a nest of the San Francisco dusky-footed woodrat was found. The California Department of Fish and Game considers the San Francisco dusky-footed woodrat a "Species of Special Concern." This unique woodrat species is about the size of an adult cat and builds stick nests on the ground or in hollow trees. Woodrat lodges may range in size from 3 to 8 feet across at the base and up to 6 feet tall (Photo 15). Colonies of 3 to 15 or more lodges may occur together in the same area. Multiple generations of woodrat may use the nests and may colonize and recolonize them over a span of 20 to 30 years. Their complex social structure makes them vulnerable to disturbance.

Although trees with potential roost features for bats (e.g., exfoliating bark, broken limbs, and crevices) were observed along Hagemann Gulch, the only special-status species that was detected (the western red bat) was found near the east side of Arana Gulch Creek (EcoSystems West 2005). Several common species of bats were also detected including the big brown bat (*Eptesicus fuscus*) and the Mexican free-tailed bat (*Taderida braziliarensis*).

4.1.4 Non-native invasive plants

Non-native invasive plants currently pose one of the greatest threats to the riparian habitat in Hagemann Gulch. Observations in 2012 suggest that Himalayan blackberry, English ivy, and French broom have displaced most of the native understory with the exception of native poison oak, which is still thriving. While these non-native species may provide cover for wildlife or food sources, they are a poor functional replacement for a diverse native riparian forest. In addition, the spreading growth forms of the vines can carry a fire into the canopy and the woody accumulations of shrubs and dead blackberry canes increase fuel loads and contribute to an increased fire risk (Photo 16). Unfortunately, each of these species is difficult to control and the presence of toxic poison oak further complicates removal. Some aspects of these species biology and ecology that may inform the selection of control options are briefly discussed.

The scrambling habit of blackberry smothers existing plant growth and the tangled mass of thorny stems blocks access of humans, livestock, equipment, and vehicles. Many animal species feed on blackberries and easily spread seeds from one area to another in their droppings. Seeds have a hard seed coat and can remain dormant in the soil for an extended period. Once seeds germinate and plants become established, expansion of a blackberry thicket is almost entirely a result of vegetative growth from rhizomes. Woody canes arise from a central crown or from buds that form along rhizomes. Although first-year canes don't produce flowers, the canes fruit and die in the second year. Tips of first-year canes that contact the ground form roots at the nodes, contributing to the lateral expansion of the plant. This ability to regenerate from the crown or rhizomes following mowing, burning, or herbicide treatment makes blackberry very difficult to control. Over time a single plant can cover a very large area and can live for 25 years or longer.

English ivy has many traits in common with blackberry. It also spreads locally through vigorous vegetative growth and smothers and inhibits regeneration of native species. New plants can grow from cut or broken pieces of stems that are able to root in the soil. English ivy seeds also have a hard coat that allows them to persist in the soil and they may be dispersed longer distances by birds or other animals. The vines also persist a long time, with one vine reported living for 433 years (Putz and Mooney 1991).

French broom is a nitrogen fixing shrub that can grow up to 10 feet tall. It becomes reproductive after two to three years, on reaching a height of one and a half to two feet. It flowers from March-July on the coast and produces copious amounts of long-lived seeds that have been known to survive at least five years in soil (Hoshovsky 1995). Plants can re-sprout from the root crown after cutting. Once seedlings are taller than approximately eight inches, their rate of re-sprouting after cutting can be over 90 percent, particularly if cut in the rainy season (C. Bossard unpubl. data).

Manual, mechanical and chemical control methods are effective in removing and killing all three of these species. Employing a combination of methods often yields the best results and may reduce potential impacts to native plants, animals and people. However, herbicide use is prohibited in the City of Santa Cruz.

Perennial weeds usually require several cuttings through manual or mechanical means before underground plant parts exhaust their reserve food supply. If only a single cutting can be made, the best time is when plants begin to flower. At this stage the reserve food supply in the roots has been nearly exhausted, and new seeds have not yet been produced.

After cutting or chopping with mechanical equipment, all of these species may re-sprout in greater density if not treated. Re-growth may by controlled by further mechanical control or by grazing or fire.

Given the steep terrain and dense poisonous vegetation present at Hagmann Gulch, grazing with goats may offer an excellent control option. Goats work well in areas where steep slopes, existing trees, and other site features limit access by machinery. Goats do not compact the soil and are low impact on areas that include wetlands and streams. They prefer woody vegetation over most grasses or forbs, so goats will eat most problematic weeds including Himalayan blackberry, English ivy, knotweed, thistle and Scotch broom. For instance, blackberry is readily eaten by goats throughout the year, even when there is an abundant supply of other plants (Amor 1974). Poison oak poses no threat to goats. Since goats will trample or browse virtually any vegetation within a fenced area, any desirable trees or shrubs must be protected. Because goats do not grub out root systems, follow-up treatment across multiple years is still necessary for most weed problems. In western Washington, a herd of 60 goats can eat about ¼ an acre infestation in 3 to 5 days (www.rentaruminant.com accessed on October 15, 2012).

4.1.5 Accessibility

A central goal of the mutli-use trail development at Arana Gulch is to provide a new entrance to the open space and increase accessibility within the trail system. At present, the steep terrain and dense vegetation throughout Hagemann Gulch renders it inaccessible and the canyon constitutes a barrier between the Arana Gulch open space and the neighborhoods to the west (Photo 17). The planned multi-use trails and new bridge spanning Hagemann Gulch will provide an entrance and trail connection to Arana Gulch from the Seabright neighborhood. Access to the Canyon Trail entrance to Arana Gulch will be from the end of Broadway Avenue along a strip of property owned by the City of Santa Cruz. The multi-use trail will extend approximately 450 feet in length before connecting with the Hagemann Gulch bridge. On the east side of Hagemann Gulch, the trail will continue across the coastal prairie and connect with other multi-use trails, including the Coastal Prairie Loop Trail, a pedestrian trail encircling the meadow.

The Hagemann Gulch bridge has been designed to minimize impacts to native heritage trees and avoid substantial disturbance to the canyon. The stress-ribbon bridge design extends approximately 330 feet in length and utilizes cables anchored in abutments located at each end of the bridge to avoid the need for structural supports within the steep canyon. This bridge will offer an interpretive overlook into the canyon and tree canopy, but will not provide access into the gulch.

4.1.6 Cultural Resources

Although no historic structures exist within Arana Gulch, a hedgerow of historic roses continues to thrive along the top of the east side of Hagemann Gulch near SCT area B (Photo 18). These "Rose of Castile" roses were originally brought from Spain to all of the Spanish colonies during the settlement period. The roses found at Arana Gulch are believed to be over 150 years old and may be from cuttings taken from the Mission Santa Cruz grounds. Although hedges of the "Roses of Castile" would have been common throughout Santa Cruz County during the Mission period, these roses at Arana Gulch are the only apparent remnants, potentially making them the oldest roses in the City of Santa Cruz. The City Parks and Recreation Department protects the roses and prohibits unauthorized cuttings.

4.2 Monitoring Plan

The monitoring plan is designed to assess progress in meeting specified goals and interim success criteria. The first step is the presentation of a simple conceptual model (4.2.1) that illustrates the direct and indirect threats to the conservation targets and identifies feasible management strategies. Next, the goals and interim success criteria (4.2.2) address the identified management strategies. Photomonitoring (4.2.3) is the primary monitoring tool that is recommended for Hagemann Gulch and the schedule and implementation procedures are described.

