ASSESSMENT OF THE PAST 30 YEARS OF HABITAT MANAGEMENT AND COVERED SPECIES MONITORING EFFORTS ASSOCIATED WITH THE **SAN BRUNO MOUNTAIN HABITAT CONSERVATION PLAN**

CREEKSIDE SCIENCE

ASSESSMENT OF THE PAST 30 YEARS OF HABITAT MANAGEMENT AND COVERED SPECIES MONITORING EFFORTS ASSOCIATED WITH THE SAN BRUNO MOUNTAIN HABITAT CONSERVATION PLAN

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Prepared for

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Executive Summary

<table>
<tr><th>REVIEW TASK</th><th>TAKE HOME SUMMARY</th></tr>
<tr><td>Chapter 2. Evaluate the Past 10 Years of Vegetation Management Activities and Reports</td><td>The 2007 Habitat Management Plan (HMP) provides a good synthesis of management activities through 2006. The HMP covers key issues and has sensible priorities. Our review will both reiterate key points as well as provide recommendations for improvements moving forward. Key considerations:

• Some invasive species are contained, but extending efforts to the goal of eradication is rarely since these efforts may be costly. Success of invasive control is dependent on timely access to wildlands within the habitat conservation plan (HCP) area.
• Oxalis (Oxalis pes-caprae) continues to be a high priority, especially outliers in high quality butterfly habitat. Successful control has occurred in several locations but not on the mountain as a whole. Oxalis is a very difficult invasive to control.
• The impacts of fennel (Foeniculum vulgare) on occupied butterfly habitat need to be further researched. Fennel is quickly establishing in many grassland patches.
• Control of the gorse/broom (Cytisus, Genista, Ulex ssp.) invasion is highly successful, but reclaiming butterfly habitat (and other covered species habitat) is unlikely due to the legacy effects of invasive shrubs. Weed control is only one aspect of restoration. Legacy effects need to be weighed in when management work is being assessed.
• Vigorous re-establishment of invasive shrubs in treatment areas is well documented. Gorse containment efforts should be continued such that populations do not rebound in previously treated areas.
• Past reviews and professional articles reviewing management activities on San Bruno Mountain conclude that scrub invasion is likely the biggest threat to existing butterfly habitat. Conversion of high quality butterfly habitat to lower quality by scrub invasion can occur over the course of only a few years, therefore critical areas should be monitored and treated regularly. West Coast Wildlands pilot projects on native brush control have been successful and cost effective. We recommend expanding these efforts and making them the centerpiece of future work.

Reporting by West Coast Wildlands (WCW) is being completed on an appropriate level of effort, with ample documentation of activities and establishes cost-basis for future work. We suggest a few changes in reporting including: contractor “self-assessment” of habitat restoration work on a coded 1-5 scale for ease of quick review, use of permanent photopoints and inclusion in document in order to communicate habitat management work qualitatively through photographs, and inclusion of projects budgets in the annual report.</td></tr>
<tr><td>Chapter 3. Assessment of Butterfly Monitoring Techniques:</td><td>Butterfly monitoring on San Bruno Mountain (SBM) has two goals: 1) establish distribution of butterfly species and 2) track abundance of butterfly populations. Here we assess the accumulated adult transect data and analyses of previous wandering transects, and San Bruno Elfin (SBE) larval counts, with the goal of designing a hybrid system that uses established fixed</td></tr>
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Butterflies, Habitat, and Host Plants	transects for abundance tracking, and rotating occupancy surveys in specified areas to track overall distribution. As per HCP guidelines, regular efforts to monitor listed butterflies on San Bruno Mountain have provided insight into three of the four covered butterflies (the 4th covered butterfly, Bay Checkerspot, has not been observed on the mountain since the mid-1980s). Our observations and conclusions are: • The transect system is robust for tracking abundance in high quality areas for both Mission Blue (MB) and Callippe Silverspot (CS). There are no long-term trends in adult butterfly observations in high quality areas where grassland remains intact, only fluctuations within a reasonable range for butterfly populations. • Recent population declines in peripheral MB and CS transects are the result of scrub encroachment. Over the long-term, scrub encroachment has reduced butterfly habitat and populations on many parts of SBM, and much more grassland is at risk in the near future. • SBE surveys, both adults and larvae, indicate that occupancy has remained stable through time, and larval abundance has not fluctuated greatly since 1999. We suggest that presence/absence surveys for SBE on a multi-year interval may be adequate for monitoring. • We recommend a combination of methods that will provide a useful picture of the distribution and abundance of butterfly populations, including tracking adult MB and CS abundance in core habitat areas using the existing transect system, monitoring MB occupancy in peripheral areas on a multi-year cycle, and rigorous testing MB egg counts to provide a potentially robust method for weather-independent tracking of population density in select areas. • Incorporating host plant mapping and monitoring into butterfly monitoring provides the direct link to habitat restoration efforts, and we recommend that lupine and Viola inventories be completed in selected areas over the next 5 years. • Lupine counts combined with MB egg counts can be used to estimate the order of magnitude of local populations, and provide a measure of restoration success as newly established lupines are used.
Chapter 4. Historic Imagery Analysis Mapping: Brush Encroachment Case Studies	Of the approximately 3,000 acres of land conserved by the San Bruno Mountain HCP, 1960 acres (65.3%) were mapped as grassland in 1932. In 1983, when the HCP was approved, 1419 acres of grassland were documented. In a 2004 vegetation classification analysis (of a 2002 aerial image), 1297 acres of grasslands were mapped on San Bruno Mountain. This equates to an average loss of 9.5 acres of grassland per year. Cursory visual analysis of 2014 aerial imagery indicates further loss of grassland since the 2004 classification effort. We conservatively estimate that grassland habitat is now reduced to less than 1180 acres. Two case studies of invasion of high quality habitat [Southeast Ridge and Transmission Line Ridge/Fire Road] are offered as examples of grassland invasion that has been observed. Three photographic images of Transmission Line Ridge are presented from 1982, 2006, and 2014 to document vegetation changes.

Chapter 5. Priority Grassland Management Areas	High quality grassland habitat needs to be defended and restored at any reasonable cost. Grasslands provide habitat for three of the four listed butterfly species, as well as many of the rare plants. It is clear that this vegetation community has been steadily decreasing since at least 1932 and species requiring this habitat are undergoing habitat loss. It is critically important to maintain large, contiguous patches of grassland to ensure that populations of CS and MB do not become reproductively isolated or even extirpated. Although the last mapping effort in 2004 reported 1296 acres of grassland, we believe that many of these areas are in imminent threat of scrub encroachment and could be converted to scrub after a good coyote brush recruitment year. Large patches of contiguous grassland with less than 2% scrub cover are quickly vanishing. Grassland vegetation mapped in 2004 overestimates the total number of grassland acres, regardless of which definition of grassland one accepts (<10% scrub cover vs. <25% scrub cover). Areas mapped as grasslands in 2004 were re-evaluated qualitatively and we present one sample area which should be mapped as scrub, not grassland. Most grasslands on SBM are at least marginally invaded with scrub except for the Northeast Ridge, which contains a large contiguous grassland with relatively low scrub cover. Scrub encroachment needs to be slowed with management action. A total of 943.7 acres within the San Bruno HCP boundary are categorized as **Priority Grassland Management Areas.** The Priority Areas Map is based on recent *Viola* surveys, CS and MB presence/abundance, and qualitative field data. High risk areas overlapping with high quality habitat are identified and prioritized for near term management: extant grasslands on north facing slopes in Owl-Buckeye/Transmission Line ridge areas, SE Ridge, Main ridge, certain south facing ridges (i.e. along transect 12), and the NE ridge are the highest priority.
Chapter 6. Stewardship Tools for SBM Habitat	Grasslands require a degree of regular and heterogeneous disturbance in order to maintain their diversity and reduce scrub succession. Future management efforts need to strategically target invading scrub in Priority Grassland areas, while continuing to contain weed infestations. Additionally, thatch buildup in grasslands is impacting habitat quality. Scrub removal and stewardship of San Bruno Mountain can occur through a diversity of methods. This chapter highlights many of those methods and offers insights to collaborative management that may meet multiple goals. For instance, fuels management activities can be planned to complement scrub removal in designated areas. Since fire is a powerful grassland management tool, creating dynamic management that focuses on opportunistic treatment of post fire landscapes will provide significant management benefits. We recommend initiating a post-fire action fund (Fire Fund) that will draw 5-10% of annual funds into an account reserved for post-fire stewardship, up to $15,000 annually. If a fund cannot be rolled over from year to year, we recommend opportunistically shifting annual project activities to leverage habitat gains made after an unplanned fire. Grazing can also be used to limit scrub establishment and reduce the dense grasses and resultant thatch that directly reduce host plant density. The Northeast Ridge is a feasible location for an operational scale grazing trial. A

	trial with intensive monitoring to document positive and negative impacts is essential. Supporting research elsewhere in the Bay Area indicates that grazing can be beneficial for Callippe. The prior, unimplemented grazing plan was overly complicated and expensive for the needs of the target species. We identify several areas where additional research can provide critical guidance for future management.
Chapter 7. Evaluation of Other Covered Species	Limited effort has been spent on monitoring species other than listed butterflies on SBM. We provide the most recent information on species (not including CS, MB, and SBE) that are covered by the HCP. We recommend compilation and review of all the existing information on other covered species to ensure they and their habitat are being maintained as much possible. Some covered species that were included in the HCP have not been observed on SBM since 1982. We recommend a recurring 5-year survey of perennial rare plants including collection of demography and recruitment data. Annual plants should be monitored at least once every 3 years. All results should be reported to the CNDDB. Because other listed animals are not currently known from the mountain, we do not recommend surveying them.
Chapter 8. Environmental Change: Climate Change and Nitrogen Deposition	Climate change will cause systemic change on SBM on decadal time scales and intensify through the 21st century. Detailed analysis of two representative climate futures shows a general trend toward drier summer-fall conditions, even if precipitation stays the same or increases. But in the next 30 years, trends will be difficult to detect from interannual noise. Key predictions include: • Fire risk will increase concomitantly with increased climatic water deficit (water stress). • Likelihood of intermittent brush establishment events should decline but not disappear. • Vegetation productivity is relatively stable, and even increases a little, except under driest future climate prediction at end of century, when productivity declines. • Phenology of plants advances with warmer winter/spring temperatures, and butterflies emerge earlier. . Nitrogen deposition will continue to impact SBM through fertilization. Key points include: • Deposition rates and impacts are greatest at low elevations closer to urbanization and can be observed in the field as increased biomass of grasses and thistles. • We coarsely mapped high N-deposition areas based on distance from development, elevation, and prevailing winds which delineates a zone where rapid growth of grasses/weeds will inhibit habitat restoration. • The South Slope and Northeast Ridge have the grasslands most affected by N-deposition. The low elevation leeward slopes from Devil's Arroyo around to Brisbane Acres have lower N-deposition • The upper slopes of SBM are less affected because they are exposed to relatively clean marine air.

	• Special attention/effort will be necessary to maintain habitat for Mission Blue and Callippe Silverspot in high N-deposition areas through grass control primarily. A slow reduction in N-deposition from NO_x is expected over the next decades; no trend in NH_3 is predicted. • Elevated soil nitrogen will remain for several decades and will increase productivity of annual grasses, thistles, other weeds, and scrub.
Chapter 9. Cost-effective Management with a Limited HCP Budget: Community Involvement in San Bruno Mountain	Effective habitat management on San Bruno Mountain will require a unique team of collaborators hailing from the County, non-profits, business and development interests, and the general public. Suggestions for increasing visitor use, volunteerism, and community education for the benefit of covered species are provided here.
Chapter 10. Sample 5 Year Site Prescription: Owl-Buckeye Ridge	We provide a conceptual workplan for a highly valuable habitat area known as Owl-Buckeye Ridge. This location is ideal for restoration as it contains both CS and MB survey transects, host plants for both butterfly species, and is easily accessible for work crews implementing a variety of stewardship tools. This plan is intended to serve as a living document that will likely be amended as different tools and techniques achieve varying degrees of success.

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Chapter 1: Introduction and Overview

Introduction

As the morning sun peeks from underneath the retreating fog bank, a male Mission blue clasps a freshly emerged female on a dewy lupine. A male Callippe silverspot butterfly starts his patrol on a hilltop studded with pink, yellow, white, and blue wildflowers growing among textured bunchgrasses, while already mated females crawl among drying violets haphazardly laying eggs. On the rocky north-slope below, fat San Bruno elfin larvae munch the yellow and pink flowers of stonecrops. The aromas of rich coastal scrub waft in the warming air, and the urbanized reaches of the northern San Francisco Peninsula appear in all directions below the steep slopes.

As the last viable remnant of the Franciscan ecosystem, San Bruno Mountain is a refuge for imperiled biodiversity including species found nowhere else on earth. Saved by scrappy citizen action from being scraped down and dumped into the Bay in the 1960s, the Mountain has been the focus of intense controversy in subsequent decades as the first ever Habitat Conservation Plan grappled with profound issues of conservation, development, habitat management, science, and advocacy. Over the more than 30 years since the HCP was adopted, the Mountain has been finally divided between development and conservation, many invasive weeds have been contained and others continue to spread, native scrub continues to encroach into grasslands, but the endangered butterflies still fly in the thousands each season.

Where is this dynamic ecosystem headed in the next 30 years and beyond? The answer lies in the people and institutions that care deeply about the Mountain. These stewards have the tools afforded by the HCP to apply to diverse management challenges across this habitat island in an urban sea. A remarkable set of habitat management skills and capabilities has been developed; their systematic application in a cooperative manner can meet the demands of the Endangered Species Act and secure key butterfly and plant habitats over the long-term in an ever changing environment.

Project Description

In early 2014, the San Mateo County Parks Department requested proposals for an assessment of the past 30 years of habitat management and covered species monitoring efforts associated with the San Bruno Mountain Habitat Conservation, as well as looking forward to the next 30 years.

There is a wealth of documentation produced over the past 30 years, and much of the goals, history, and implementation of the HCP has been covered in detail in the original HCP documents, annual monitoring reports, and the 2007 Habitat Management Plan. In addition, we have solicited direct input from stakeholders during formal field tours with the Technical Advisory Committee (TAC) and other tours/visits with individuals.

The purpose of this report and assessment is not to comprehensively present the whole history of the SBM HCP, rather it is to focus on the recent past and look forward to both the near term (5 years) and longer term (30 years) to plot a course that will lead to thriving populations of the covered species in conserved habitat. Thirty-two years since the original HCP was passed, the allocation between conserved and developed areas and the long-term funding sources for management and monitoring have been established. Only a few undeveloped parcels remain to be dedicated to the HCP. Our focus is on the current ecological conditions on SBM, future trajectories, and how the existing institutional and funding structure can be directed through an adaptive management process to address issues such as scrub encroachment, invasive weeds, monitoring methods, and environmental change.

We have drawn on carefully selected parts of the voluminous record to address the following topics organized into the following chapters:

- Chapter 2. Evaluate the past 10 years of vegetation management activities and reports: Recommend improvements moving forward
- Chapter 3. Assessment of butterfly monitoring techniques: butterflies, habitat, and host plants
- Chapter 4. Historic imagery analysis mapping: brush encroachment case studies
- Chapter 5. Priority grassland management areas
- Chapter 6. Stewardship tools for priority grassland management areas
- Chapter 7. Evaluation of other covered species
- Chapter 8. Environmental change: climate change and nitrogen deposition
- Chapter 9. Cost-effective management with a limited HCP budget: Community involvement in San Bruno Mountain
- Chapter 10. Sample 5 year site prescription: Owl-Buckeye ridge

In the Conclusions chapter (11), we present habitat management goals for the next 5 years. These goals – primarily native scrub and invasive weed control – focus on almost immediately securing essential grasslands that are core habitats for MB and CS. We also propose adaptive management experiments, including host plant enhancements and a grazing trial. Inventory and monitoring needs of butterflies, host plants, and other covered/locally rare species are assessed.

These goals are drafts for consideration by the TAC and Trustees, who are ultimately responsible for implementation. Implementation will require coordination of existing capabilities (field contractors, volunteers, nursery operations, scientists, advocates, and government) to use a limited, but long-term, budget to adaptively manage and monitor SBM over the coming decades

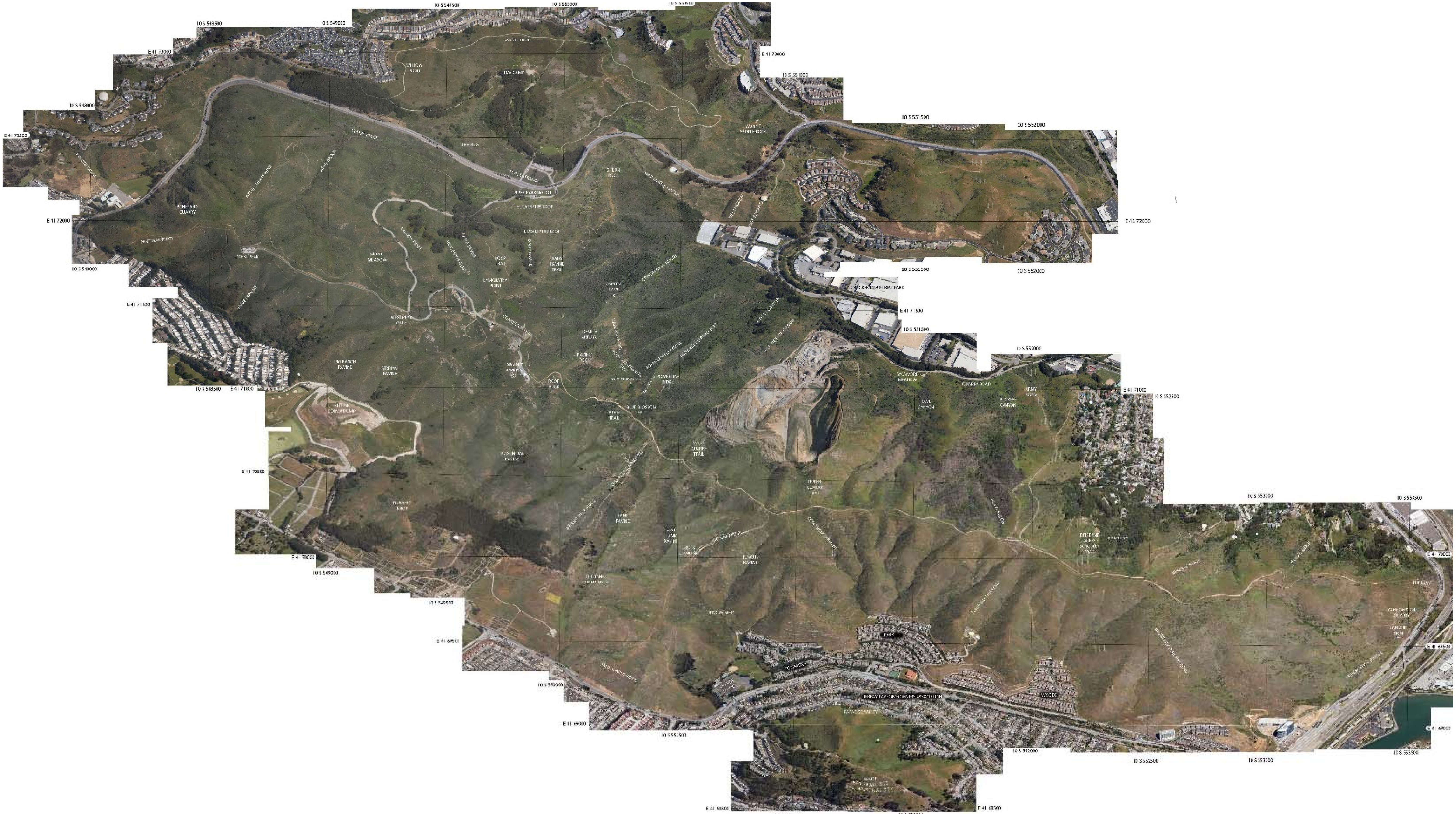

Figure 1- 1: Overview Map of San Bruno Mountain with Place Names by David Nelson

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Figure 1- 2: 1948 Sunderland aerial image of San Bruno Mountain from the west

Chapter 2. Evaluate the Past 10 Years of Vegetation Management Activities and Reports

Summary

The 2007 Habitat Management Plan (HMP) provides a good synthesis of management activities through 2006. The HMP covers key issues and has sensible priorities. Our review will both reiterate key points as well as provide recommendations for improvements moving forward. Key considerations:

- Some invasive species are contained, but extending efforts to the goal of eradication is rarely since these efforts may be costly. Success of invasive control is dependent on timely access to wildlands within the habitat conservation plan (HCP) area.
- Oxalis (*Oxalis pes-capre*) continues to be a high priority, especially outliers in high quality butterfly habitat. Successful control has occurred in several locations but not on the mountain as a whole. Oxalis is a very difficult invasive to control.
- The impacts of fennel (*Foeniculum vulgare*) on occupied butterfly habitat need to be further researched. Fennel is quickly establishing in many grassland patches.
- Control of the gorse/broom (*Cytisus*, *Genista*, *Ulex*) invasion is highly successful, but reclaiming butterfly habitat (and other covered species habitat) is unlikely due to the legacy effects of invasive shrubs. Weed control is only one aspect of restoration. Legacy effects need to be weighed in when management work is being assessed.
- Vigorous re-establishment of invasive shrubs in treatment areas is well documented. Gorse containment efforts should be continued such that populations do not rebound in previously treated areas.
- Past reviews and professional articles reviewing management activities on San Bruno Mountain conclude that scrub invasion is likely the biggest threat to existing butterfly habitat. Conversion of high quality butterfly habitat to lower quality by scrub invasion can occur over the course of only a few years, therefore critical areas should be monitored and treated regularly. West Coast Wildlands pilot projects on native brush control have been successful and cost effective. We recommend expanding these efforts and making them the centerpiece of future work.

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The San Bruno Mountain HCP area covers over 3,000 acres of diverse habitat. From grassland to oak woodland to sand dunes, each habitat has unique characteristics and threats associated with it. The diversity of habitats and the unique requirements of the various covered species make San Bruno Mountain an exceptional management challenge. Place the mountain within an urban matrix of jurisdictional boundaries and concrete, and management becomes an ever more complicated challenge.

We review the past ten years of vegetation management activity on San Bruno Mountain that has been mainly conducted by West Coast Wildlands from Pacifica, CA. Additionally, central to our analysis is highlighting key aspects of the 2007 Management Plan (TRA 2007) and the original HCP (County of San Bruno 1982) for the purpose of assessing implementation of the HCP.

One management issue that permeates through time is access. In order to control weeds, access needs to be granted in a timely manner. In many cases, land owners have coordinated access with knowledgeable land managers to allow for weed removal. In other cases, unmanaged properties can serve as invasion foci, allowing for new weed populations to get established from seeds dispersing from them. We recommend continuing to foster partnerships with neighbors in order to reduce access problems. For instance, we recommend coordination with fuels work (Chapter 6) which can benefit the adjacent land owner, as well as the HCP lands. Additionally, we recommend garden certification (Chapter 10) as a possible approach to involving local homeowners. Collaboration will provide greater access, thus making management more cost effective in the long term.

1982 Management Planning

The original HCP is divided into two volumes. The first volume offers legal and procedural guidance for the plan implementation. The second volume is dedicated to management prescriptions for lands within the HCP boundary. The HCP divides the habitat into four planning areas: Southeast Ridge, Guadalupe Hills, Saddle, and Radio Ridge. Evaluating the summaries of the original management plans for each of these areas leads us to believe that management in many cases was headed in the right direction. For instance, the Guadalupe Hills summary is reproduced below:

> "Enhancement during the first phase will be limited to the creation or extension of corridor areas by thinning existing patches of exotics, and stopping the spread of both brush and exotics by eliminating seedlings which are invading open areas. The second phase will concern the control of extensive colonies of exotics in other areas with lesser corridor value, and revegetation of areas where the exotics were eliminated. Long term enhancement goals include continued brush and exotic species management and introduction of host plants into new areas" (Page VI-8, San Mateo County 1982).

This prescription aims to reduce isolation of butterfly populations by maintaining dispersal corridors. Management targets invasive (and scrub) seedlings that are invading open grassland areas, followed by control of more extensive patches of weeds. The plan clearly directs effort towards "stopping the spread of … brush". Without discussing each of the individual summaries, we note that targeting scrub for removal has been recommended for over 30 years.

Other management recommendations such as eucalyptus and gorse removal in the Saddle area are less sound. The HCP reports that the Saddle area is "low grade habitat" and recommends concentrating on experimental work:

> "Since the Saddle contains such low grade butterfly habitat and is mostly disturbed, there exists the opportunity to try enhancement techniques and attempt to manipulate the environment to reclaim the unique ecology of the Mountain (i.e. chaining, burning, seeding, etc.). Therefore, the approach to the Saddle Planning Area is to proceed with proposed techniques of habitat enhancement in appropriate areas and accomplish some of the experimentation that is required." (Page VI-12, San Mateo County 1982)

Now, 30 years later, areas of ecological value have been reclaimed and restored: headwaters of Colma Creek, the wetland, and patches of grassland surrounding core butterfly habitat in the eastern portion of the Saddle. Although removal of eucalyptus from the headwaters of Colma

Creeks benefits the overall system and seems to be a good investment of money, removal of other isolated patches of eucalyptus that have been established for half a century (or more) likely will not produce significant improvement in habitat without expensive logging and habitat restoration efforts. Removing smaller trees to prevent colony spread (containment of existing groves) should be sufficient and economical.

Invasive Plant Management

Invasive plant management has constituted the single largest budget item over the past 30 years. Invasives pose a significant threat to habitat on San Bruno Mountain. Over the past 30 years, and notably in the past ten years, WCW and the County have contained and controlled many populations of invasives, while others continue to expand. For instance, gorse distribution and density has decreased since McClintock's (McClintock et al. 1990) San Bruno Flora, whereas it is likely that management efforts have helped keep oxalis at bay (McClintock et al. 1990 notes this is a "common weed").

Efforts to identify and eradicate the species which can cause the largest threat to existing habitat are essential. The Technical Advisory Committee (TAC), in concert with contractors, researchers and the County, need to constantly evaluate weed control efforts and priorities. Currently, there are more invasive plant populations than can be treated with the existing budget, so prioritization is paramount. Below, we offer a cursory analysis of treatment activities for three weeds on SBM. The land manager annually treats a larger suite of weed species, but we have focused on three which receive regular control effort.

Gorse

Gorse (*Ulex europea*) has a long-lived seed bank and therefore is a difficult weed to eradicate. It is imperative to be cautious about pronouncing eradication efforts a success until at least 10 years have passed and the seed bank is mostly exhausted. Instead, these areas need to be designated as "maintenance sites," or in "maintenance mode" to indicate some small degree of regular work is ongoing. Management work has substantially reduced gorse distribution and cover in the HCP area. The 2007 HMP reports that 85% of the gorse on SBM was removed by 2007 (Figure 2-1). We would prefer to divide the two layers represented as either: a) dense untreated stands of gorse, or b) maintenance sites.

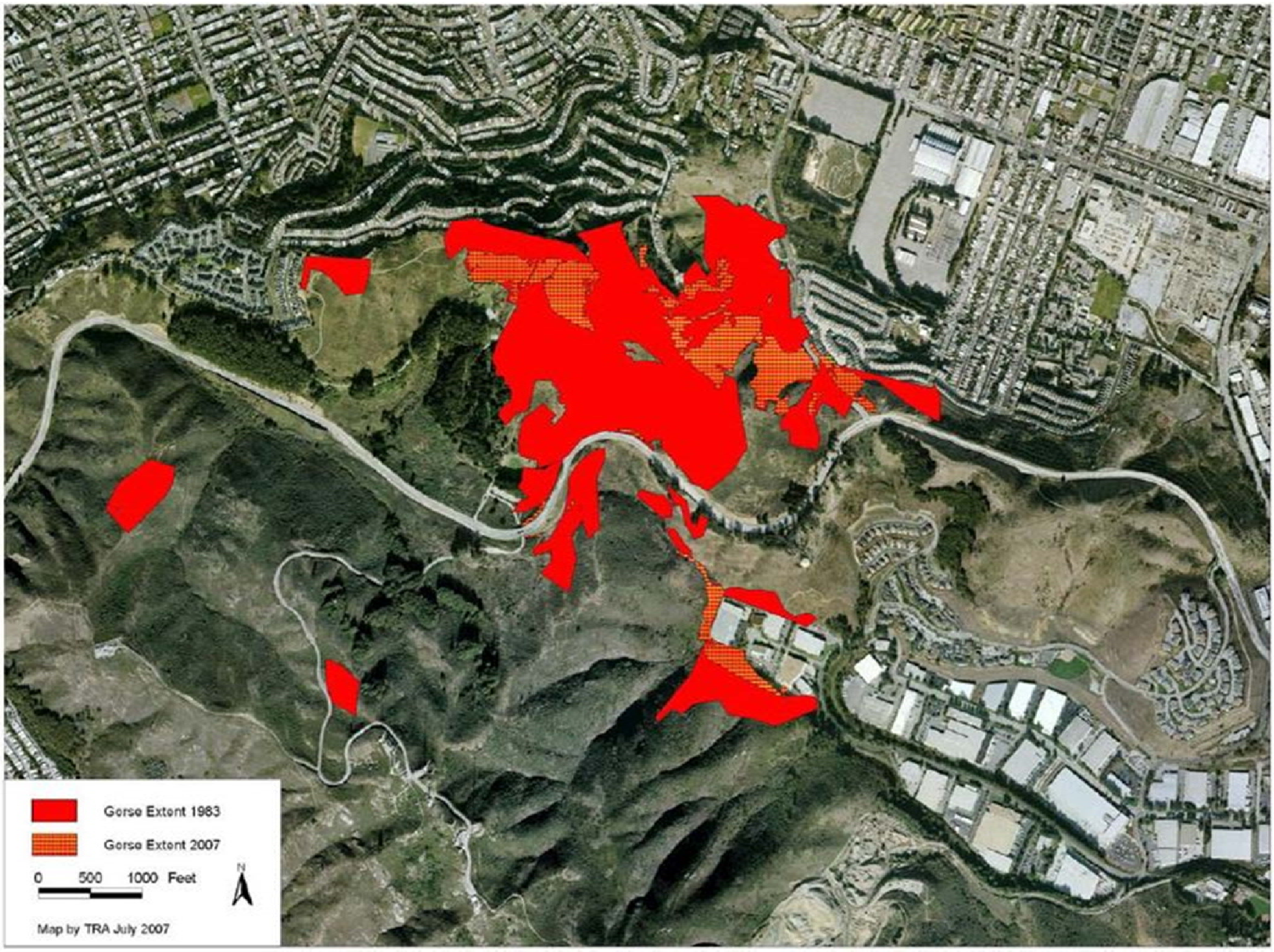


Figure 2- 1: Changes in gorse distribution (1993-2007), as reported by the 2007 HMP. Many areas still require follow-up work to remove seedlings.

Using the Saddle as an example, we highlight one of the successful gorse reduction projects (Figure 2-2). GIS maps show the treatment polygon (from 2006) and the grassland that now occupies this site (2014 aerial). A 2006 photograph shows dense gorse in nearly monocultural stands.

Figure 2- 2: Gorse treatment area 3, pretreatment photo from the Saddle looking at San Bruno summit. Photo shows the pretreatment conditions where most of the dark green vegetation in the foreground is gorse. This area is mostly clear of gorse now in 2014 (lower photo, detail view of grassland looking north (up from Saddle trail). Although the current habitat is low quality grassland habitat, it is preferable over having a gorse monoculture.

Although gorse control has been effective, the per acre cost of gorse over the 10-15 year commitment it takes to meet management goals (for instance 99% control) may not constitute the best use of limited funds. The above-mentioned snapshot was a subproject from a four year gorse removal project funded by California State Proposition 12 bond (May and Associates 2008). The treatment procedure called for Control efforts several times per year, and included spot treatment of gorse with herbicides and mechanical removal. The four year post monitoring study found the estimated gorse cover to be 2.4% measured along sampling transects. Only by 2008 were all mature plants were controlled along the transects, indicating that some mature plants can withstand 3 successive years of herbicide and mechanical removal (May and Associates 2008).

Although control projects have been effective, we believe that for the next 5 years, gorse management projects should be reduced to follow up of previously treated areas, containment of existing invasions, and treating any isolated, nascent populations to prevent seed bank establishment. Conversion of dense stands of gorse to high quality habitat is a long and expensive process that may not represent the best use of resources.