4.2.1 A conceptual model for Hagemann Gulch

An initial step in the adaptive management process presented in Section 2.0 involves identifying the key factors that influence each of the management areas and developing a conceptual model that visually illustrates the relationships between direct threats to the conservation targets and the important indirect factors that influence those direct effects. A simple conceptual model for the Hagemann Gulch Riparian Woodland Management Area is presented in Figure 4.1. As discussed in section 3.6.1, the model is purposefully simple to focus attention on those elements that were identified as high priority in the Master Plan and to limit the amount of data inputs and monitoring resources that are required to faithfully represent those components and their role in the ecological system.

In the conceptual model for Hagemann Gulch, the three main conservation targets identified in the Master Plan are the coastal riparian woodland habitat, sensitive wildlife species, and the Roses of Castille. The riparian oak woodland provides the habitat for the sensitive species that are known to occur in the gulch, none of which currently require any focused conservation measures. Consequently, protection and restoration of the riparian vegetation is the primary focus of this plan. The Roses of Castille occur outside of the riparian woodland and while they would be threatened by fire spreading out of the gulch, they can be protected independently.

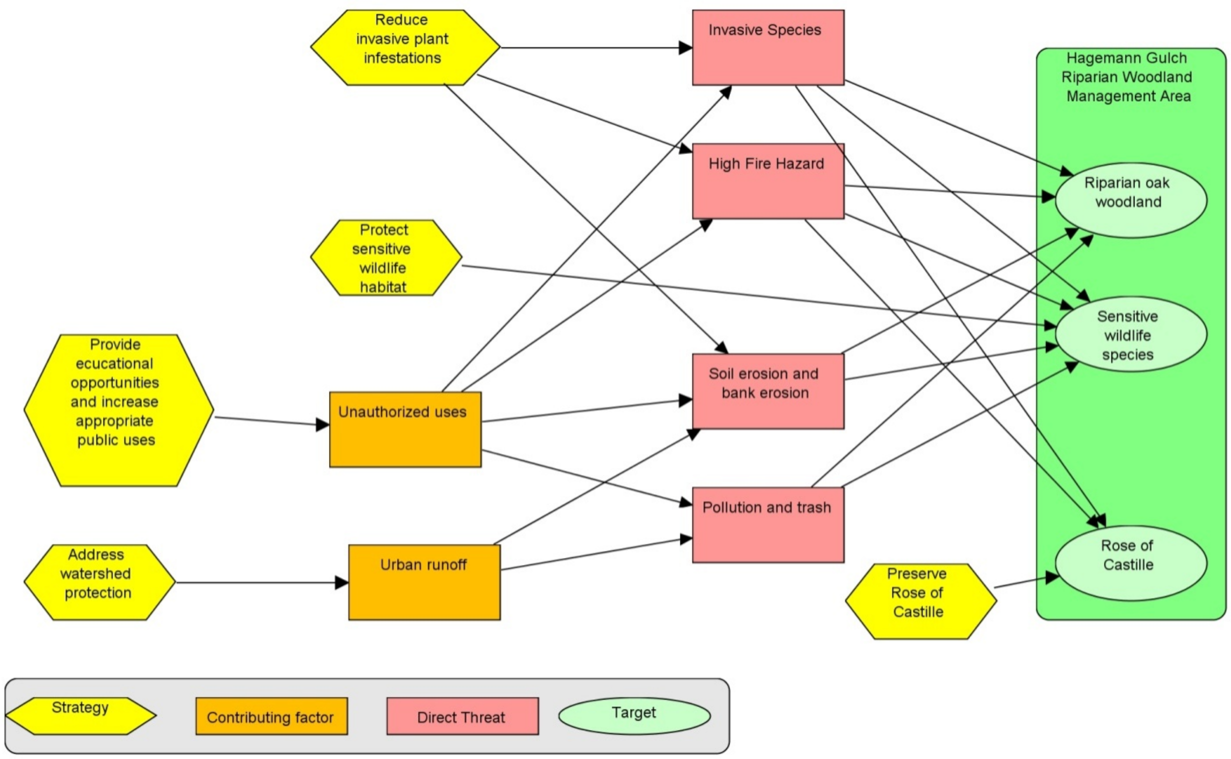

Figure 4.1 Conceptual model for the Hagemann Gulch Riparian Woodland Management Area at Arana Gulch.

Within the riparian oak woodland, the direct threats from invasive plants and high fire risk, as well as the contributing factor of unauthorized use in the area were identified in the Arana Gulch Master Plan as important factors. Additional threats from erosion, pollution and trash from urban runoff are general threats in most natural areas in urban settings. In addressing these threats, only a few select strategies that focus on on-site management at Hagemann Gulch are feasible options.

The strategy to reduce invasive plant infestations is the top priority for Hageman Gulch. Invasive plants limit access to such a great degree that it is almost impossible to collect quantitative baseline data on the species composition of the infestation or its full extent. Reducing the extent of blackberry thickets and poison oak is the first step in gaining a fuller assessment of additional restoration and enhancement needs. However, improper removal of vegetation can lead to soil erosion and an unintentional proliferation of the infestation and exposed soil can be more easily invaded by new suite of invasive plant species. This strategy requires additional objectives that address the need for regular monitoring and follow-up removal efforts.

As already mentioned, none of the sensitive species known to occur in the gulch currently require any focused conservation measures. However, the large scale clearing of poison oak and blackberry that is needed has the potential to damage SF dusky footed woodrat nests or bat habitat. A separate strategy to monitor and protect wildlife habitat features addresses the need to monitor these resources and account for potential impacts in the invasive plant removal strategy.

Providing educational opportunities and increasing appropriate public uses is a universal strategy of the management at Arana Gulch. The Public Access Management Plan (in development by the City of Santa Cruz) will address the required elements of the interpretative program, while the new trail construction and decommissioning of unauthorized trails during the development of the multi-use trail system will both concentrate and increase use across the site. An increase in the number of users has the potential to increase observation and reporting of illegal activities and may act as a deterrent to inappropriate uses. The installation of education kiosks further promotes authorized uses. This strategy was further addressed under coastal prairie and SCT management in section 3.6.2.

Finally, the general strategy to address watershed protection is included to highlight the connection between Hagemann Gulch and the surrounding urban development that provides an ongoing source of pollution, trash and potentially new invasive species propagules to the drainage. Addressing these threats requires a watershed approach with a significant investment in time and resources. Such off-site measures are beyond the scope of this Habitat Management Plan.

4.2.2Goals and Interim success criteria

This section of the Arana Gulch Habitat Management Plan develops goals and objectives for the five strategies currently identified for the Hagemann Gulch Riparian Woodland Management Area: 1) reduce the understory of non-native invasive plants, 2) reduce the fire hazard, 3) protect sensitive wildlife species, 4) increase appropriate uses, and 5) preserve the Roses of Castille. The goals are broad statements that set an overall direction for management and have been largely derived from the resource management guidelines presented in the Master Plan. The objectives are more specific and constitute the interim success criteria for implementation of this portion of the Habitat Management Plan in the near term. The development of such interim success criteria is a specific requirement of the

Coastal Development Permit conditions of approval. Monitoring results are tied directly to the annual reporting requirements (section 2.3.2).

The rationale behind each goal presented below is briefly explained. The objectives describe the variables that will be monitored and specify a desired direction of change. Compared to the concise objectives presented for the CPTMA, these objectives are less specific, but they still meet the criteria of being measureable over a particular time period. Through the process of monitoring and data evaluation, the AMWG may adjust objectives, and possibly goals, as necessary.

Goal 1: Seek funding to develop an integrated pest management (IPM) plan to reduce the understory of invasive non-native species in Hagemann Gulch.