Oxalis

Oxalis, or Bermuda buttercup, (*Oxalis pes-caprae*) is an aggressive perennial plant that invades grasslands and reduces the cover of host and nectar plants. Oxalis has been known to be a threat to San Bruno habitat since at least 1990 when the Flora of San Bruno notes the plant as "common" and a "very troublesome weed" (McClintock et al. 1990).

In FY2012/13 an aggressive oxalis treatment was initiated on a new population found on the Ridge trail. In 2013, a follow-up treatment reports a 50% reduction in cover in the treatment polygon (WCW, 2014). A second oxalis reduction project in the Owl/Buckeye area reports an 85% reduction after 2 years (page 6, WCW 2014). We recommend continuing each of these oxalis control projects, but there is a need for more quantitative monitoring in order to determine if eradication goals can be met. Pretreatment photographs from the Canon sign area (Figure 2-3) indicate an area where oxalis is well established at the edge of higher quality grassland habitat. It would be instructive to rephotograph this area 3-4 years post-treatment to assess the value of the management project.

Figure 2- 3: Oxalis at the "Canon" sign area. Oxalis is well established in this area bordering higher quality grassland habitat, February 2011.

Fennel

Fennel (*Foeniculum vulgare*) is a perennial semi-woody forb that can colonize grasslands and compete with host and nectar plants. Fennel is of particular importance since restoration after removal of fennel has shown to be extremely difficult, often leading to annual grass conversion in treated areas (Ogden and Rejmanek 2005). This research informs us that these sites may require an extra management action (i.e. seeding, solarization) after herbicide treatment in order to restore high quality grasslands. Fennel is well distributed on the south faces below the Ridge Trail, and it is especially easy to recognize in the late summer when the yellow inflorescences are in flower (Figure 2-4). Although effort is being placed into cutting, digging, and spraying this plant, it is difficult to understand how effective the work has been when considering the full infestation. In light of current research on treated and untreated fennel (Ogden and Rejmanek 2005) we recommend close monitoring of a subset of locations treated for a) reduction in fennel cover and b) presence/cover surveys for desirable plants to ensure that funding is being spent wisely. We recommend any future work with fennel initiate a set of permanent transects that will report at minimum frequency of the plant encountered along 200-500 meters of transect.

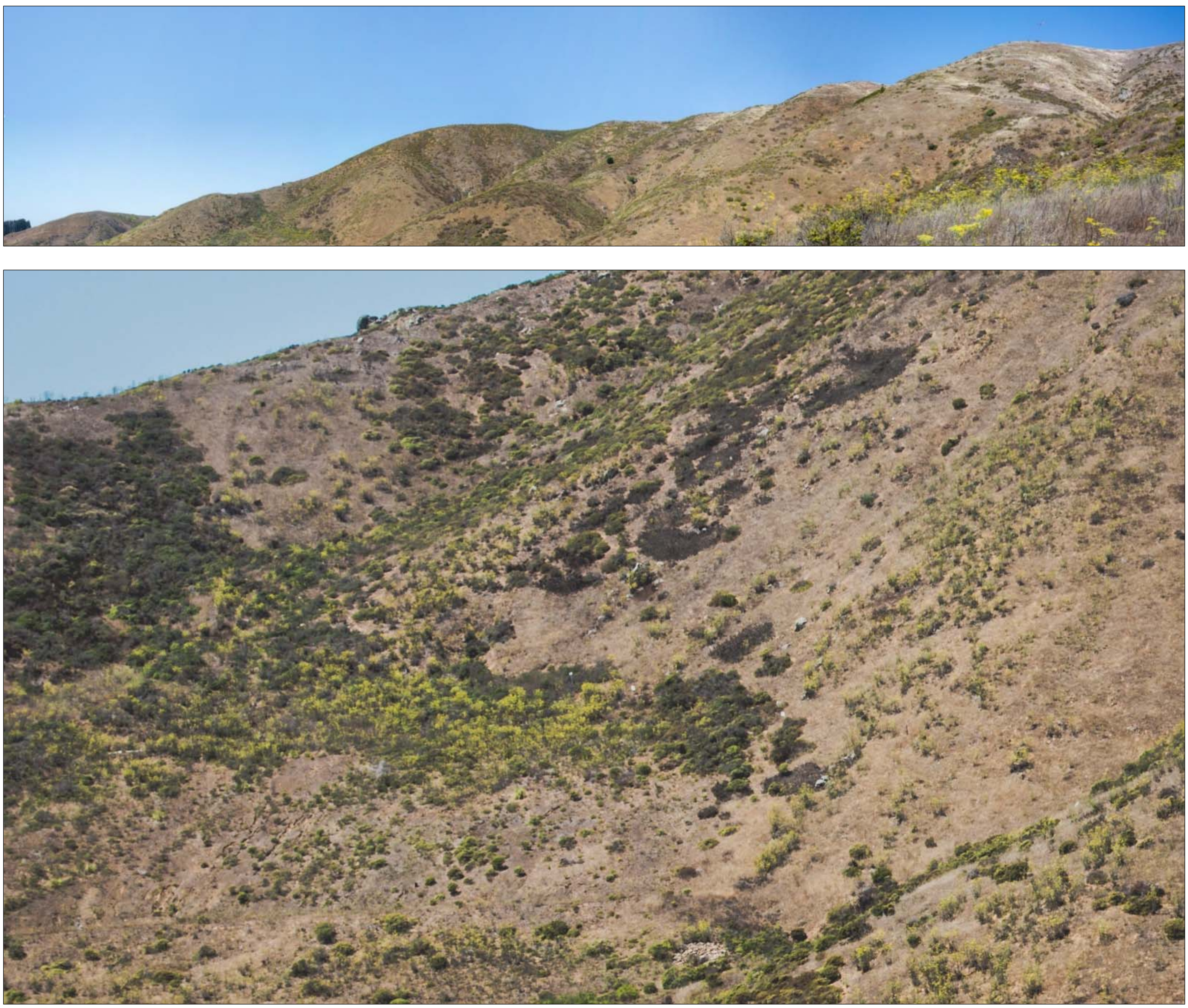


Figure 2- 4: Fennel on the South face of San Bruno Mountain, Main Ridge, August 2014. Lower photo is a magnified section of top panorama.

Scrub Management

Unfortunately, as discussed in depth in Chapter 4, we feel that this particular goal of the HCP has been largely unmet. Scrub control efforts are rarely documented until 2012, when management priorities were refocused toward scrub removal. Within the past few years, the County and WCW have initiated more scrub control projects, but the results aren't well documented in annual reports. We recommend, at a bare minimum, documenting areas of scrub removal with photopoints, which should be taken annually for at least three years. Before/after photos should be included in reports.

One example of cost effective scrub removal is offered from a removal project on the Ridge trail in 2014 (Figure 2-5). We highly recommend continuing efforts at this level in targeted areas, namely Priority Grassland Areas (see Chapter 5). We would recommend this site is rephotographed and the project is described for the 2015 Vegetation Management Activities Report.

Figure 2- 5: Southeast Ridge scrub treatment before (left) and after (right) photos. An example of well-documented photo monitoring that allows for an easy assessment of the project. We recommend rephotographing this area annually three years after treatment, March 2014.

Photodocumentation is an extremely powerful tool when planned and executed correctly. Although we recommend that professional monitoring be used for land management activities, citizen scientists may be able to help collect important information in several key areas where easy photopoint brackets identify standard, repetable locations where photographs can be taken (see Chapter 9 for more information).

Recommendations for Reporting Results

The annual Vegetation Management Activities Report written by WCW offers a fair assessment of the annual work that has been completed (e.g. WCW 2014). The annual effort that WCW places into managing HCP lands is impressive. We recommend the following additions to further improve on what we believe to be a good product:

1. Reports should include an appendix that shows the annual budget for that management year. This can simply be cut and pasted from the original budget document presented to the Technical Advisory Committee (TAC). Any substantial deviations from the preliminary budget can be reported here.
2. A self-assessment of value of each management task would be informative. As reviewers of the past reports, it is extremely helpful to understand how the contractor would evaluate the effort and cost of the treatment. A simple 1-5 scale could be used to assess whether a project is exceeding expectations (5) at its best, to limited value (1) if poor to no results are observed. This simple 1-5 rating will allow a reader to understand if the contractor recommends continuing the current project. An easily identifiable *Contractor Assessment* comment section, as brief as 1-2 sentences, could be included at the end of each chapter.
3. When introducing new projects or treating new invasive species, we recommend implementing a simple two part monitoring technique so results can be easily evaluated for cost (effort) and results. 1. Establish and GPS (map) a photo monitoring location that is easy to relocate without GPS (a rock, a tree, a power tower, etc.). Take one pretreatment photo, one after treatment effects can be observed and rephotograph before and after any additional work is completed. These photographs should be included in reports. 2. Utilize a 50 meter tape and place it in the treatment area. Tape can be placed in a non-straight line as long as it is placed in a random line/polyline that is well dispersed through the treatment area. Record if the invasive plant is present at each of the ½ meter marks (a total of 100 points). This will provide a simple quantitative estimate of cover. If cover is below 5% (5 hits), further declines will be difficult to detect. Instead monitor frequency by recording the number of 50-cm segments (out of 100) that touch the target plant.
4. Each invasive species project should be assigned one of three goals: 1) eradication (total elimination), 2) control (decrease of whole population to a predefined cover, such as less than 1%), or 3) containment (establishment of a hard perimeter, outside of which all individuals are treated). At this point, and for the near future while the budget is limited and scrub management is a priority, the majority of weed work needs to be directed towards containment and locally focused control. Eradication of a weed population should generally be used only in early detection/rapid response scenarios.

Management for Non-Butterfly Related Resources

One glaring omission in the 1982 HCP Volume II is managing for the benefit of other covered species. The 2007 Habitat Management Plan offers little insight into the current trends of other covered species, nor is any management or research recommended. The following tasks have been completed (TRA 2007):

> "Rare plant distribution data has been collected in GIS format within the last 5 years for all plant species on San Bruno Mountain that are listed federally, by the state, and/or CNPS List 1B species (Appendix D). This includes the manzanita colonies (all species), Diablo helianthella, San Francisco Lessingia, San Francisco spineflower, San Francisco campion (*Silene verecunda verecunda*), and dune tansy (*Tanacetum camphoratum*). Historically reported occurrences of white-rayed pentachaeta (*Pentachaeta bellidiflora*) and San Francisco gumplant (*Grindelia hirsutula maritima*) occurrences on San Bruno Mountain have not been verified."
> (TRA, 2007)

No actual mapping has been completed. We recommend further study of other covered species including an analysis on trends, threats, and management recommendations. Further discussion on evaluation of other covered species (excluding MB, CS, SBE) is offered in Chapter 7 as well as in a recent report from the community (Nelson et al. 2015).

Chapter 3. Assessment of butterfly monitoring techniques: butterflies, habitat, and host plants

Summary

Butterfly monitoring on San Bruno Mountain (SBM) has two goals: 1) establish distribution of butterfly species and 2) track abundance of butterfly populations. Here we assess the accumulated adult transect data and analyses of previous wandering transects, and San Bruno Elfin (SBE) larval counts, with the goal of designing a hybrid system that uses established fixed transects for abundance tracking, and rotating occupancy surveys in specified areas to track overall distribution.

As per HCP guidelines, regular efforts to monitor listed butterflies on San Bruno Mountain have provided insight into three of the four covered butterflies (the 4th covered butterfly, Bay Checkerspot, has not been observed on the mountain since the mid-1980s).

Our observations and conclusions are:

- The transect system is robust for tracking abundance in high quality areas for both Mission Blue (MB) and Callippe Silverspot (CS). There are no long-term trends in adult butterfly observations in high quality areas where grassland remains intact, only fluctuations within a reasonable range for butterfly populations.
- Recent population declines in peripheral MB and CS transects are the result of scrub encroachment. Over the long-term, scrub encroachment has reduced butterfly habitat and populations on many parts of SBM, and much more grassland is at risk in the near future.
- SBE surveys, both adults and larvae, indicate that occupancy has remained stable through time, and larval abundance has not fluctuated greatly since 1999. We suggest that presence/absence surveys for SBE on a multi-year interval may be adequate for monitoring.
- We recommend a combination of methods that will provide a useful picture of the distribution and abundance of butterfly populations, including tracking adult MB and CS abundance in core habitat areas using the existing transect system, monitoring MB occupancy in peripheral areas on a multi-year cycle, and rigorous testing MB egg counts to provide a potentially robust method for weather-independent tracking of population density in select areas.
- Incorporating host plant mapping and monitoring into butterfly monitoring provides the direct link to habitat restoration efforts, and we recommend that lupine and *Viola* inventories be completed in selected areas over the next 5 years.
- Lupine counts combined with MB egg counts can be used to estimate the order of magnitude of local populations, and provide a measure of restoration success as newly established lupines are used.

Butterfly population biology

Butterfly populations are capable of huge fluctuations over orders of magnitude because of high reproductive output (an individual female can lay one hundred or more eggs over a short lifespan) and high mortality of immature stages. The driving forces of mortality are diverse, and include annual weather causing direct mortality and driving phenological synchrony/asynchrony with host plants, parasitoids and predators, and availability/quality of host plants and nectar sources.

The availability of host plants is the fundamental limitation of butterfly habitat over the long-term. Maintaining and Increasing the distribution and abundance of host plants on San Bruno Mountain should be the primary focus of habitat management and restoration.

The spatial structure of habitats, combined with limited dispersal, creates separate local populations that can fluctuate independently, spreading the risk of population extinction. The spatial structure creates a metapopulation (population of populations) where local extinction, recolonization, and demographic rescue play out through time. The San Bruno Elfin is a good example of highly discrete habitat – patches of *Sedum* on rocky north-facing slopes separated by scrub and grassland with no host plants. The grassland habitat across much of SBM has declined in area and has become more fragmented through time with scrub encroachment. The metapopulation concept is applicable to MB and CS, albeit at different scales.

Review of previous work

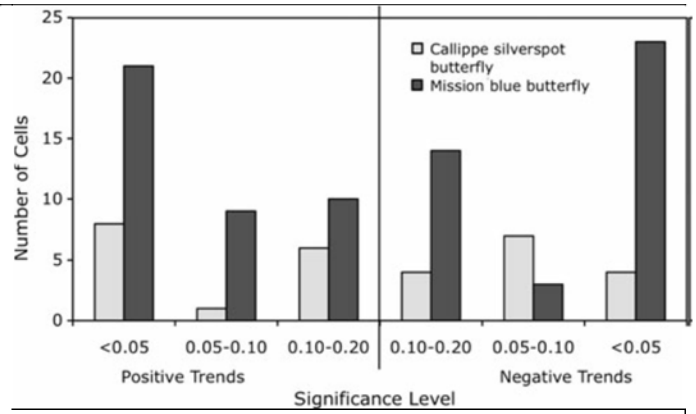
The original mark-recapture studies in 1980 and 1981 provide an important baseline on the population size, structure, and connectivity of MB and CS. The population sizes of MB and CS on SBM were estimated to be 18,000 and 7,000 respectively. The overall populations were divided into subpopulations by intervening scrub and development, but dispersal rates were high enough to tie these subpopulations together genetically. Typical MB dispersal distances are on the order of tens of meters, with occasional longer flights over hundreds of meters; MB stay very close to their host plants. CS is much more mobile and dispersal distances of hundreds of meters are common, males strongly hilltop, and adults may be found far from stands of *Viola*.

A review of the first 20 years of wandering transects by Longcore et al. (2004, 2009) showed changes in both MB and CS distribution. Trends in occupancy at the 250 m scale were mixed across SBM in well-sampled areas (Figure 3-1). MB occupancy exhibited 22 cells with strong ($p<0.05$ logistic regression) negative trends, and 23 cells with strong positive trends in occupancy. CS shows fewer strong trends in either direction (8 decreasing and 3 increasing). The cells with strong declines correspond to scrub encroachment and development areas.