Observations in 2012 identified the main target non-native invasive plants in the canyon as Himalayan blackberry, English ivy, and French broom. Unfortunately, each of these species is difficult to control and the steep terrain, high potential for soil erosion, and the presence of toxic poison oak further complicates the selection of removal options. Development of an Integrated Pest Management (IPM) plan will facilitate the selection of the proper combination of control methods. Because the target species are all capable of vigorous re-sprouting, vegetative growth, and/or prolific seed production, the selected control methods will require appropriate timing and follow-up monitoring to locate and kill re-sprouts and new seedlings. IPM offers flexibility to tailor the plan depending on the time, labor and other resources that are available.

Objective 1A: Use a combination of methods, to reduce the cover of non-native invasive woody plant thickets from baseline levels in the first year.

Detailed assessments of the cover or extent for each plant species is not needed to determine progress toward meeting the goal of reducing the non-native species understory. Rather, the amount of open space present in a photo can be quantified on a relative percent scale. Initially, cover will be measured using photopoints and placement will be limited to the top slope of the riparian woodland on the coastal prairie side of Hagemann Gulch. As removal efforts open up access, phototpoints locations can be moved inward.

Objective 1B: Monitor re-sprouting of removed vegetation and recruitment of new seedlings on a regular basis, for at least 5 years after initial removal efforts.

The timing of follow up monitoring is critical and will need to be assessed as part of the IPM approach. The biological characteristics of Himalayan blackberry, English ivy, and French broom require a longer follow-up period than some other species. A period of five years is offered as a basic starting point.

Objective 1C: If passive restoration is not adequately controlling erosion, use re-vegetation with appropriate native species or other cultural methods to limit the amount of exposed soil and the potential for re-infestation and erosion.

Re-vegetation with fast growing native species can help hold the soil in place and prevent erosion. As per the Coastal Development Permit (CDP) conditions of approval; "Any planting with seeds or container plants shall be made up exclusively of native taxa that are appropriate to the habitat and Arana Gulch region. Seed and/or vegetative propagules shall be obtained from local natural habitats so as to protect the genetic makeup of natural populations. Horticultural varieties shall not be used."

Goal 2: Reduce the fire hazard within Hagemann Gulch.

The perceived high fire risk in Hagemann Gulch is the result of the proliferation of shrubs like French broom along with an accumulation of woody vines such as blackberry that create an infrastructure of dead plant material. One concern is that these species function as ladder fuels that can carry fire into the canopy. Canopy fires are more intense than surface fires and pose a greater threat to the surrounding neighborhood and to the coastal prairie. Ideally, it is possible to target ladder fuels in invasive species removal efforts. However, the steep slopes in Hagemann Gulch functionally reduce the importance of the concept of ladder fuels because the canopy itself is continuous as the slope increases (i.e. the top of the canopy of a tree lower on the slope can be at the same level as the bottom of the canopy of a tree higher on the slope). Consequently, efforts to reduce the fire risk in Hagemann Gulch are best targeted at reducing the overall amount of biomass rather than altering forest structure.

Objective 2A: Reduce the cover of woody thickets as per Objective 1A to reduce the overall fire risk.

While fire risk reduction is a stated strategy for the management of Hagemann Gulch, initially it is best achieved indirectly through the reduction in fuel load that will result from the removal of woody plant thickets.

Objective 2B: Prioritize the removal of eucalyptus trees where feasible.

Eucalyptus trees contain volatile and highly flammable compounds in their leaves which accumulate on the ground and are resistant to decay from fungi and other microorganisms. The accumulated leaf litter makes an inhospitable environment for native plant recruitment and increases fire spread. Several very large eucalyptus trees are present on the top slope of the riparian woodland and the feasibility of their removal needs to be addressed in the IPM plan before a more specific objective can be developed. Removal of small trees and seedlings can help to reduce the eucalyptus infestation and contain expansion, but the continued presence of the large trees ensures an ongoing source of new propagules.

Goal 3: Protect wildlife habitat features in Hagemann Gulch.

Of the special-status wildlife species suspected to occur at Hagemann Gulch, only the San Francisco dusky-footed woodrat has been documented. Hagemann Gulch also supports trees with potential roost features for sensitive bat species, including the western red bat colony that was found near the east side of Arana Gulch Creek during surveys in 2005. Surveys and monitoring are not necessary within the entire Gulch and will be restricted to the bridge construction area and 25 m adjacent buffer area.

Objective 3A: The number of SF dusky footed woodrat nests occurring within 25m of the Hagemann Gulch bridge construction zone will be identified and the nests will be protected.

Documentation of woodrat nests will likely occur as part of pre- construction surveys. These can be marked and avoided during invasive plant removal. Reconnaissance level surveys can assess the status of nests on a periodic basis.

Objective 3B: Monitoring for sensitive birds and bat roosts and/or nests occuring within 25m of the Hagemann Gulch bridge construction zone will be identified and protected and continued for 3 to 5 years post-construction.

Reconnaissance level surveys for the nests of sensitive bird species and bat roosting can be combined with surveys for woodrat nests.

Goal 4: Increase appropriate uses in Hagemann Gulch.

Unauthorized trail use and illegal activities such as arson or vandalism could threaten investments in restoration improvements, public education kiosks, or the integrity or appeal of the Hagemann Gulch bridge. The goal to increase appropriate public uses is based on the assumption that an increase in the number of users at Arana Gulch that will occur as a result of the multi-use trail development will increase the number of opportunities to observe and report illegal activities. Thus, greater use of the site acts as a deterrent to unauthorized uses and the installation of education kiosks further promote appropriate uses.

Objective 4A: Observe the condition of all improvements at least four times per year in the first three years and at least twice per year, thereafter.

Observations can be timed at either regular intervals or to coincide with management events. This type of qualitative site level monitoring provides a record of appropriate and inappropriate uses over time that the AMWG can use to inform new improvements.

Goal 5: Preserve the "Rose of Castille" historic roses.

Construction of the Hagemann Gulch bridge will occur in the vicinity of the rose hedges. These roses are situated on the fence line of the property boundary on the periphery of the coastal prairie. Avoidance of the rose hedge during construction could be feasible. Ongoing preservation may be accomplished with education using interpretive panels developed as part of the Public Access Plan.

Objective 5A: Relocation of the roses will occur only if no other alternative is feasible for development of the Hagemann Gulch Bridge. Any relocation will be done in the vicinity of the existing roses, in consultation with the City Arborist.

Objective 5B: Address the public education benefits of identifying the Rose of Castille and providing interpretative panels.

Interpretive panels developed as part of the Public Access Plan may be an integral component of the long term preservation of the Rose of Castille. However, identifying any sensitive resource, especially a rose with attractive blooms, can pose a risk of exposing the resource to vandalism.

4.2.3 Monitoring schedule and implementation

While a quantitative approach to monitoring would be most desirable, the current extent of poison oak and impenetrability of the vegetation in Hagemann Gulch limits the ability to develop a quantitative baseline assessment or monitoring approach. Since there are no endangered species present in the riparian oak woodland and the initial protection and restoration needs of the habitat are largely defined by the need to reduce non-native invasive plants and the associated fire risk, the goals and objectives for the Hagemann Gulch Riparian Woodland Management Area are less detailed than those presented for the Coastal Prairie and Santa Cruz Tarplant Management Area. Therefore, a qualitative approach with photo point monitoring is initially sufficient to monitor changes in vegetation and other site conditions and can be extended over the long term.

The critical step in the implementation of the HMP for Hagemann Gulch will be obtaining funding to implement the proposed monitoring plan. Table 4.1 lists the variables that will be tracked for each of the objectives using photo point monitoring. The required frequency of measurement and the desired direction of change is specified for each interim success criteria. However, interim target dates are not provided due to the lack of certainty over obtaining funding to implement the monitoring program in Hagemann Gulch.

Table 4.1 The biological variables included in the baseline assessment and monitoring plan for the Hagemann Gulch Riparian and Woodland Management Area.

Objective	**Variable**	**measurement frequency**	**Desired direction of change**
1A/ 2A	non-native invasive woody plant cover	before and after every removal effort	decrease
1B	re-sprout and seedling emergence of target weeds	after every removal effort	decrease
1C	area of exposed soil (bare ground)	after every removal effort	decrease
2B.	area occupied by eucalyptus	after every removal effort	decrease
3A	number of SF dusky footed woodrat nests	yearly	stable
3B	sensitive bird or bat detections	yearly	increase
4A	observation of infrastructure condition	4x per year	stable
5A/B	presence of Rose of Castille	yearly in June/July	stable

5.0 Arana Gulch Creek Riparian and Wetland Management Area

This section of the Habitat Management Plan is devoted to the Arana Gulch Creek Riparian and Wetland Management Area. The area is located along the eastern side of the greenbelt and features the creek channel of Arana Creek and the associated riparian corridor and wetlands. This section includes the required elements of the Habitat Management Plan as directed in the Coastal Development Permit conditions that will allow for the restoration, enhancement, and management of the natural resources of Arana Creek. The Baseline Assessment (5.1) includes a qualitative description of current conditions including the characteristics of the watershed (5.1.1), Arana Creek (5.1.2), the riparian vegetation (5.1.3), the emergent wetland (5.1.4), wildlife habitat (5.1.5), and accessibility issues (5.1.6). As the baseline assessment makes clear, only a watershed approach will adequately address the pervasive erosion and sedimentation that is degrading the riparian and tidal system in Arana Gulch. Therefore a separate section (5.2) is devoted to the Arana Gulch Watershed Enhancement Plan that was developed in 2002 by Balance Hydrologics. Although 10 years old now, the plan represents the most comprehensive assessment of current stream and habitat conditions in the watershed and suggests recommendations for restoring it. The Monitoring Plan (5.3) includes a simple conceptual model (5.3.1) that illustrates the direct and indirect threats to the conservation targets. elements from the watershed plan and the Master Plan in the Goals and Objectives (5.4.1). The photo monitoring schedule and implementation completes the plan (5.4.2).

5.1 Baseline Conditions

The Arana Gulch Creek Riparian and Wetland Management Area is the 34.5 acres along the eastern side of the greenbelt property. It includes the lowest reach of Arana Gulch Creek, the riparian forest and scrub along the creek channel, and the adjacent emergent wetland. Qualitative descriptions of the watershed, Arana Creek, and the riparian scrub and wetland, and potential wildlife habitat are largely derived from the watershed enhancement plan (Balance Hydrologics 2002) and environmental assessment documents based on past surveys including; Habitat Restoration Group (1996); Bland and Associates (1999), Entrix (2004), and EcoSystems West (2005).

While quantitative elements of the baseline assessment will eventually be required, a qualitative approach can provide a level of detail commensurate with the goals and objectives for the management area. Qualitative monitoring with photopoints, achieved through a series of photographs taken before, during, and after the multi-use trail development, can effectively document changes in vegetation and other site conditions over time. More detail on using photopoints is provided in the monitoring plan.

5.1.1 Arana Gulch Watershed

Headwaters of Arana Gulch Creek begin in the foothills of the Santa Cruz Mountains at about 600 ft elevation. The upper watershed consists of three steep-walled drainage systems, comprising the eastern, central and western branch of Arana Gulch Creek. The three upper branches of the Creek flow southward through rural lands of Santa Cruz County before converging on the east side of the DeLaveaga Park and Golf Course north of Highway 1. Downstream of the confluence, the main branch of Arana Gulch Creek is channelized as it flows under Highway 1 and along the east side of Harbor High School where there is a sediment retention basin. The creek then flows through a culvert under Capitola Road before crossing the broader flood plain of the Arana Gulch greenbelt property and into the upper Santa Cruz Harbor.

The Arana Gulch Creek watershed drains an approximately 3.5-square-mile area. It is a critical source of recharge for the Santa Cruz and Soquel aquifers that supply drinking water for the resident community. This small watershed is considered an intrinsically sandy watershed because of the underlying sandstones and siltstones of the Purisima Formation and the unconsolidated terrace deposits that weather to sand and silt with very little gravel or cobble sized debris. Less than 10% of the bedload in the watershed is naturally occurring gravel (Balance Hydrologics 2002). Sandy watersheds pose particular challenges when it comes to restoration and enhancement because sand sized sediments tend to accumulate in pool and riffles and degrade habitat conditions for steelhead trout. This sedimentation is exacerbated by man-made disturbances and development within the watershed. The focus of enhancement efforts within an intrinsically sandy watershed is about limiting the amount of sand in the system.

5.1.2 Arana Gulch Creek

After entering the Arana Gulch property through a culvert under Capitola Road, the creek meanders along the eastern boundary southward toward the Santa Cruz Harbor. At the southern end, the creek flows through four large culverts (72-inch diameter) that extend 300 feet under the parking area to allow flow between Arana Creek and the Harbor (Photo 19). There the waters of Arana Creek become brackish from the blending of fresh water and the salt water tides of Monterey Bay.

The terminus of the Arana Creek watershed occurs on the floodplain of the Arana Gulch property where Arana Creek meets the sea. The floodplain covers approximately 21.6 acres. Thus, the conditions in this management area are the result of conditions in the upper watershed and conditions in the tidal zone. Streambank erosion is prevalent along the entire length of Arana Creek as it crosses the greenbelt property (Photo 20). Within the southern tidal reach, the stream banks have collapsed and there is substantial channel head cutting. Pools within the channel are generally shallow and filled with fine sediment. In addition, accelerated erosion of the hillslope below Agnes Street and Park Way South has resulted in a gully that is a large source of sediment directly to the tidal reach.

Previous studies (Harvey and Hecht, 1982) identified alterations in tidal action as the primary cause of bank instability and collapse. Lower Santa Cruz Harbor was developed in 1964 and the culverts were installed as part of the development of the Upper Harbor in the early 1970s. The culverts are approximately 2 feet below the natural grade of the original stream elevation. This man-made lowering of the base level of Arana Gulch Creek has likely disconnected it from its floodplain. Regular flooding and the associated sediment capture by the emergent wetlands no longer occur. Instead, fine particle sandy sediment accumulates in the creek and scours the streambank leading to channel incision and bank collapse in the tidal reach. However, during large storm events, the culverts result in ponding of storm water runoff within Arana Gulch which can increase erosion. Increasing sedimentation from the upper watershed is likely also contributing to channel widening.

Similar to other coastal watersheds within the Central Coast region, Arana Gulch Creek has historically provided habitat for fisheries, amphibians, and waterfowl. The brackish habitat provides nursery and transition zones for many species of anadromous fish, including steelhead, and also serves as a feeding ground for aquatic birds, like double-crested cormorant, egret, and great blue heron. The tidal reach and surrounding estuary also provide shelter for water birds during strong winter storms. However, the development of the Harbor and culverts and increasing development within the watershed has decreased habitat values for fisheries and other aquatic species within Arana Gulch. Now Arana Creek is considered substandard fisheries habitat compared to other coastal streams in Santa Cruz County.

Stream flow in Arana Gulch Creek is highly variable both seasonally and in response to rainfall events. The steep topography in the upper watershed, the low water holding capacity of the Purisima formation soils, and the high amount of impervious cover in the urbanized area create conditions where stream flow can change very rapidly in response to short, high-intensity rainfall events. Harvey and Hecht (1982) estimated mean monthly stream flow for Arana Gulch Creek could vary from 0 at the culverts during the summer months, to a peak flow of 650 cubic feet per second (cfs) for a 10 year flood event, to 2010 cfs for a 500 year flood event. In January 1982, an approximately 25-year storm event was estimated to have generated peak flows of 870 cfs. During this event, the storm water exceeded the capacity of the culverts at the Upper Harbor, temporarily impounding an estimated 100 acre-feet of storm water within Arana Gulch.