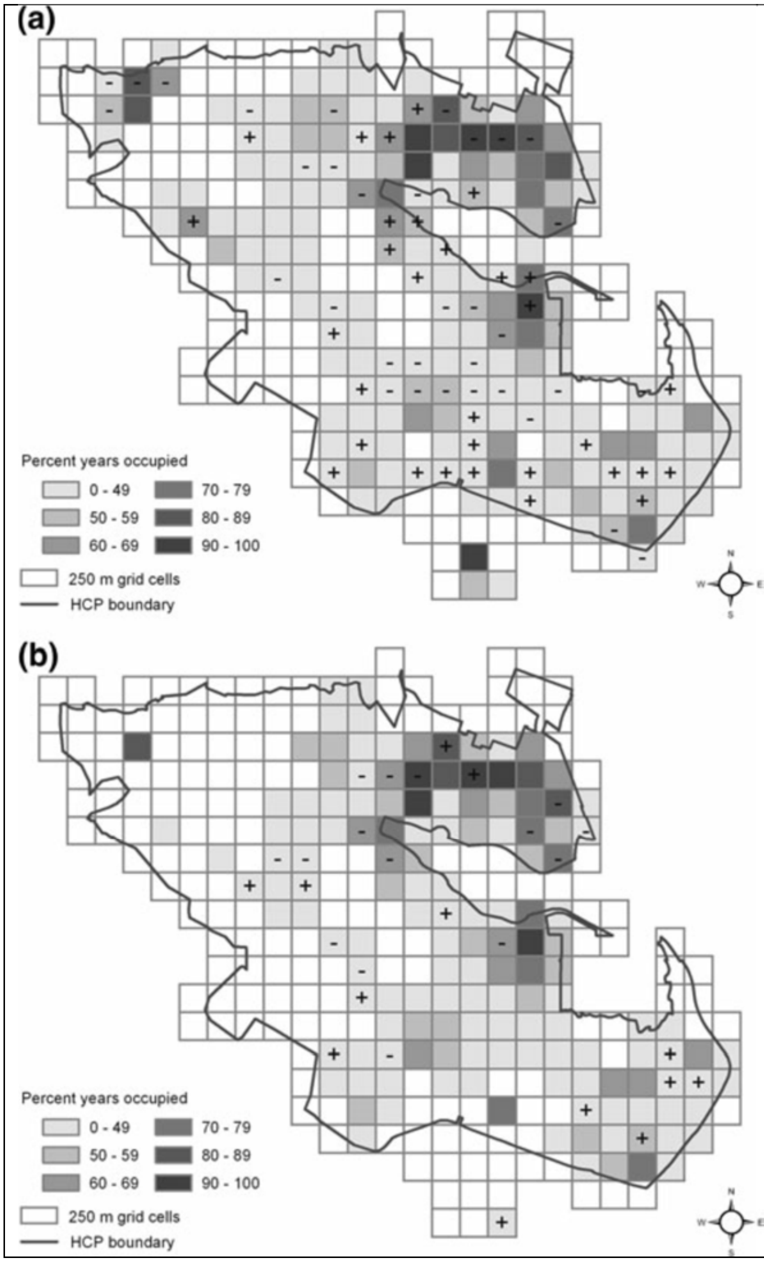
A finer scale example of habitat loss detected by the wandering transects is shown in Figure 3-2 (reproduced from 2007 Habitat Management Plan). The encroachment of scrub into grassland in Buckeye Canyon has obviously reduced the area occupied by MB between the 1980s and 1990s. However, this reduction in habitat will not necessarily produce a trend in occupancy at the 250m scale, except when a cell nearly completely fills in with scrub.

The wandering transects established the full distributional range of both butterfly species across SBM, and demonstrated that declining occupancy trends track local declines in grassland habitat. These localized declines will be discussed later in management strategies for MB and CS. Longcore et al. (2004) proposed a method of monitoring occupancy by visiting 250 m grid cells across the mountain three times during the season. This monitoring design was determined to be well beyond the scope of a typical annual SBM HCP budget.

The wandering transects have proven less useful for tracking abundance. The lack of standardization from year to year prohibits direct comparisons of densities (butterflies/hr) without attempting to use complex statistics to adjust for level of effort. Longcore et al. (2009) pushed the data as far as feasible, and further work on this data set are unlikely to yield any more information.



Above: Significance of trends in presence by cell for Callippe Silverspot butterfly and mission blue butterfly (from Longcore et al. 2009, Fig.6)



Left: Status and trends of Mission Blue butterfly (a) and Callippe Silverspot butterfly (b) at San Bruno Mountain. Percentage of years occupied is depicted for all cells surveyed for 10 or more years 1982–2000. Trends in occupancy ($P < 0.20$) determined by a logistic regression are indicated with + and - symbols in cells surveyed at least 10 years (from Longcore et al. 2009, Fig. 5)

Figure 3-1: Summary figures from Longcore et al. 2009 for 1981-2001 wandering transect data.

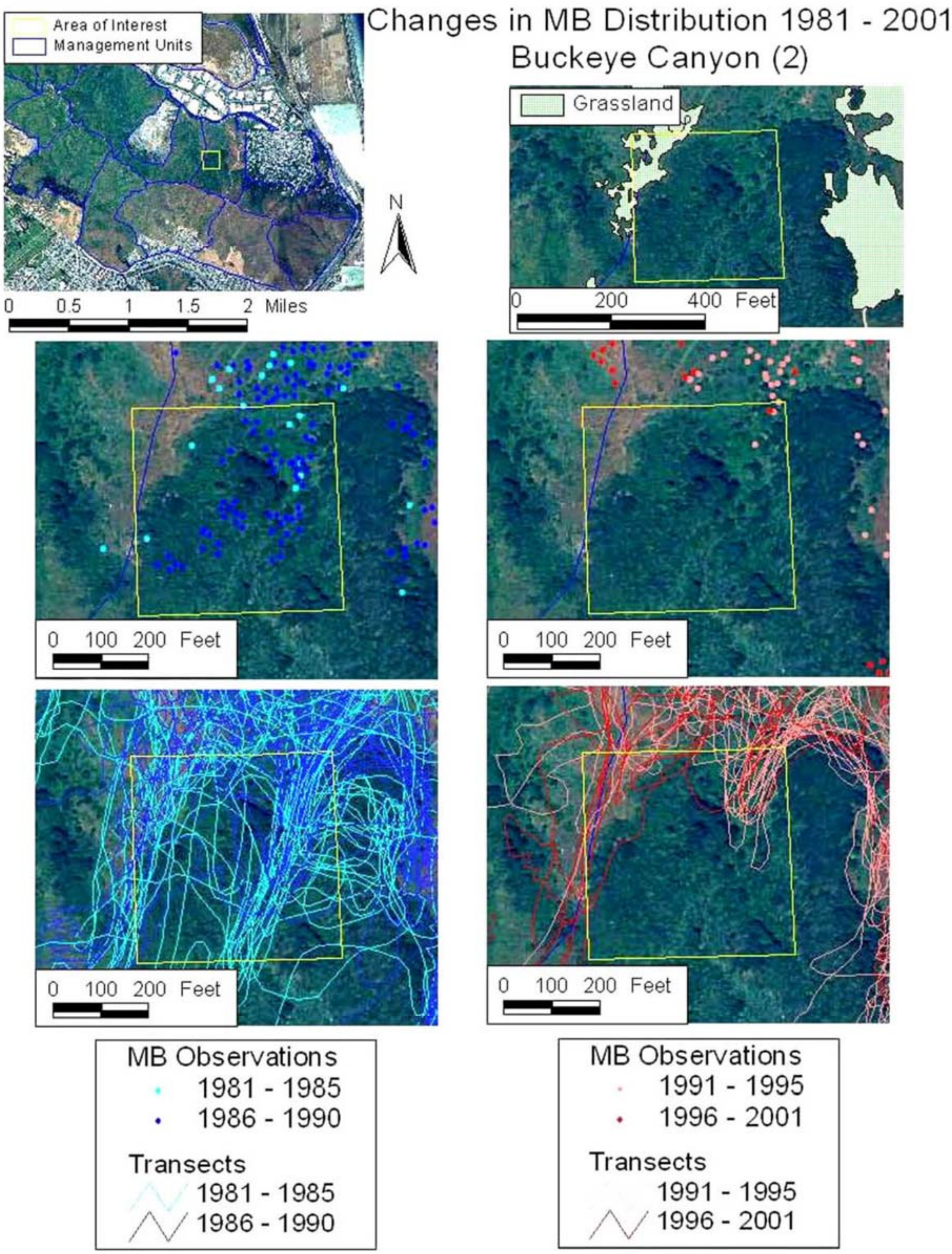
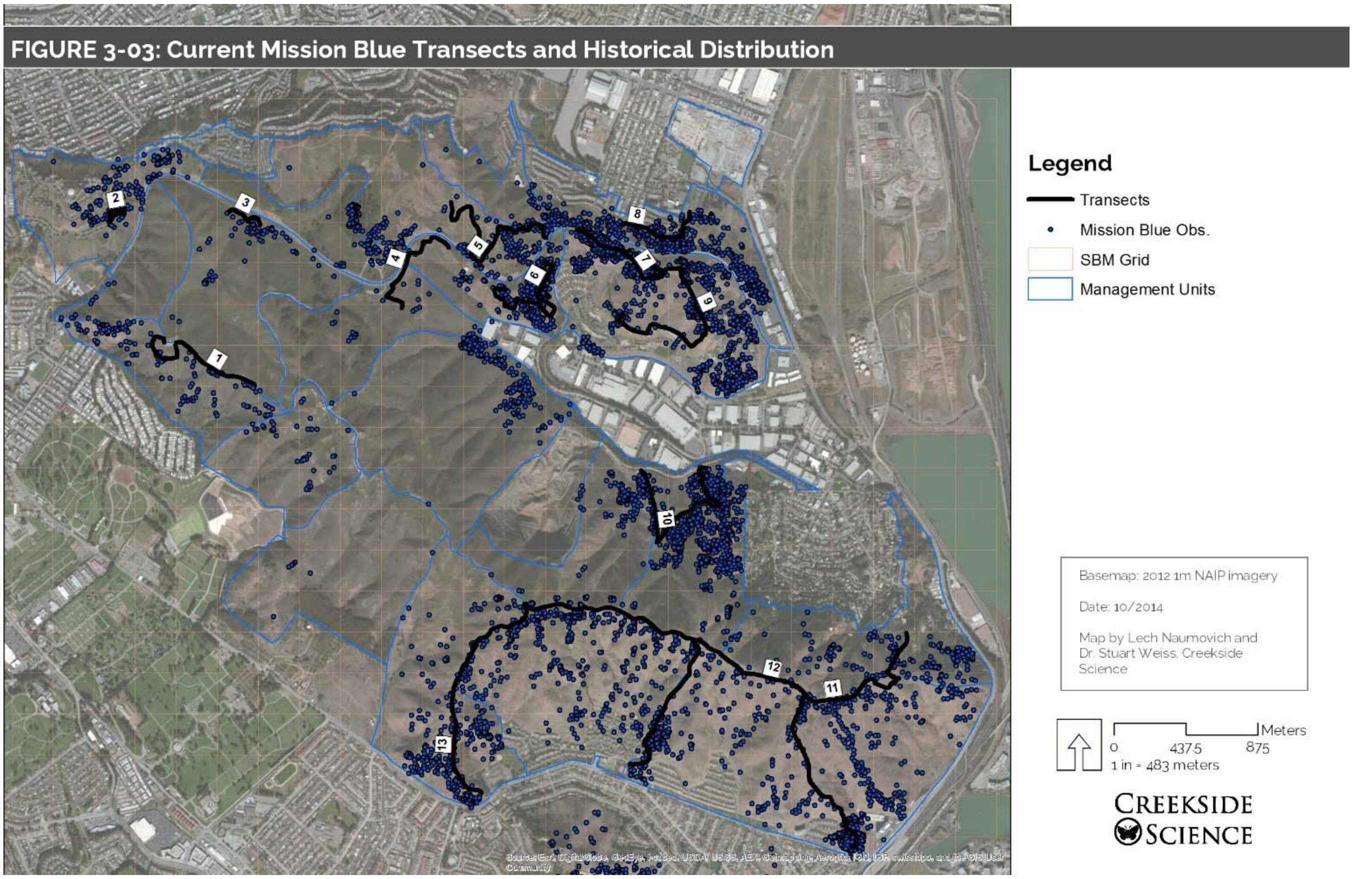


Figure 3-2: Change in MB in Buckeye Canyon (Figure 14 from 2007 Habitat Management Plan) indicates former occurrences and survey patterns before scrub became established. Scrub has moved into once occupied habitat.

Mission Blue Transects

From 1998 to 2005, adult MB were monitored annually using short fixed transects. An analysis of 4 years of these data in the 2003 Monitoring Report was inconclusive - statistical power was low because of low numbers observed, the level of effort involved was high, and the overall distribution of MB were not being tracked. Longer transects for MB abundance were initiated in 2006. The 2006 - 2012 transects, overlaid with the 1981-2001 distribution data are shown in Figure 3-3.



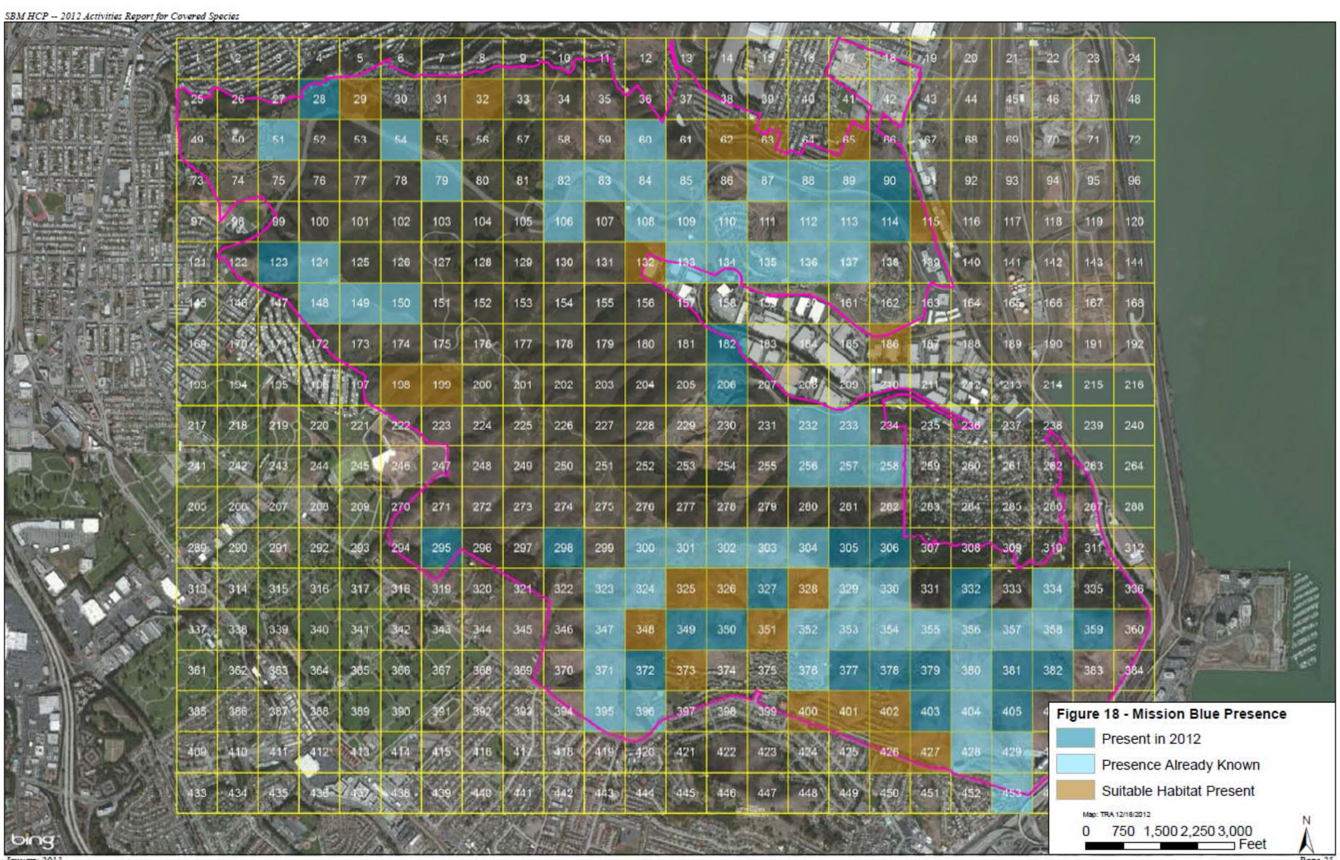


Figure 3-3: Current Mission Blue Transects and Historical Distribution and Results of 2012 presence surveys

These MB transects have been sampled every other year for a total of 4 rounds 2007-2013. Peak densities are used as the population index. Transects cover most of the MB distribution. Notable exceptions include lower Olivet Ravine, Summit and Serbian Ravine, the eastern part of the NE Ridge (some lost to development), and Devil's Arroyo (much lost to scrub).