Water quality sampling at Arana Gulch Creek has been conducted intermittently over the past 30 years (summarized by Balance Hydrologics, 2002). Storm events can flush sediment and pollutants commonly found in urban runoff such as heavy metals, hydrocarbons, persistent pesticides, and pathogens. Sampling conducted in 1982 just upstream of the Arana Gulch property included testing for minerals and heavy metals. Results showed the freshwater inflow to be of good quality and comparable or better than the water quality in coastal streams of similar flows. Sampling of the tidal reach was also conducted in 1977 and found the water quality to be within the ranges typically found in estuarine systems. More recent sampling in 1998 included measurements made at 3 locations along the creek throughout the year of water temperature, dissolved oxygen, turbidity, specific conductance, and pH. In general, the results indicated that water quality was within specified objectives. However, significant development has occurred in the watershed since these measurements were taken. New testing is needed to assess current water quality, especially with respect to heavy metals and other contamination.

5.1.3 Riparian Scrub

Riparian scrub occurs along the broad Arana Gulch Creek floodplain, featuring thickets of arroyo willow *(Salix lasiolepis)*, yellow willow *(Salix lucida ssp. lasiandra),* red willow *(Salix lasiolepis),* and coffeeberry *(Rhamnus californica).* Non-native black acacia (*Acacia mearnsii*) are scattered in the riparian corridor, especially near the culverts. Eucalyptus dominates most of the eastern bank of Arana Creek, although most of that area is outside the boundaries of the Master Plan (Photo 21). The native component of the dense understory includes poison oak, California wild rose *(Rosa californica),* gooseberry *(Ribes divaricatum ssp. pubiflorum),* and coyote bush. Non-native invasive species are prevalent, especially dense thickets of Himalayan blackberry. Other non-natives include scattered French broom and tall white top (*Lepidium latifolium*) along with many ruderal grass and herb species including ripgut brome, rattlesnake grass, Italian rye grass, wild radish, and prickly lettuce. There is also a large, dense patch of the non-native vine, periwinkle (*Vinca major*).

The riparian scrub along Arana Creek may be classified as arroyo willow thicket (CDFG 2010) or coast arroyo willow riparian forest (Holland 1986). This habitat type is recognized as a special status natural community (CDFG 2010). Most riparian and wetland communities are special status in California because of their limited distribution and potential vulnerability to impacts from projects. However, illegal encampments, erosion from unauthorized pathways and trash degrade the sensitive habitat of riparian scrub along Arana Gulch Creek, disrupting bird and animal nesting sites, and trampling desirable native vegetation.

5.1.4 Emergent Wetland

Much of the central portion of the Arana Gulch Creek floodplain is characterized as emergent wetland (Photo 22). Emergent wetlands support mostly herbaceous water-loving plants that tolerate or even require frequent flooding. Rushes (*Juncus spp*), sedges (*Carex spp*) and large perennial bunch grasses are typical components. Upstream of the Santa Cruz harbor, adjacent to the tidal channel of Arana Gulch Creek, the vegetation is subject to salt water influences from Monterey Bay. In this tidally influenced area, characteristic salt and brackish water plant species include alkali heath *(Frankenia salina)*, jumea *(Jaumea carnosa)*, and spearscale (*Atriplex triangularis*). Pickleweed *(Salicornia virginica) and* saltgrass (*Distichlis spicata*) grow in dense patches close to the edge of the channel. A dense infestation of non-native iceplant (*Carpobrotus edulis*) lines the west creek bank near the culverts (Photo 23). Further upstream in a marshy area bordering the riparian scrub, common marsh species include Pacific Oenanthe *(Oenanthe sarmentosa),* California bulrush, Pacific silverweed *(Potentilla anserina subsp. pacifica),* spreading rush, western goldenrod (*Euthamia occidentalis*), and Douglas' baccharis or false willow (*Baccharis douglasii*). Perennial non-native grasses, such as velvet grass, Italian rye grass, and creeping bentgrass (*Agrostis stolonifera*) also dominate much of this wetland area.

In the central portion of this emergent wetland area, north of the confluence of two tidal channels, the salt marsh species are narrowly confined to the banks of the channels. Most of this area is dominated by Italian rye grass, with weedy associates such as curly dock, bird's-foot trefoil (*Lotus corniculatus*), and Italian thistle. Northward, there is an area dominated by the weedy species wild radish and poison-hemlock, along with prickly lettuce and bull thistle. Scattered shrubs of coyote brush occur throughout the southern and central portions of the emergent wetland area. Dense patches of Himalayan blackberry also occur along the southern border of the area and in the central portion.

5.1.5 Wildlife

The riparian corridor and emergent wetlands of Arana Gulch Creek likely supports the highest concentration and abundance of wildlife across the property. The presence of surface water and dense cover attracts a wide variety of wildlife. The emergent vegetation provides habitat for fish, amphibians, aquatic reptiles, and essential reproductive habitat for invertebrates. Birds and mammals come to find an abundant supply of food, water, cover, and nesting sites. Many animals utilize the succulent forage of this habitat long after the grassland has dried and gone to seed. Virginia opossum, striped skunk, and raccoon travel through the protected corridors of the scrub and drink from the surface water.

Detailed surveys for special-status wildlife species have been conducted in the past by various consultants as part of the environment review process. The highest priority wildlife species known to occur on the site is the federally Threatened steelhead trout (*Oncorhynchus mykiss*), which was recorded in Arana Creek in 1999.This species is briefly discussed below. Suitable habitat features were not detected for two other federally listed species, the tidewater goby (*Eucyclogobius newberryi)* or the California red-legged frog. Both of these species are therefore unlikely to occur on the site (Habitat Restoration Group, 1996, Entrix, 2004, and EcoSystems West, 2005).

An extremely small population of steelhead trout (*Oncorhynchus mykiss*) was recorded in the lowest reach of Arana Gulch Creek in a survey conducted by D.W. Alley in 1999. They attributed the low densities to extremely poor spawning habitat conditions and limited rearing habitat. The Arana Gulch population occurs in the Central California Evolutionary Significant Unit (ESU) which is listed as "Threatened" under the federal Endangered Species Act (USFWS 2010). Compared to other steelhead populations in the San Lorenzo River and other coastal streams in the ESU, the Arana Gulch Creek population is very small and the habitat is considered substandard. It is unknown whether steelhead are still present in Arana Creek. However, restoration of this run is a stated goal of the Arana Gulch Watershed Enhancement Plan (section 5.2) and so a brief description of the steelhead lifecycle is provided below.

Steelhead are anadromous salmonids that spend their first few years of life in fresh water before migrating to the ocean and then returning from the ocean to their native waterways to reproduce. Steelhead require spawning sites with loose gravels, a minimum of sand and silt, and clean flowing water. Spawning migration is primarily January through April. Fry usually emerge between April and June. Juvenile steelhead remain in fresh water streams and lagoons for 1 to 3 years, preferring deep pools higher stream flow to enhance food availability. Riparian vegetation with sufficient canopy cover is needed to provide shade and keep water temperatures cool, while eddies created by large woody debris and boulders provide cover and refuge. After undergoing a physiological transformation to adapt to saltwater, called smolting, steelhead migrate to the ocean in late March through May. Steelhead reach maturity in1 to 2 years and then return to their native waterways to spawn. Migration may be blocked by log jams, bedrock falls, and shallow riffles, or man-made alterations to the stream.

In addition to steelhead, previous studies have documented three different California Species of Special Concern. Great blue herons were observed in flight in 2012 and EcoSystems West (2005) recorded night-roosting as occurring in a stand of eucalyptus on the east side of Arana Gulch Creek. In 1996, the Habitat Restoration Group documented yellow warblers (*Dendroica petechia brewsteri)* nesting in the Arana Gulch area. Nesting pairs of this neotropical migrant are considered Sensitive as are the nests and rookeries/night-roosts of great blue herons. EcoSystems West (2005) also has observed trees with potential roost features for sensitive bat species (e.g., exfoliating bark, broken limbs, and crevices) along Arana Creek and in the area near Agnes Street. They found one special-status species, the western red bat (*Lassiurus blossevillii)* near the east side of Arana Gulch Creek.

5.1.6 Accessibility

Under the provisions of the Arana Gulch Master Plan, public use will be limited within this Management Area to minimize impacts to wildlife species. No trails will be located within the wetlands or willow stands along the riparian corridor. However, a segment of the Creek View Trail that occurs on Port District property outside of the Arana Gulch Master Plan boundaries will be located within the 100-foot buffer from Arana Gulch Creek and associated emergent wetlands. The new formal pedestrian trail will be developed along an existing user path and will provide an overlook and interpretive opportunities for the tidal reach of Arana Gulch Creek.

5.2 The Arana Gulch Watershed Enhancement Plan

In the early 1990s, several community groups and agencies became concerned about the increasing development pressures and the health of the Arana Gulch watershed. An advocacy group called the Friends of Arana Greenbelt began meeting in 1994 and two years later, the Coastal Watershed Council's (CWC) Volunteer Water Monitoring Program began in Arana Gulch. The collaborative efforts of these two groups initiated a Coordinated Resources Management and Planning (CRMP) effort for the Arana Gulch watershed in August 1996 with the support of the Santa-Cruz County Resource Conservation District (RCD), the Santa Cruz Port District, and the USDA Natural Resources Conservation Service (NRCS). A series of public meetings in 1996 through 1998 generated a list of resource issues and community concerns and established a watershed steering committee that became known as the Arana Gulch Watershed Alliance (AGWA).

In 1999, the AGWA sought and received funding from the California Department of Fish and Game and the California Coastal Conservancy to develop a watershed enhancement plan. Balance Hydrologics worked with other firms and the CWC to prepare the Arana Gulch Watershed Enhancement Plan Phase 1: Steelhead and Sediment Assessments (Balance Hydrologics 2002). The field work for the sediment source analysis, baseline water quality, and steelhead assessment was conducted primarily in 1999 and 2000. Importantly, a riparian vegetation assessment was not conducted as part of the project. The status of the vegetative cover in the riparian corridor is integral to streambank stability and steelhead habitat suitability and this lack of information is a limitation to the plan.

While this plan is now ten years old, it remains the most comprehensive assessment of stream and habitat conditions within the Arana Gulch Watershed and is the only source of recommendations for restoration. Working meetings between the project consultants and the Arana Gulch Technical Advisory Group resulted in a list of 19 projects designed to reduce sediment and improve steelhead habitat. Of those projects 11 are sediment related, including four new sediment basins and 8 are for fish habitat. These 19 projects have been prioritized and organized into conceptual repair plans with a suggested 10 year implementation period including Phase 1 (1-3 years), Phase 2 (3-5 years), and Phase 3 (5-10 years). Monitoring plans are also suggested to track the success and failure of implemented repairs and aid in documenting further changes in the watershed. The suggested repair and monitoring plans include the following components:

- Site specific repair and stabilization of point and non-point sediment
- Removal of steelhead migrational barriers with coordinated efforts to leave large woody debris in the channel, as needed
- Re-vegetation plans for areas where riparian communities have been lost
- Enhanced removal of sandy sediment with small scale sediment basins and off channel storage surfaces
- Monitoring of areas prone to erosion problems
- Monitoring of summer baseflows and water quality to establish a stronger understanding of baseflow characteristics

Only two if the 19 projects occur in the boundaries of the Arana Gulch property. The so called “Greenbelt gully” is located on the hillslope below Agnes Street and Park Way South. Accelerated erosion of the hillslope has resulted in a gully that is large source of sediment directly to the tidal reach. The plan recommends stabilizing the hillslope with backfill and planting of fast-growing native species along with measures to improve drainage and re-direct run off. This project is ranked the highest (medium-high) of the five site-specific Phase 2 projects described in the plan. A cost of $20,000 to 50,000 is estimated for gully repair alone. With significant improvements to the drainage configuration the cost estimate increases to $100,000+. These cost estimates require adjustment for inflation.

The other identified watershed project within Arana Gulch is the Tidal Reach. The problem is identified as accelerated channel headcutting and channel bank failure through the tidal reach that results in increased loading of sandy sediment to the harbor and the tidal reach itself. However, no repair was recommended because of disagreements that emerged during the preparation of the plan over the culverts. Some agency staff believed the culverts make steelhead passage more difficult and should be removed or reconstructed, while the restoration team fisheries biologist believed that the culverts pose no difficulties for the steelhead.

Despite the lack of consensus over the tidal reach, the watershed enhancement plan makes it clear that while implementing improvements to a single reach of Arana Creek may offer short-term benefit, long term improvements can only be sustained with a watershed approach. In particular, it becomes apparent that pouring a huge amount of resources into improving the terminus of the system in Arana Gulch cannot be sustained if conditions in the upper watershed continue to deteriorate and the sediment supply continues to increase. Thus, achieving the general objectives of this Habitat Management Plan to provide for the protection, restoration, and enhancement of the Arana Creek Riparian and Wetland Management Area will require elements of the watershed approach presented in the Arana Gulch Watershed Enhancement Plan (AGWEP).

The AGWEP has made notable progress over the years despite the difficulty in acquiring funding because of the small size of the watershed and the fact that funds are often directed at larger watersheds undergoing rapid change. In addition, a majority of the targeted repair sites in the plan are on private property and there are a large number of jurisdictions with land and water use authority in the watershed. Those jurisdictions regularly take actions that affect the watershed, and a tremendous amount of coordination is required for any implementation of the AGWEP. Despite those limitations, the City has completed three of the five sediment- related projects within City Limits. Most recently, the Port District entered into an agreement with the Resource Conservation District of Santa Cruz County (RCDSCC) to staff a position in the Arana Gulch Watershed Alliance and complete a workplan. The first task under the agreement is to convene a Technical Advisory Group (TAC) to determine a priority list for the Phase II projects included in the Arana Gulch Watershed Enhancement Plan. The TAC convened in September 2012.. Additional tasks are to solicit further project funding and collaborate with Balance Hydrologics to conduct a preliminary re-assessment of the Arana Gulch watershed. A representative of the AGWA TAC could be invited to participate in targeted meetings of the AMWG to address issues in the Arana Creek Management Area.

5.2 Monitoring Plan

The monitoring plan is designed to assess progress in meeting specified goals and objectives for the Arana Gulch Riparian and Wetland Management area. The first step is the presentation of a simple conceptual model (5.2.1) that illustrates the direct and indirect threats to the conservation targets and identifies feasible management strategies. Next, the goals and interim success criteria (5.2.2) address the identified management strategies. The schedule and implementation (5.2.3) describe the variables that will be tracked using photo point monitoring, and provide the desired direction of change for each interim success criteria.

5.2.1 A conceptual model for the Arana Creek riparian corridor and wetlands

The Arana Gulch Riparian and Wetland Management area includes ecological systems that are inherently complex, variable, and contingent on a multitude of inter-connecting factors. In developing a conceptual model for such a system there is a strong tendency to develop a highly complex model. However, as discussed in section 3.6.1, complex models are generally unjustified and unwarranted in ecological systems because of data gaps and uncertainty over ecological and other relationships, and because of constraints on resources that limit the number of variables that can be monitored. There is a still a risk of oversimplifying the system, but given resource constraints, a simple model is better than none at all or one that is unwieldy. The conceptual model for the Arana Gulch Riparian and Wetland Management Area (Figure 5.1) is purposefully simple to focus attention on those elements that were identified as high priority in the Master Plan and to limit the amount of data inputs and monitoring resources that are required to faithfully represent those components and their role in the ecological system.