In 2012 a comprehensive presence survey was executed, and resulted in confirming occupancy in 23 cells in addition to the 58 already known cells. These new confirmed cells correspond mostly to the peripheral areas identified in the wandering transects 1981-2001, as well as filling in unsampled parts of the South Slope and Southeast Ridge.

The mean and range of peak densities by transect are shown in Figure 3-4. Note the logarithmic scale. There are two classes of transects, core and peripheral. Seven core transects had average densities >5/hr and never fell below 1/hr. The high values along T11, T12, and T13 on the South Slope and Southeast Ridge indicate a large dense population occupying many lupine patches along the ridgeline roads, rock outcrops, and thin/disturbed soils throughout the grassland. T11-SE Ridge in particular had the highest densities and lowest variability, and includes a large patch of *Lupinus formosus*. These densely populated transects provided a total of 111 adult female butterflies for translocation to Twin Peaks in 2009, 2011, 2012, and 2013, and did not exhibit any measureable decline.

T10 Owl-Buckeye has been reduced in extent and is now more isolated by scrub from the large SER-South Slope complex, but densities remained locally high (8/hr) as of 2013. Note that densities declined to ~1/hr in Owl-Buckeye in 2009 following the 2008 fire, but recovered to ~10/hr in 2011 and 2013.

The other 6 transects averaged <2/hr and had at least one year with <0.1/hr. Several of these peripheral abundance transects were modified in 2013 into presence/absence transects.

How many MB are there on SBM? In the 1983-84 TRA monitoring report, it was calculated that a rate of 1 MB/hr translates into a density of 8.1 MB/ha (3.38/ac). Because lupines are not randomly distributed across the grasslands, and transects traverse relatively high density lupine stands along ridgelines and dirt roads, a simple extrapolation to the entire grassland area would be misleading. But, limiting the extrapolation to just a 10 m swath multiplied by transect length gives a one day peak density estimates between 1,098 and 1,526 MB over the 4 sample years. Obviously, the habitat extends well away from the transects, many high density areas are not sampled, and the flight season lasts several weeks, so we can confidently say that that there are many thousands of MB on SBM over the course of a flight season, likely in the range estimated in 1981 (18,000) with the majority on the Southeast Ridge and South Slope. This avenue of population estimation should be pursued in more detail, contingent on mapping lupines in selected areas.

Future Monitoring of Mission Blue

Moving forward, the core transects should be continued, with the current spacing of 10-20 days between samples. This timing captures the population peak, and allows for complete population turnover between samples, and captures much of the phenological diversity afforded by the complex terrain on SBM and diversity of lupine species. *L. formosus* in particular provides a later flight season, especially on cooler slopes.

The peripheral transects can be reduced to presence/absence (a process already occurring). Once it is established that habitat is occupied, no further visits are necessary. In addition, a rotating occupancy survey (~5-year interval) in recently unsampled areas (Olivet Ravine, Serbian Ravine, West Quarry, and interstices among transects on the South Slope) should be instituted to monitor the overall distribution of MB, with a goal of inventorying the distribution over the next few years. Establishing occupancy on the grid system on a five-year rotating basis would effectively track distribution. The 2012 presence surveys reproduced above provide the new baseline for distribution.

We also recommend estimating lupine populations on an appropriate logarithmic scale in key grid cells using methods described below.

Eggs can also establish occupancy. MB eggs are readily observed over a several week period, independent of weather. With some training, MB eggs can be readily distinguished from other insect eggs. Based on recent work at Twin Peaks, each MB female lays about 70-90 eggs in her brief lifespan. These occupancy surveys should be coordinated with estimates of lupine populations (lupine surveys are discussed below in host plant mapping/monitoring). Weekly samples of 30 lupines have proven sufficient to estimate relative MB numbers on Twin Peaks, and are being calibrated to approximate absolute population sizes. Egg surveys can demonstrate use of restored host plant populations (distinguished by lupine species). We suggest that MB egg surveys be tested in peripheral areas, as well as some select core areas, to work out operational details.

Post diapause MB larvae can also be found by skilled observers, but are far fewer and more cryptic than eggs. Distinctive feeding evidence on lupine leaves ("window-pane") can also be detected. At low MB densities, high numbers of lupines need to be searched and the level of effort is greater than egg surveys. Post diapause larval surveys should only be used in highly targeted situations, such as to definitively determine patterns of use of restored lupine populations.

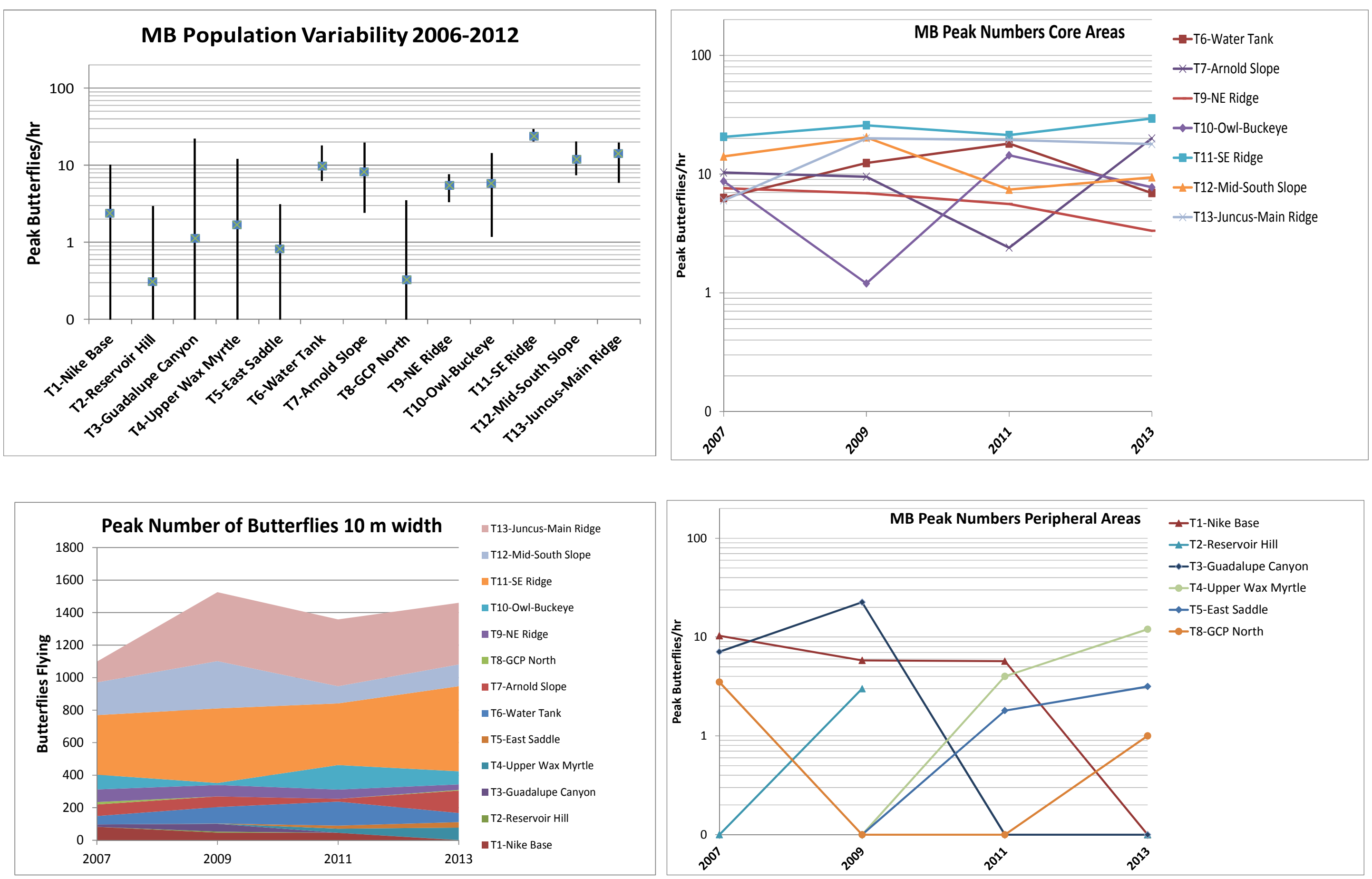
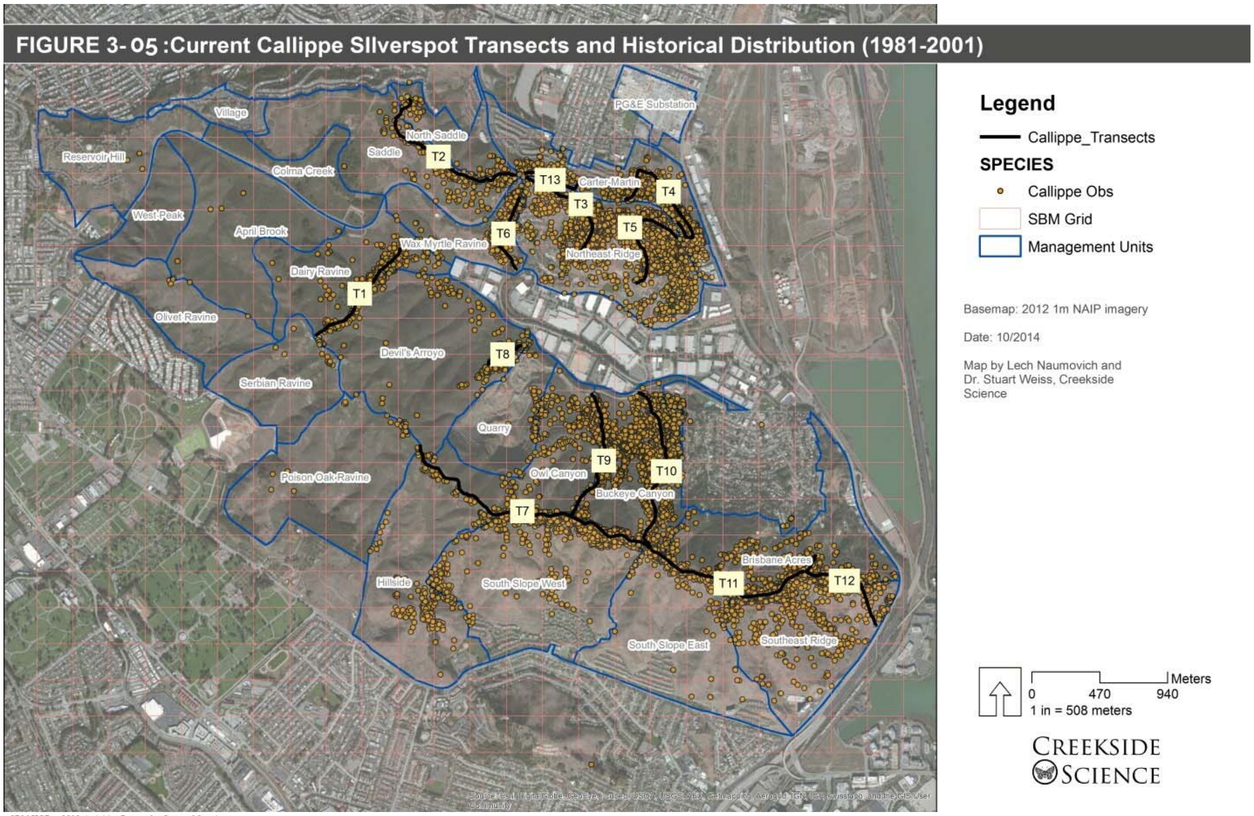


Figure 3-4: Mission Blue Variability (top left), Peak Densities in Core Areas (top right), Peak Densities in Peripheral Areas (bottom left), Peak Numbers in a Belt Transect (bottom right). Note: data is not continuous, lines are only used to connect points in order for the reader to more easily follow the individual populations.

Callippe Silverspot Transects

In 2000, long fixed transects for CS abundance were initiated. The 2000-2012 transects and the 1981-2001 distribution data are shown in Figure 3-5. These CS transects were sampled annually from 2000-2006, and biannually since then, for a total of 10 rounds 2000-2012. Typically, 4-6 survey rounds are done to make sure that the peak seasonal density of the season is captured, but the most recent survey year reported (2012) had 3 rounds. Peak density is a consistent index of population size and its continued use is recommended. Because populations experience exponential growth and decline, it is critical to track density/abundance on a logarithmic scale.

In 2012 a comprehensive presence survey was executed, and resulted in confirming occupancy in 13 cells in addition to the 52 already known cells. These new confirmed cells correspond to most of the peripheral areas identified in the wandering transects 1981-2001. The area around Hillside/Juncus appears to be a subpopulation worth monitoring for abundance in future years (see below).



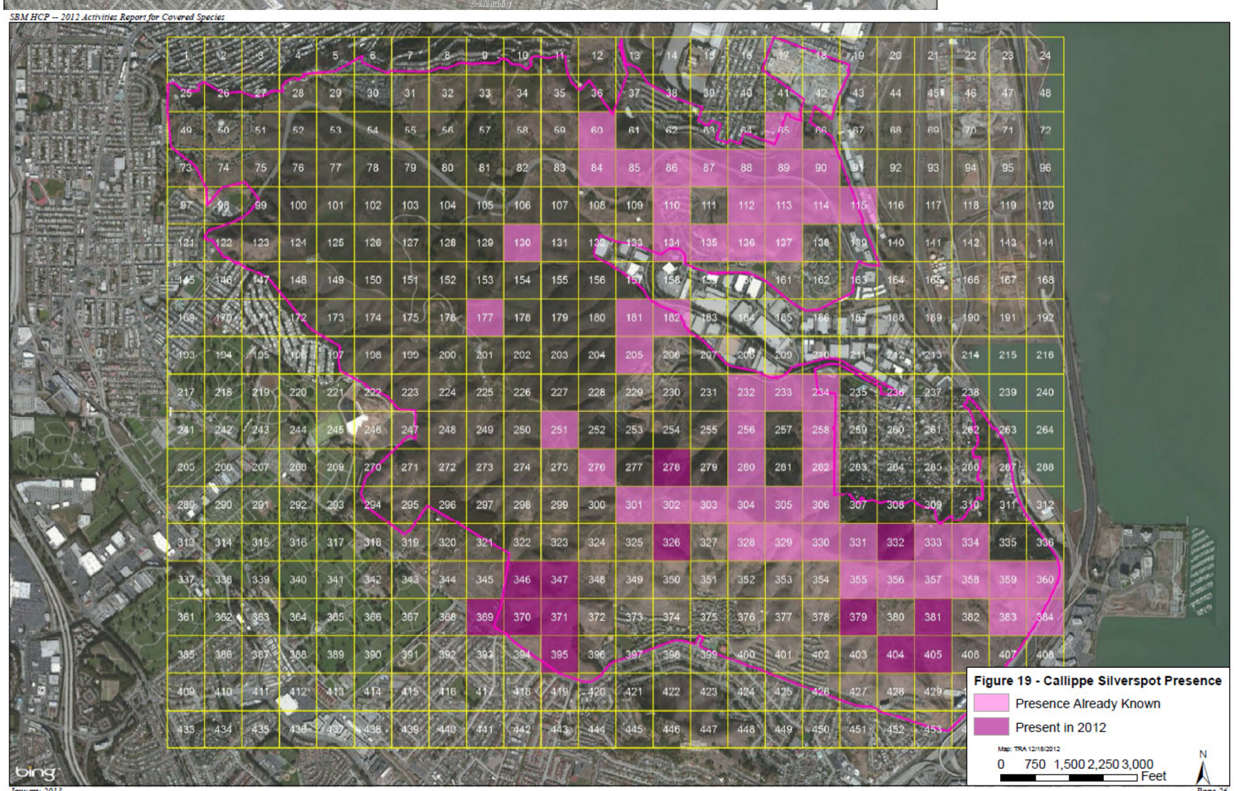


Figure 3-5: Current Callippe Silverspot Transects and Historical Distribution and Results of 2012 Presence Surveys

The summary of mean, maximum, and minimum peak densities observed in the 10 sample years shows several patterns (Figure 3-06). The highest annual peak density was 132/hr on Transect 11 (SER-Mid, above Brisbane). The geometric mean values for core habitats on the Southeast Ridge, Owl-Buckeye, and Northeast Ridge ranged 20-40/hr. The range of density variability observed in the core habitats was about a factor of 6-10.