The four main conservation targets at Arana Creek identified in the Arana Gulch Master Plan are the riparian plant community, the emergent wetland, and the steelhead population. The direct threats and the contributing factors were also identified in the Master Plan, the Watershed Enhancement Plan, and environmental documents. The selected strategies are focused and linked directly to the outcomes in the vision for Arana Gulch (section 2.3) and each has been determined to be feasible to some extent.

The strategies to stabilize the tidal reach of Arana Creek and restore the eroded gully are the top priorities for this Management Area. Both strategies are best addressed within a larger watershed approach that addresses sedimentation and steelhead habitat conditions throughout the Arana Creek Watershed. As discussed in the previous section (5.2) achieving the general objectives of this Habitat Management Plan to provide for the protection, restoration, and enhancement of the Arana Creek Riparian and Wetland Management Area will require elements of the watershed approach presented in the Arana Gulch Watershed Enhancement Plan.

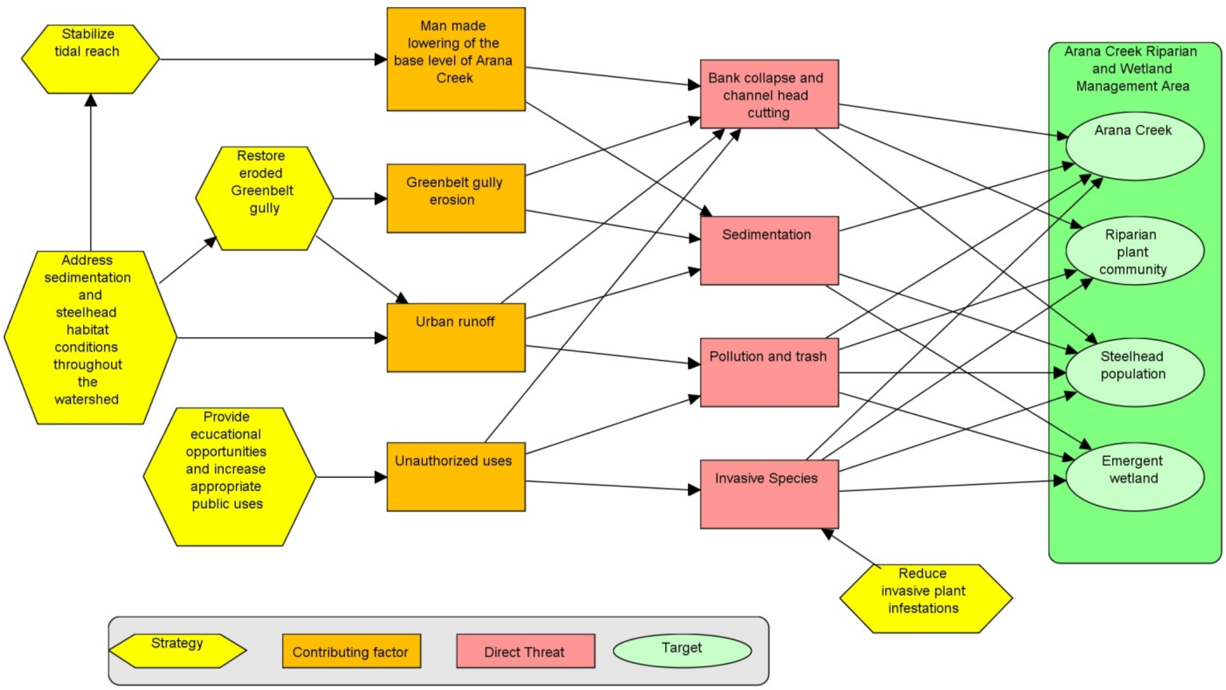

Figure 5.1 Conceptual model for the Arana Creek Riparian and Wetland Management Area

The strategy to reduce invasive plant infestations is a much lower priority. As long as the flooding regime is out of balance and the creek is disconnected from its floodplain in most years, removing invasive species will be time consuming and costly and could be more systematically addressed with creek restoration. Many of the invaders could not survive the periodic inundation that would result. Along the creek channel itself, several invasive plants like ice plant are the only thing left to help stabilize the bank and removal could lead to further erosion. The large scale clearing of poison oak and blackberry that is needed also has the potential to cause further erosion. The eucalyptus infestation on the east bank is largely outside of the property boundaries.

Providing educational opportunities and increasing appropriate public uses is a universal strategy of the management at Arana Gulch. The Public Access Management Plan (in development by the City of Santa Cruz) will address the required elements of the interpretative program, while the new trail construction and decommissioning of unauthorized trails during the development of the multi-use trail system will both concentrate and increase use across the site. An increase in the number of users has the potential to increase observation and reporting of illegal activities and may act as a deterrent to inappropriate uses. The installation of education kiosks further promotes authorized uses. This strategy was further addressed under coastal prairie and SCT management in section 3.6.2. Finally, the general strategy to address watershed protection was discussed in detail in section 5.2

5.2.2 Goals and Interim success criteria

This section of the Arana Gulch Habitat Management Plan develops goals and objectives for the five strategies currently identified for the Arana Creek Riparian and Wetland Management Area: to 1) stabilize the tidal reach, 2) restore the eroded greenbelt gully, 3) address sedimentation and steelhead habitat on a watershed scale, 4) reduce the understory of non-native invasive plants, and 5) provide educational opportunities and increase appropriate uses. The goals are broad statements that set an overall direction for management and have been largely derived from the resource management guidelines presented in the Master Plan. The objectives are more specific and constitute the interim success criteria for implementation of this portion of the Habitat Management Plan in the near term. The development of such interim success criteria is a specific requirement of the Coastal Development Permit conditions of approval. Monitoring results are tied directly to the CDP reporting requirements (section 2.3.2).

The rationale behind each goal presented below is briefly explained. The objectives describe the variables that will be monitored and specify a desired direction of change. Compared to the concise objectives presented for the CPTMA, these objectives are less specific, but they still meet the criteria of being measureable over a particular time period. Through the process of monitoring and data evaluation, the AMWG may adjust objectives, and possibly goals, as necessary.

Goal 1: Reduce sedimentation and improve steelhead habitat conditions within the Arana Creek watershed.

The AMWG may want to pursue collaboration with the Resource Conservation District of Santa Cruz County (RCDSCC) and the Arana Gulch Watershed Working Group to address sedimentation and steelhead habitat and pursue funding.

Objective 1A: High priority sediment-related projects identified in the Arana Creek watershed enhancement plan are implemented.

Objective 2A: High priority steelhead habitat improvement projects identified in the Arana Creek watershed enhancement plan are implemented.

Goal 2: Stabilize the tidal reach of Arana Gulch Creek.

Accelerated channel headcutting and channel bank failure through the tidal reach results in increased loading of sandy sediment to the harbor and the tidal reach itself. However, no repair was recommended in the watershed enhancement plan because of disagreements that emerged during the preparation of the plan over the culverts.

Objective 2A: Engage the RCDSCC Arana Gulch Working Group staff to attend targeted AMWG meetings to identify possible solutions for the tidal reach of Arana Gulch Creek.

Objective 2B: Work with RCDSCC staff to obtain funding to design and implement a bank restoration project that reduces head cutting and bank erosion along the tidal reach of Arana Gulch Creek.

Goal 3: Restore the eroded Greenbelt Gully.