The actual annual and biennial densities in the core transects show no long-term trend. A few notable short-term declines include T12 SER East in 2002 and T9 Owl-Buckeye in 2003, followed by recovery to more typical, pre-disturbance values between 10-20/hr. The T9 Owl-Buckeye transect also documented a decline from 30/hr in 2008 (just prior to the June 23, 2008 fire) to 10/hr in 2010, and a recovery to 25/hr in 2012. Peak densities were even higher in 2014 (Autumn Meisel, TRA Environmental, pers. comm.). This indicates that CS can repopulate fire areas over the course of a few years, and can take advantage of the increases in Viola that typically follow fires.

The other set of transects are in more peripheral areas, and have exhibited declines through time (with the exception of T4 GCP East). T8 Quarry West is still extant in an ever diminishing grassland area. CS declines correspond to areas of scrub encroachment. The T1 Summit transect is barely occupied (possibly a stray since most grasslands with Viola is gone from this area), the butterflies observed on these areas are likely wide ranging transients.

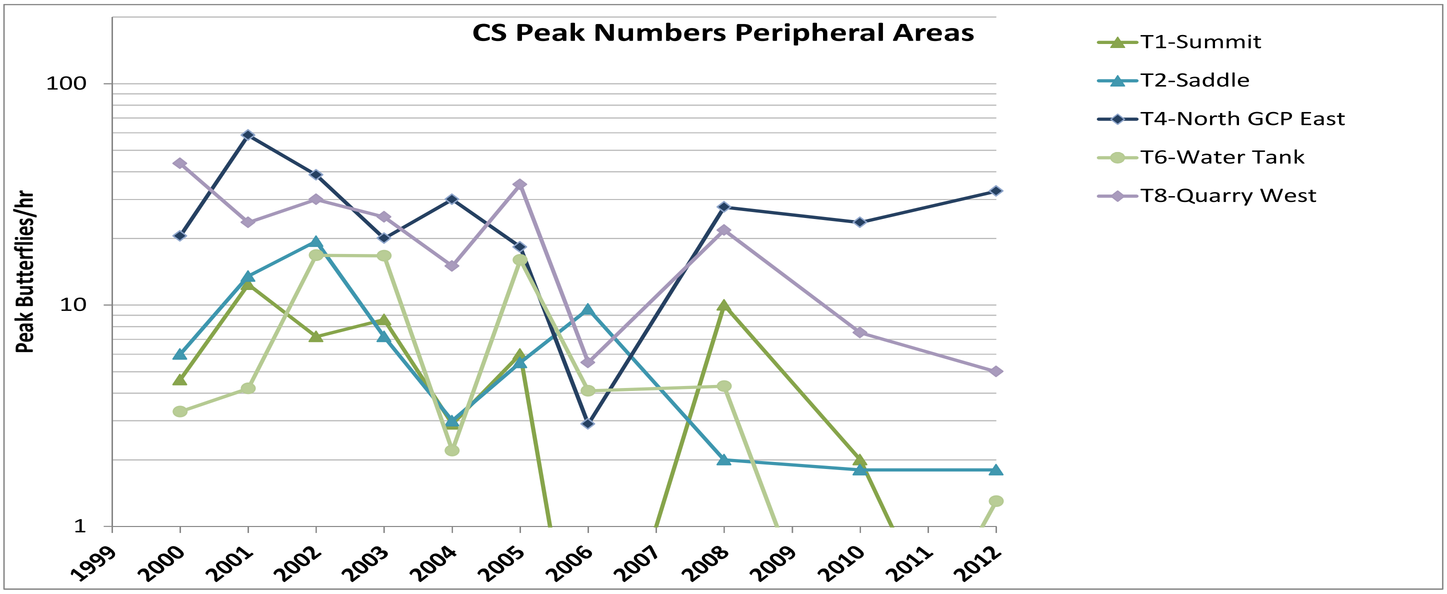
The CS transects overall indicate that the core areas that have maintained grasslands continue to support CS with fluctuations that are normal for butterfly populations. The declines in the peripheral areas, as well as the historical contraction of distribution, indicate that scrub encroachment is the single largest threat to CS populations. Key CS areas that are at risk of scrub conversion include Owl-Buckeye and Brisbane Acres. CS habitat and Viola distribution is a key factor in delineating essential grasslands (Chapter 5).

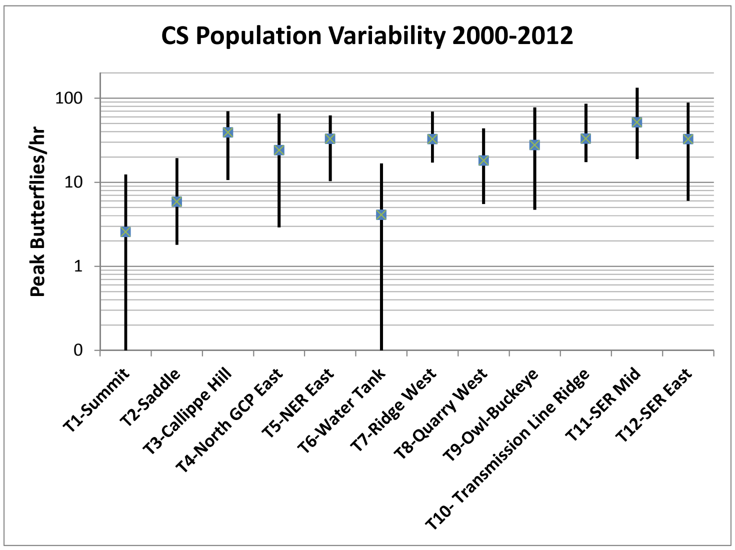
Future Monitoring of CS

The existing transects on the South Slope, Southeast Ridge, Owl-Buckeye, and Northeast Ridge track overall abundance effectively. Efforts could be saved by restricting sampling to the peak weeks (3 sample rounds spaced at least 10 days apart as in 2012, compared with 4-6 weeks in other years). Converting peripheral transects into presence absence surveys would save time and effort. In addition, establishing occupancy on the grid system on a five-year rotating basis would effectively track distribution.

We do recommend that abundance transects be instituted at Hillside/Juncus area, since this appears to be an important subpopulation that has been occupied for many decades.

The immature stages of CS are not amenable to monitoring. Larvae are cryptic and nearly impossible to find, and eggs are randomly scattered in the grassland near but not on Viola. Mapping and quantifying Viola densities (see below) would be a key addition to increase the connection between habitat management/restoration and butterfly response.





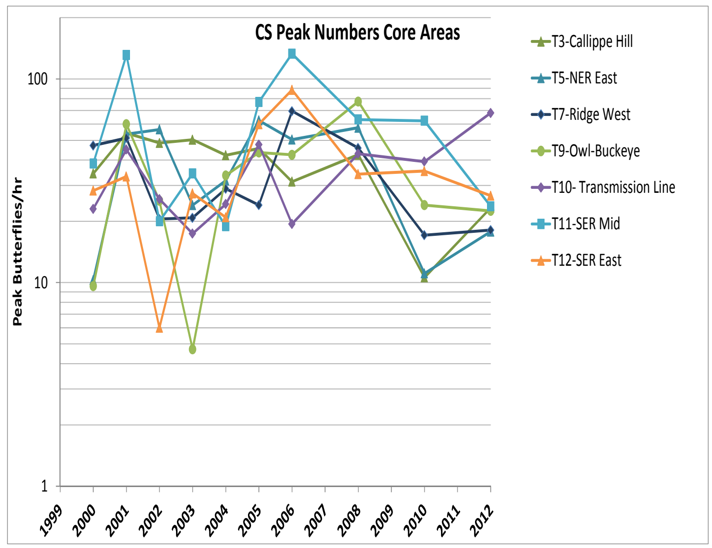


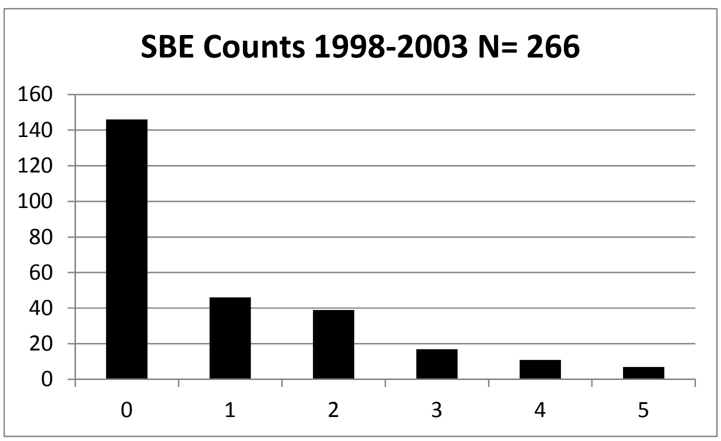
Figure 3-6: CS Variability (top left), Peak Densities in Core Areas (top right), Peak Densities in Peripheral Areas (bottom). Note: data is not continuous, lines are only used to connect points in order for the reader to more easily follow the individual populations.

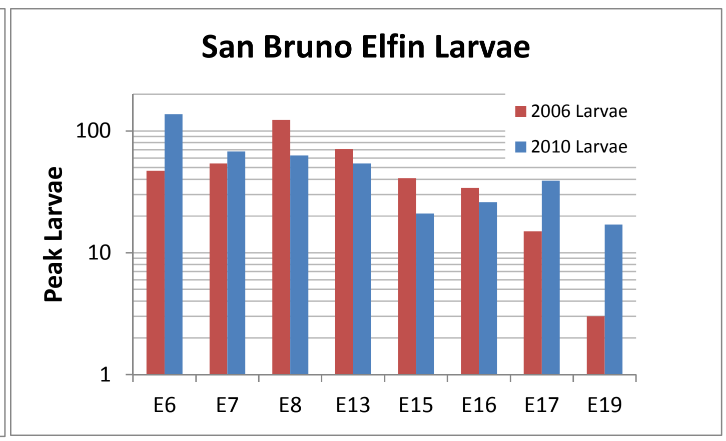
San Bruno Elfin

SBE adults were monitored in walking transects from 1981-1997. From 1998-2003, timed point counts were instituted. Daily counts were always low (0-5 butterflies/visit, Figure 3-8 top left); these low numbers prohibit tracking of abundance. Adult surveys of any reasonable intensity are not suitable for anything except presence/absence, and the fickle weather on SBM in the March-April flight season makes any adult surveys challenging. Adult surveys were stopped after 2003. The major result from the wandering transects and the point counts is that SBE occupancy has remained stable through time, but fluctuations in abundance cannot be detected reliably with adult surveys.

Post diapause larvae feeding on flowering *Sedum* are readily observed. Counts were initiated in 1999. In 2006, biennial surveys of post diapause larvae were instituted at eight sites. In 2006, 2008, and 2010, all *Sedum* within a 25 m radius were searched for larvae during the flowering season (May-June), and as much time as necessary was taken to search all plants. Only 2006 and 2010 data are presented (Figure 3-7B); 2008 surveys were incomplete and missed the peak larval season, and are useful only for presence data. When several rounds were done each year, the maximum number of larvae was taken as the population index. Data are reported on a log scale. Note that the fluctuations are not synchronous, and the changes between years ranged from a factor of 8 upward (E19) to a factor of 2 downward (E8). This synchronicity leads to spreading of risk and metapopulation persistence. Inclusion of 2014 data will bolster this data set.

The trend in total larvae observed in the 8 sites from 1999-2010 indicate a slight upward trend (Fig 3-7C), but as mentioned above, not all subpopulations fluctuated in synchrony. Addition of 2014 data to this series is desirable.





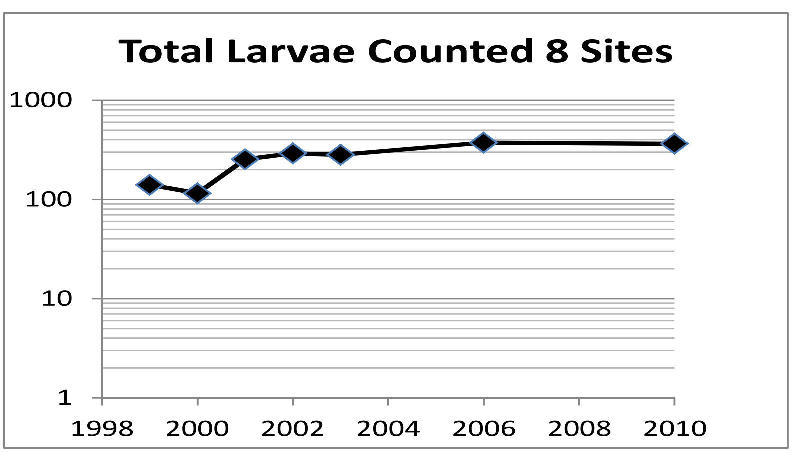


Figure 3-7: SBE Larval and Adult Counts. Note: data is not continuous, lines are only used to connect points in order for the reader to more easily follow the individual populations.

Future monitoring of SBE

The San Bruno Elfin appears to be secure in high quality coastal scrub habitat, and tracking abundance may not be worth the time and effort. An alternative is to establish presence surveys at all historic sites, using larval presence surveys at appropriate times of year (late May-early June in most years) on a 3-4 year interval. Including a short timed search (10 person-minutes) once larvae are found would allow for coarse density classes to be reported as supplementary information.

Developing host plant mapping and monitoring techniques

Host plant mapping and monitoring for the target butterfly species is potentially time intensive, but the distribution and abundance of host plants provides the true link between vegetation management and butterfly population health. Cost-effective monitoring needs to be tied to explicit management triggers and responses, and carefully designed for appropriate levels of statistical rigor. We evaluate current mapping techniques and investigate alternatives for sampling along transects and extending sampling outside transects. Appropriate methods for sampling Viola and *Lupinus* densities are considered and tested. Our methods will prescribe thresholds for initiating broader scale surveys to determine whether host plant populations are stable.

Host plant data for the CS and MB are currently not being collected quantitatively. Annual covered species reports offer qualitative information on the host plant presence, density, and restoration efforts: (e.g. See page 7 in TRA, 2012):

> "Transect 10 does not intersect a great quantity of MB host plants, although the transect does traverse grassland habitat with diverse nectar sources. Part of this transect was burned in the June 2008 fire, and Lupinus formosus is rapidly regenerating."

Although the descriptive qualitative information is valuable, an independent observer cannot quantitatively compare the host plant habitat. Quantitative field measurements allow land managers to compare densities through time unequivocally. Quantitative data may also allow for the establishment of adaptive management thresholds based on host plant density.

Given time and budgetary constraints, we recommend two different host plant mapping techniques: one for Viola and a second for *Lupinus*, which will allow for a land manager to easily monitor trends and determine when action should be initiated. Both techniques rely on density of host plants as a reliable indicator for habitat quality.

Viola mapping for Callippe Silverspot

Viola (*Viola pedunculata*) is a low growing perennial forb that serves as the sole host plant for the Callippe Silverspot butterfly. A high local density of Viola is critical for the CS given that the plant is usually dormant at the time of oviposition. Newly hatched larvae have a finite capability to move to a host plant before they run out of energy, so high densities increase survival through the larval stage.

Two methods for measuring Viola density were tested in the field. The point-centered quarter method is ideal for plants with a random distribution. In the field, at high densities, this method was quick, but once we encountered lower density areas, we spent quite a bit of time wandering and looking for the nearest plant. Results from two pilot transects in a high and low density area were statistically the same, indicating this method is fairly low resolution, and especially inappropriate for a clumped distribution of plants.

The second method we piloted was the plotless wandering quarter distance (PWQD) method. This method is ideal for clumped or irregularly distributed plants (Figure 3-8). PWQD was able to discern between low-density habitat on the Northeast ridge and denser habitat on Transmission Line ridge (Table 3-1).