Accelerated erosion of the hillslope has resulted in a gully that is large source of sediment directly to the tidal reach. The watershed enhancement plan provides specific recommendations for stabilizing the hillslope with backfill and revegetation. Cost estimates are also provided for this project, making it a readymade and attractive option for any ongoing funding opportunities.

Objective 3A: Work with RCDSCC staff to pursue funding for the Greenbelt Gully restoration project.

Goal 4: Seek funding to develop an integrated pest management (IPM) plan to reduce the understory of non-native species in the Arana Gulch Creek management area.

Development of an Integrated Pest Management (IPM) plan will facilitate the selection of the proper combination of control methods. Because the target species are all capable of vigorous re-sprouting, vegetative growth, and/or prolific seed production, the selected control methods will require appropriate timing and follow-up monitoring to locate and kill re-sprouts and new seedlings. IPM offers flexibility to tailor the plan depending on the time, labor and other resources that are available.

Objective 4A: Remove and reduce the cover of non-native invasive species in the riparian woodland relative to baseline conditions including: black acacia found near the culverts, dense thickets of Himalayan blackberry, scattered French broom, tall white top, and periwinkle.

Goal 5: Provide educational opportunities and increase appropriate uses.

Unauthorized trail use and illegal activities such as arson or vandalism could threaten investments in restoration improvements or public education kiosks. The goal to increase appropriate public uses is based on the assumption that an increase in the number of users at Arana Gulch that will occur as a result of the multi-use trail development will increase the number of opportunities to observe and report illegal activities. Thus, greater use of the site acts as a deterrent to unauthorized uses and the installation of education kiosks further promote appropriate uses.

Objective 5A: Observe the condition of all improvements at least four times per year in the first three years and at least twice per year, thereafter.

Observations can be timed at either regular intervals or to coincide with management events. This type of qualitative site level monitoring provides a record of appropriate and inappropriate uses over time that the AMWG can use to inform new improvements.

5.2.3 Monitoring schedule and Implementation

Implementation of the HMP for the Arana Gulch Creek Riparian and Wetland Management Area can only proceed on a limited basis without obtaining funding to implement the proposed monitoring plan. Collaboration with the RCDSCC Arana Gulch Watershed Working Group emerged as an important opportunity since the group is exploring high priority projects in the Arana Gulch watershed for ongoing grants. Unlike the other two management areas, the goals and objectives for the Arana Creek management area are oriented toward management and therefore the measured variables listed in Table 5.1 are also management- oriented with the exception of the invasive plant cover, which can be measured using photo point monitoring. The required frequency of measurement and the desired direction of change is specified for each interim success criteria. However, interim target dates are not provided due to the lack of certainty over obtaining funding to implement the monitoring program in this management area.

Table 5.1 The variables included in the baseline assessment and monitoring plan for the Arana Gulch Creek Riparian and Wetland Management Area including frequency of measurement, desired direction of change in the variable.

Objective	Variable	measurement frequency	Desired direction of change
1A	# of completed sediment-related projects with the RCDSCC	yearly	increase
1B	# of completed steelhead habitat improvement projects with the RCDSCC	yearly	increase
2A	RCDSCC attendance at AMWG meetings	yearly	increase
2B.	Funding level for the tidal reach restoration	yearly	Obtain/increase
3A	Funding level for the Greenbelt Gully project	yearly	Obtain/increase
4A	non-native invasive woody plant cover	yearly	decrease
5A	Observation of infrastructure conditions	4x	stable

6.0 Funding and cost estimates

The City has been successful in obtaining over $4 million in federal and local funds to implement the Arana Gulch Master Plan, including construction of the multi-use trail. These funds are critical to enabling the City to implement the habitat restoration and monitoring components of the Arana Gulch Master Plan, and physical improvements including the installation of fencing for cattle grazing and seasonal wetland protection, as well as the installation of interpretive displays and overlooks. The Federal Transportation Enhancement (TE) funds are commonly used in this type of setting and purpose; to develop pedestrian, bicycle and accessible trails.

The Santa Cruz City Council has set aside funds for implementing the adaptive management of the Santa Cruz tarplant. The local funds come from the County of Santa Cruz and from the sale of City property between Frederick Street and Arana Gulch adjacent to the open space. This property is valued at over $1.0 million. Of these funds, approximately half is identified in the Santa Cruz County Regional Transportation Plan as a local match to the grants for design and construction of the multi-use trail. The other portion is to be placed in an Arana Gulch Master Plan specific subaccount of the City's Trust Fund and will be designated to restore and manage habitat in the long term.

As discussed in section 2.2, it is the role of the Adaptive Management Working Group (AMWG) to advise the Executive Committee of the management actions, funding efforts, and regulatory requirements for timely implementation of the Habitat Management Plan. In the course of operations, the AMWG will recommend management strategies to the Executive Committee for implementation. The Director of Parks and Recreation will develop an annual budget based on those recommendations for all activities at Arana Gulch related to this HMP. The Director of Parks and Recreation and his or her designee is the entity that presents the budget, recommends it for approval by the City Council, and administers the approved budget. Any substantive change to an approved budget requires additional approval by the City Council. Because the budget will be derived from public funds it is a focal point for transparency.

6.1 Funding sources and allocation

Costs associated with the implementation of the HMP include costs for plan implementation and administration, baseline assessments and monitoring. Table 6.1 provides a breakdown of one-time costs associated with the infrastructure and the annual costs associated with the HMP implementation. Funding is committed through the City's operational and capital improvement budget and the funding sources currently include federal and state grants, general fund and the storm water fund.The implementation and administration of the plan will include a variety of tasks by City employees and consultants. These tasks include supporting the AMWG, coordination of all activities such as, training, baseline surveys, monitoring, grazing, and preparation of annual reports. This does not include the ongoing maintenance and security activities that take place on a day to day basis. Costs for the baseline assessment and monitoring and other components of implementation of the HMP are rough estimates. Detailed cost estimates for the work will be solicited by the AMWG and submitted as part of a recommendation package to the City Department of Parks and Recreation Executive Director.

In Hagemann Gulch, some resource management responsibilities will be undertaken directly by City Parks Maintenance Workers and Rangers and volunteers may also assist with invasive species removal and habitat enhancement activities. Funding is needed for technical consultants to develop an IPM plan and contractors to implement recommended weed control measures. A cost estimate for development of the IPM is initially required. Cost estimates for specific weed removal will be included in the IPM plan.

An unspecified cost estimate for grazing with goats to remove invasive plants on the steep slope at Hagmann Gulch was obtained during the preparation of this HMP. According to one grazing operator, general costs for the initial set up of an 80 x 80 enclosure would cost $500 to $750. Subsequent sections would cost $400. On onsite consultation is required to assess further details about the size of the herd and the number of sections that would be required.

Table 6-1 Estimated Costs to Implement the Plan

Plan implementation and Administration		**One Time Cost**	**Annual Cost**
	Staff salary and office expense		$ 20,000
	Consultant services for AWMG	$ 25,675	$ 2,000
	Web page development and support	$4,240	$1,000
Habitat Management Plan			
SCT and Coast Prairie Habitat	Baseline assessment and monitoring	$ 25,000	$ 10,000
	Mowing, raking, scraping, burning and other actions		$ 12,000
	Evaluation and research		$ 10,000
	Grazing (fencing costs included in Construction Plan)		$0
	Public Education (for maintenance for all habitats)		$ 2,000
Hagemann Gulch Riparian and Woodland			
	Develop IPM plan		TBD
	Vegetation removal with goat grazing		$ 7,000
	Baseline assessment and Monitoring		$ 2,000
Arana Gulch Creek Riparian and Wetland			
	Support AGWA (storm water fund)		$9,000
	Develop IPM plan		TBD
	Work with RCD to apply for grants		TBD

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Appendix A Photos