Table 3-1: Pilot Viola Density Measurement Results using PWQD

General location	NE ridge (east)	NE ridge (south)	Transmission Line ridge
Density of Viola plants per meter^2	**0.23**	**0.36**	**1.87**
Distance of transect	105	23	107
Standard Error	0.45	0.07	0.06

In high density Viola habitat we often found that plants were nearly overlapping. At lower densities, plants were still fairly easy to locate within the allowable 90 degree angle, but the standard error tended to be higher. The most critical shortcoming to this method is locating areas where data can be recorded for 100 contiguous meters. PWQD was piloted in three areas (two on NE Ridge and one on Transmission Line Ridge) within known Viola populations. Both of these areas have CS transects where butterflies were surveyed in the last reported survey (TRA, 2012). We expect that Transmission Line Ridge is one of the densest Callippe and Viola areas on San Bruno Mountain, and our density measurements corroborate this observation. This PWQD method is fairly simple, requires little equipment, and allows one to discern between very high quality habitat all the way to potential habitat. Standard error calculations can offer information about the heterogeneity of the habitat. Based on our pilot studies, we recommend:

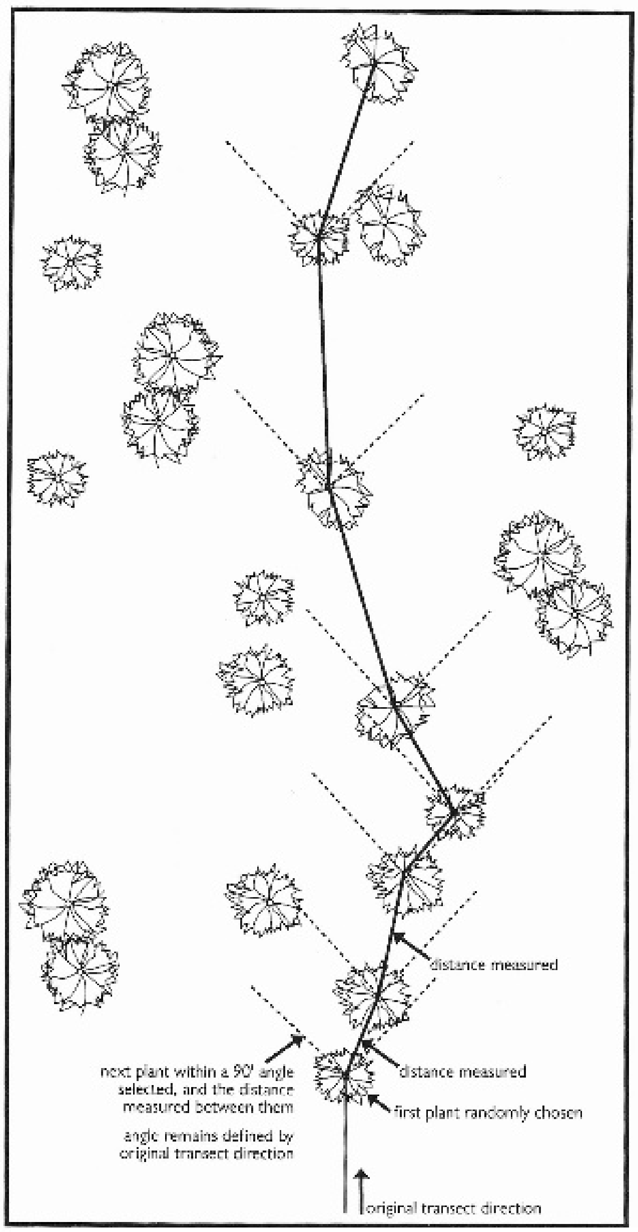


Figure 3-8: Plotless Wandering Quarter Distance Method, excerpted from Elzinga et al. 1998.

- A 100 meter transect to capture a robust sample. The 100 meters can be divided into 50 meters or shorter sub transects spaced at least 25 meters apart if a single 100 m transect cannot be laid out in a straight line.
- Since this is a plotless method, we recommend using a GPS to approximately determine past transect start points, but no permanent markers are needed.
- Since Viola is a moderately long lived perennial, we recommend resampling every 5 years.
- The larger Viola patches mapped in 2004 provide a universe of sample sites. At least one transect should be established in the following core CS areas: Lower Owl-Buckeye, Upper Owl-Buckeye (off main ridge) Transmission Line Ridge, Brisbane Acres, Southeast Ridge, Northeast Ridge, and Hillside/Juncus.
- West of Quarry is an area targeted for scrub control and we recommend establishing a Viola transect there.

- Recording the size classes of plants to allow for demographic analysis of the Viola. Plants can easily be classified into 3 classes: small (up to 6 inch diameter), medium (>6 inches to 12 inches) and large (> 12 inches).
- Repeat sampling will indicate trends in the higher density Viola stands.
- Local distribution mapping, similar to 2004, may be repeated if observational evidence warrants.

Lupine mapping for Mission Blue

The Mission Blue utilizes three lupines known from San Bruno Mountain as host plants: silver bush lupine (*Lupinus albifrons*), summer lupine (*L. formosus*), and varied lupine (*L. variicolor*)[1]. MB prefers silver bush and summer lupine, although varied lupines may be important for sustaining the population. Silver bush lupine is susceptible to a root crown fungus in wet warm springs, and MB populations have crashed in silver bush lupine dominated areas in years like 1998, while they have persisted in mixed lupine stands. Diversifying the lupine host plant base is a core recommendation for all MB management at SBM, Twin Peaks, and GGNRA.

Mapping and demographic monitoring can provide valuable information for decision making by helping answer three critical questions: 1) how much of the distribution of the MB is at risk from encroaching scrub?; 2) are lupine populations reproducing naturally, and 3) should lupine populations be enhanced by planting additional silver bush lupine, or by also amending with summer lupine and varied lupine.

Creekside Science staff conducts plot-based census of MB host plants on Twin Peaks, San Francisco in conjunction with the San Francisco Recreation and Parks Department and USFWS (Weiss, Niederer, Wayne, & Swenerton, 2013). In 2008 and 2013, staff completed a census of the entire 64 acre park, since only about 15 acres are occupied with lupines. We recommend an analogous method for monitoring lupine on sentinel sites on San Bruno Mountain.

The priority for monitoring lupine to inventory a subsample of isolated or at risk stands that have historically supported MB. The demography information is critical for management decisions. The method consists of delineating reasonably sized survey areas (usually about ¼ - ½ acre where lupine numbers will be in the range of 50-500 plants) in occupied habitat. These areas can be delineated with permanent stakes, so they can be relocated easily, but GPS points and use of landmarks are also useful. We recommend counting individuals of each species of lupine and assigning them to a size class - small (up to 6 inch diameter), medium (>6 to 12 inches) and large (> 12 inches). Plots can be relocated and censused every 5 years to monitor host plant populations. The 5-year interval is a useful timeline for perennial lupines on Twin Peaks, San Francisco. A graph from the 2013 Twin Peaks report (Wayne et al. 2013) illustrates lupine demographics and change over a 5 year time period (Figure 3-9).

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[1] We have changed the reference convention for lupines since common names are rarely used when discussing lupine species for MB restoration/habitat purposes. Therefore, lupines will be typically identified by taxonomic name and not common name.

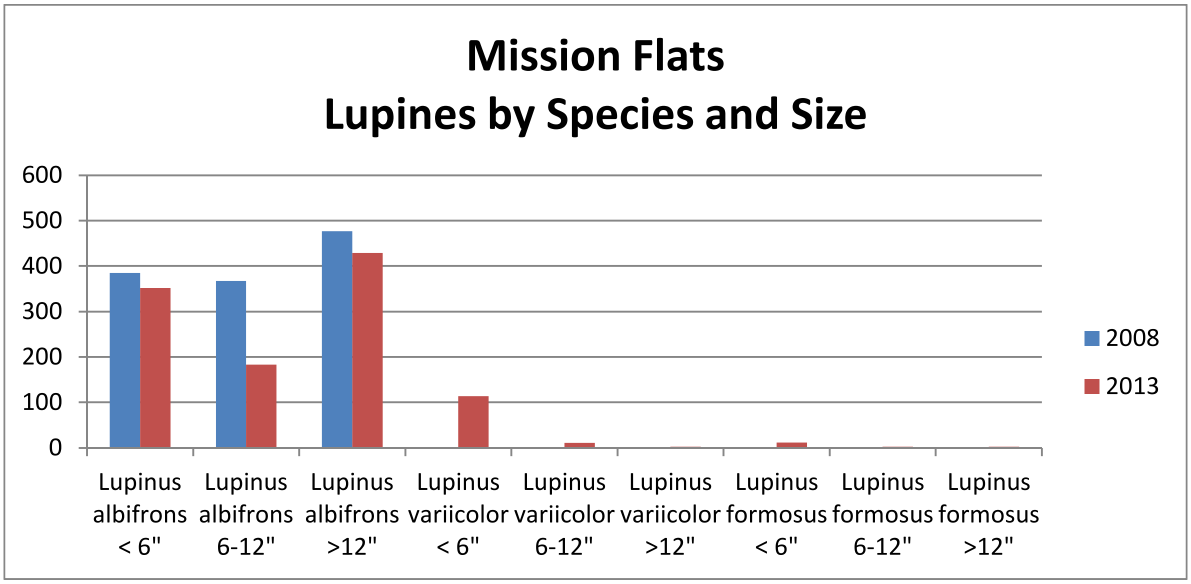

Figure 3-9: Population and demographic monitoring data of three lupine species on Mission Flats area, Twin Peaks, SF. The increase in L. variicolor and L. formosus reflects planting and restoration efforts.

We recommend selecting from the following areas that meet the abovementioned criterial: West of Quarry, Reservoir Hill (transect T2), East Saddle Loop (transect 5), West Peak (transect 1). This is a preliminary list of suggestions, once scrub management has begun it is worth revisiting the selection.

We also recommend establishing reference plots in high quality habitat: Owl-Buckeye Ridge (transect 10), SE Ridge with *Lupinus formosus* (transect 11), and selected spots on South slope (transect 12 and 13 vicinity). These reference plots are important to assess assumptions about how quickly lupines are lost to scrub and well they respond to scrub management.

Bay Checkerspot butterfly

The Bay Checkerspot butterfly (BCB) was once known from San Bruno Mountain (SBM), but the local population went extinct in the mid-1980s as documented in annual SBM reports. Low numbers of adults were detected in from 1982-1985, but none have been observed since. The extinction was attributed to habitat degradation by fires and increased densities of storksbill (*Erodium spp.*) and annual grasses that decreased the distribution and abundance of larval host plants Dwarf Plantain (*Plantago erecta*), Owls clover (*Castilleja densiflora)*, and purple owl's clover (*C. exserta*) (TRA Environmental Science 1985a, 1985b, 1986).

With funding from USFWS (through the San Francisco Wildlife Society), Creekside Science is investigating whether it is feasible to reintroduce the butterfly, given recent success in reintroduction at Edgewood Natural Preserve. Initial habitat surveys have shown suboptimal densities of host plant dwarf plantain, with the largest patches of contiguous dwarf plantain habitat nearing 2 acres in size (Figure 3-10).

Figure 3-10: Two views of one of the larger polygons of dwarf plantain located on San Bruno Mountain. May, 2014.

San Bruno Mountain hosts widespread and abundant populations of the nonnative perennial English plantain (*Plantago lanceolata*). Because checkerspots are known to use multiple hosts that contain iridoid glycosides, this nonnative may be a suitable host for BCB. Several populations of Taylor's Checkerspot (*Euphydryas editha taylori*) in Oregon and Washington, and a population in the Sierra Nevada (Schnieders Meadow), have switched from native host plants to *P. lanceolata* and have thrived. The possibility of reintroducing this butterfly should be considered with long-term management decisions. Because checkerspots require grassland habitat, managing for scrub is not expected to conflict with checkerspots, although more specific recommendations will be made should the idea of reintroduction develop further.

Chapter 4. Historic Imagery Analysis Mapping: Brush Encroachment Case Studies

Summary

Of the approximately 3,000 acres of land conserved by the San Bruno Mountain HCP, 1960 acres (65.3%) were mapped as grassland in 1932. In 1983, when the HCP was approved, 1419 acres of grassland were documented. In a 2004 vegetation classification analysis (of a 2002 aerial image), on 1297 acres of grasslands were mapped on San Bruno Mountain. This equates to an average loss of 9.5 acres of grassland per year. Cursory visual analysis of 2014 aerial imagery indicates further loss of grassland since the 2004 classification effort. We conservatively estimate that grassland habitat is now reduced to less than 1180 acres.

Two case studies of invasion of high quality habitat [Southeast Ridge and Transmission Line Ridge] are offered as examples of grassland invasion that has been observed. Three photographic images of Transmission Line Ridge are presented from 1982, 2006, and 2014 to document vegetation changes.

Historic imagery analysis is a powerful tool for detecting and reporting vegetation changes on a landscape (Dunn et al 1990). Large scale, contiguous changes of vegetation, such as afforestation or desertification can usually be reported with accuracy. The efficacy and value of this tool is most typically limited by the quality of the historic imagery, making smaller scale changes more difficult to analyze (Kadmon and Harari-Kremer 1996). Aerial imagery has only recently become both high resolution and readily available. Although aerial images of San Bruno Mountain dating back to at least 1943 are publicly available (Figure 4-1), these earlier images fail to provide resolution that would allow for quantitative mapping of grasslands. Despite limitations, it is apparent that shrubs and trees were extremely limited in the southeastern portion of San Bruno Mountain, particularly on the south facing slopes.

Figure 4-1: San Bruno Mountain Aerial image from 10-11-1943. Photographed resolution: 1:20,000. Although this image is valuable, it is difficult to analyze for vegetation changes.

Digitization of vegetation communities on a regular basis will allow for accounting of acres of each habitat type. This vegetation classification was originally completed by the US Forest Service in 1932 (Figure 4-2). Vegetation mapping efforts completed by TRA in 1980-1981 are presented below the 1932 map (Figure 4-2).

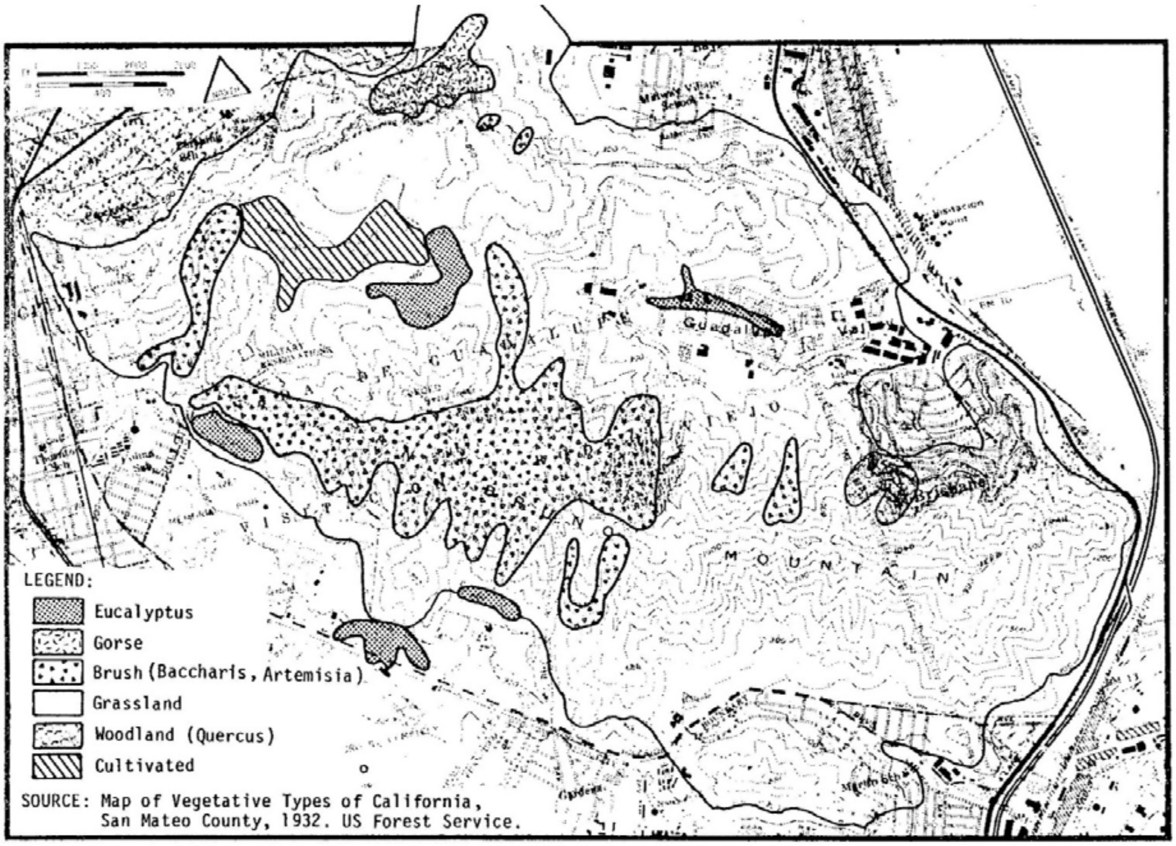

FIGURE S-5
MAJOR VEGETATION COMPONENTS --SAN BRUNO MOUNTAIN -- 1932

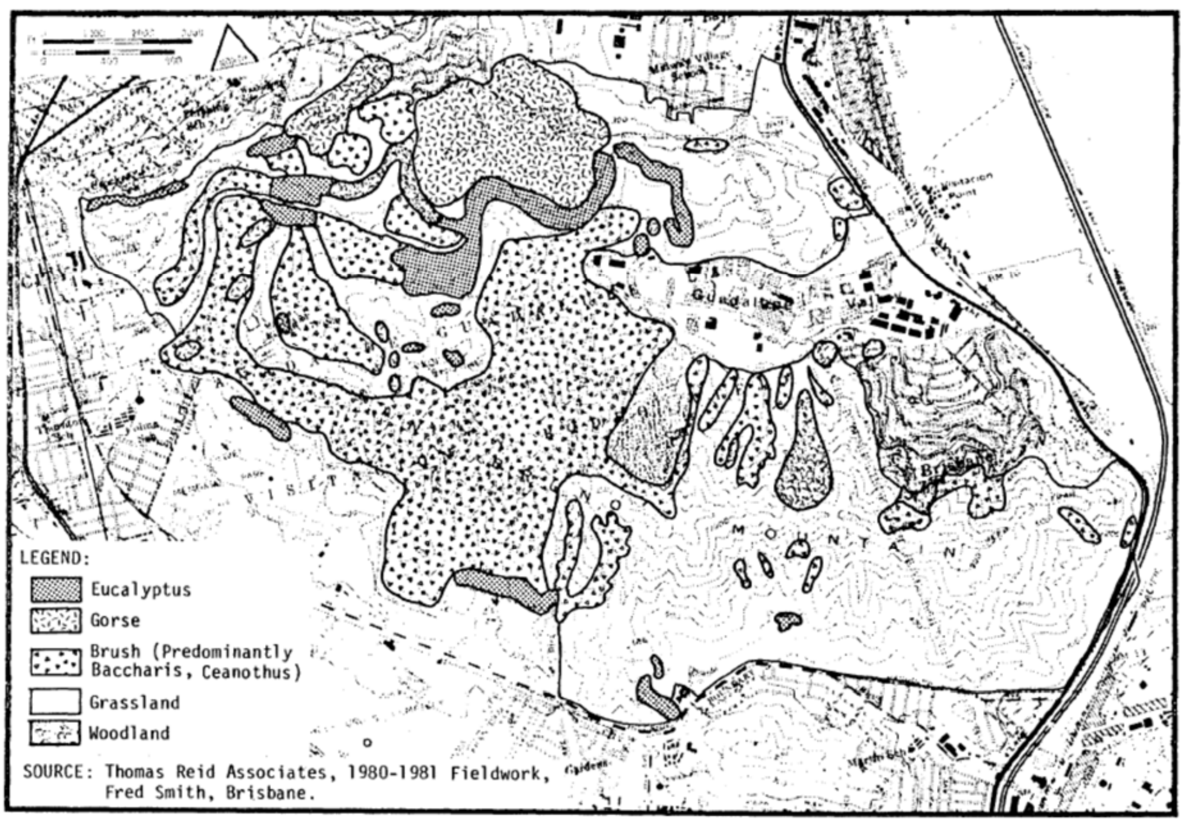

FIGURE S-6
MAJOR VEGETATION COMPONENTS --SAN BRUNO MOUNTAIN -- 1981

Figure 4- 2: Map of vegetative types of California, 1932 (top). Excerpted from HCP Volume I. Major vegetation components - San Bruno Mountain – 1981 (bottom). Map by TRA.

1960 acres of San Bruno Mountain HCP land were classified as grassland in 1932 by the Weislander Vegetation Type Maps (map 82C) (Weislander 1961). Thomas Reid and Associates field mapped 1419 acres from 1980-1981 (Figure 4-2), showing approximately 541 acres of grassland were lost to other expanding vegetation communities over 50 years (San Mateo County, 1982).

Average rate of annual grassland loss (1932-2002) is calculated to be 9.5 acres per year (Table 4-1). The HCP was approved in 1982, so for this analysis the decline between 1981 and 2002 are a more appropriate time series to consider. The rate of grassland loss since the HCP was approved is lower than the pre-HCP rate of loss (Table 4-1).

Table 4-1: Loss of grassland acres mapped on San Bruno Mountain

Year	Acres of Grassland	Average Acres Lost Per Year
1932	1960	N/A
1981	1419	11.0
2002	1297	5.8
1932-2002 Average	**663**	**9.5**

Since we do not have aerial imagery for the 1932 and 1981 mapping efforts, our historic imagery analysis begins with 1993 aerials. We offer two case studies of two different areas on San Bruno Mountain: the Southeast Ridge and Transmission Line Ridge. These two areas were selected for case studies due to regularly surveyed CS and MB. Aerial photography imagery was downloaded from the San Mateo County website. Aerial images were only digitally cataloged and posted online by the County through 2001, so our first analysis illustrates what happened in the most recent 13 years. A second set of comparative images are offered from Google Earth's historic imagery server dating back to 1993.

Southeast Ridge Case Study

The Southeast Ridge is a topographically diverse ridgeline with both dry, hot south facing grasslands and cool north facing grassland/scrub vegetation. Mission Blue transect 12 is partially located in this area and is regarded as good habitat for the MB (See Chapter 3). We selected this area for comparison of 2001 and 2014 aerial photos (Figure 4-3). Three locations are labeled on each map (1, 2, and 3). Location 1 is a small ridge on a south facing slope where a "C" shaped stand of coyote brush included about 100 individuals with grassland in between most individual shrubs. By 2014, the "C" form of the stand is indiscernible and brush forms a continuous layer of scrub. Scrub has become nearly continuous over to the fire road to the east of the 1. Location 2 is a 2-5% slope located just below the Southeast ridge proper. In 2001 this area also contained about 50 well dispersed individuals. By 2014, the majority of the grassland was invaded by coyote brush forming dense patches and stands. We estimate that in a 50 foot circle around the number "2" scrub vegetation increased from about 5% cover to about 70% cover. Location "3" is located just north of the ridgeline on a north facing slope. This area is more mesic and considered to be high quality coastal prairie. In 2001, this local area contained 5 shrubs. By 2014, a discernible stand has formed with some 30 individuals.

2001 SE Ridge Scrub Invasion

Disclaimer: Information displayed here is for reference. For precise boundary data or information, consult official records. Printed: Tue Sep 16 2014 01:03:20 PM.

2014 SE Ridge Scrub Invasion

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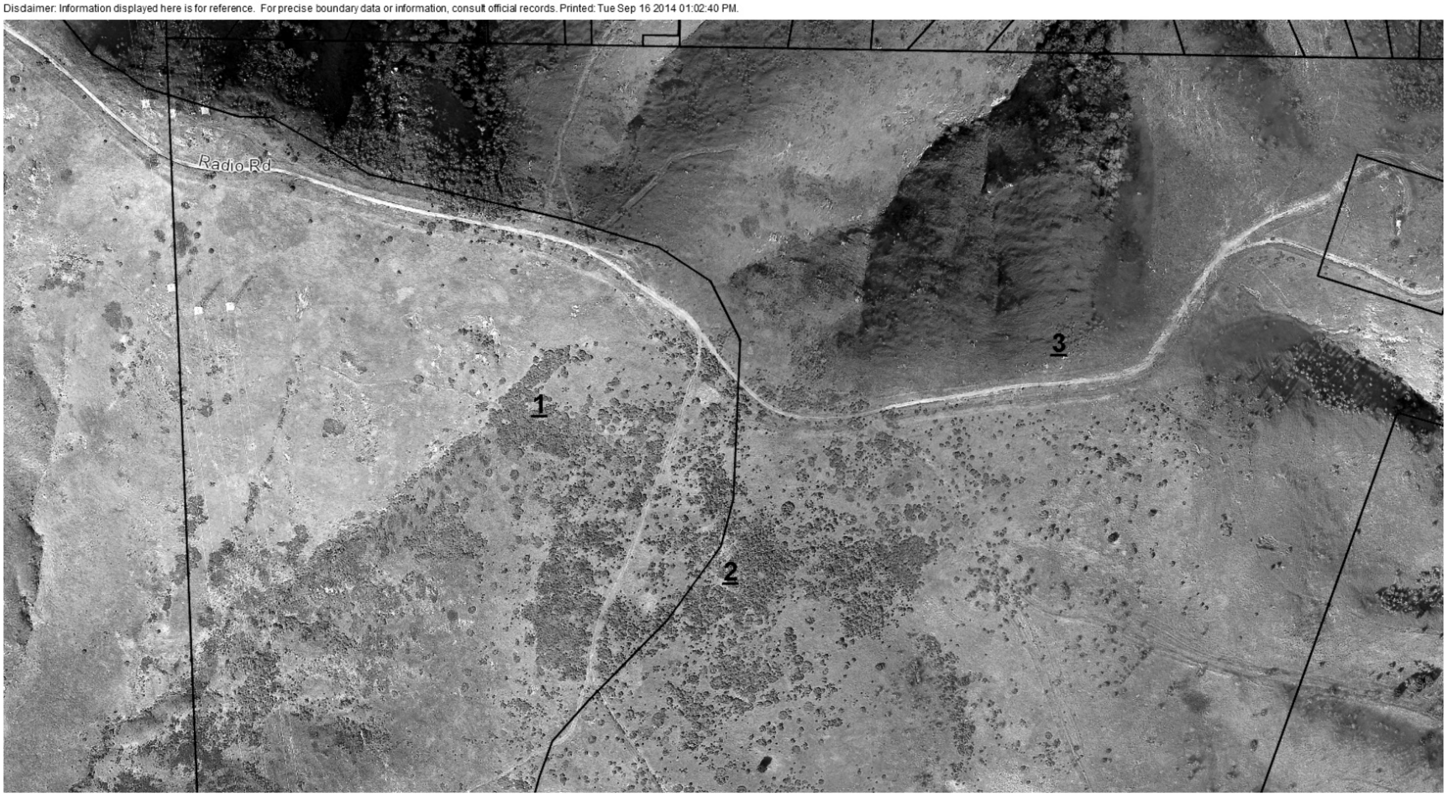

Figure 4- 3: Comparison of 2001 and 2014 aerial images of the Southeast Ridge

Mature scrub and woody vegetation often displays as distinct dark dots on the recent (2000 onward) aerials, although sometimes grasslands appear dark on north facing slopes or in deeper soils. Immature scrub may be difficult to differentiate from a grassland mosaic. This difficulty is apparent when comparing an older aerial (1993) to a more recent, high resolution aerial (see Figure 4-4). Older aerials which may present as scrub free can be misinterpreted because individual plants are often beyond the resolution of the sensor and lens.

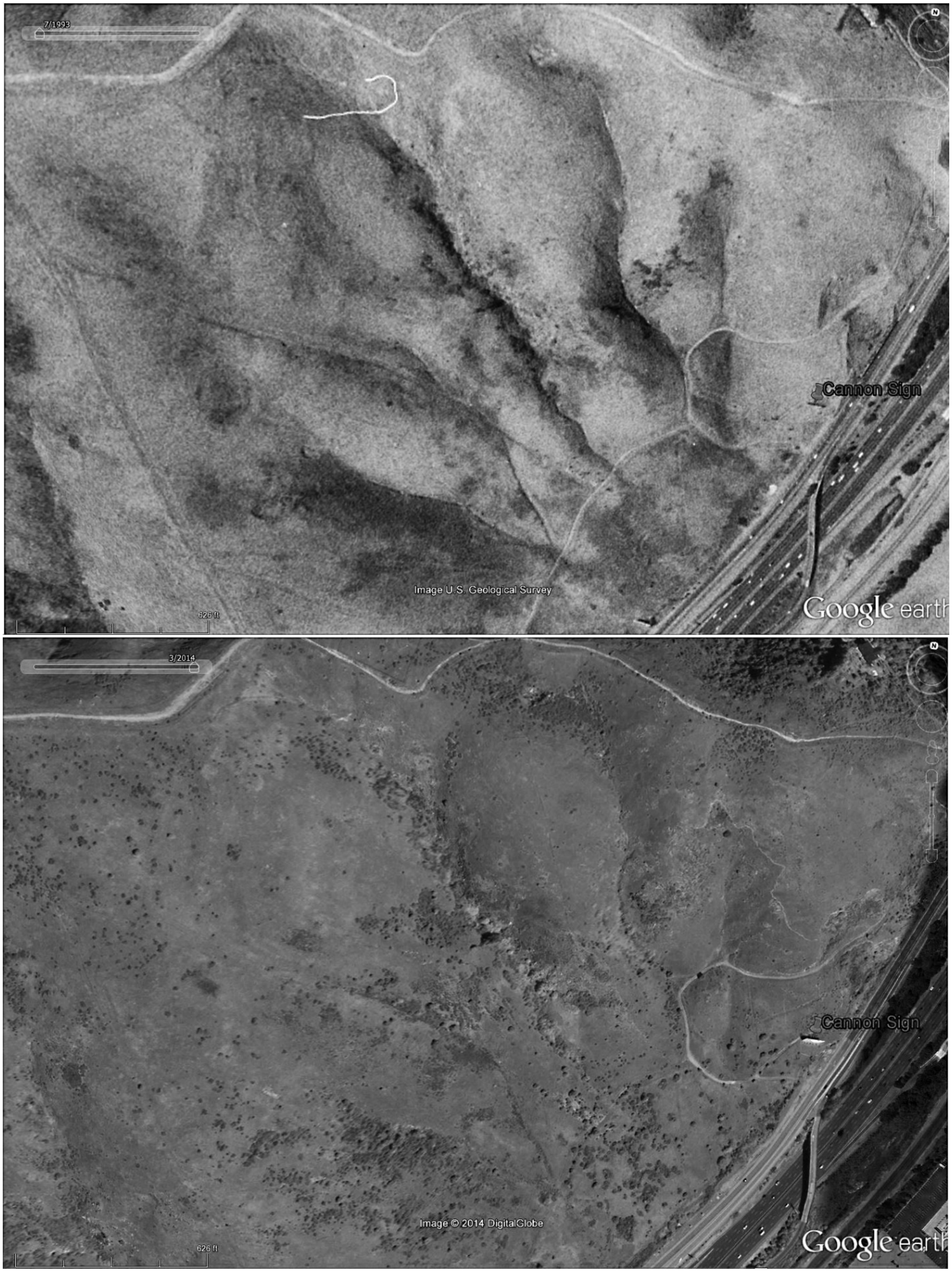

Figure 4- 4: Comparison of 1993 (top) and 2014 aerial images extracted from Google Earth. Trees and mature, large scrub are discernible in the 1993 image of the Southeast Ridge/Cannon Sign area. The top left edge of the aerials roughly corresponds with location 3 in Figure 4-3.

Transmission Line Ridge Case Study

Transmission Line Ridge is a well-studied north facing ridgeline that currently harbors large populations of both CS and MB. This area is characterized as coastal prairie grassland with an ever encroaching north coastal scrub vegetation on all sides. Powerlines on this ridge are maintained by PG&E and the road bisecting the ridge also serves as a fire road. We selected this area for comparison of 2001 and 2014 aerial photos (Figure 4-5). Three locations are labeled on each map (1, 2, and 3). Location 1 is near the bottom of the slope directly under transmission lines. In 2001, this location had intermittent scrub cover surrounded by large grassland patches. In 2014, grassland has been fully displaced by a large polygon of scrub. Location 2 locates a patch of woody vegetation (likely oaks) on the ridge. In 2001 there were a few mature trees and many saplings. In 2014, many of those saplings have increased in size and the grassland is converting to oak woodland which will be difficult and controversial to restore back to grassland. Location 3 is a trail that once connected Transmission Line Ridge to Owl-Buckeye ridge. In 2001, this trail is highly visible with grassland running along the edges for nearly the full length of the trail. By 2014, the trail is reduced to a 2-3 foot wide footpath that is difficult to traverse in single file.

2001 Transmission Line Ridge Area

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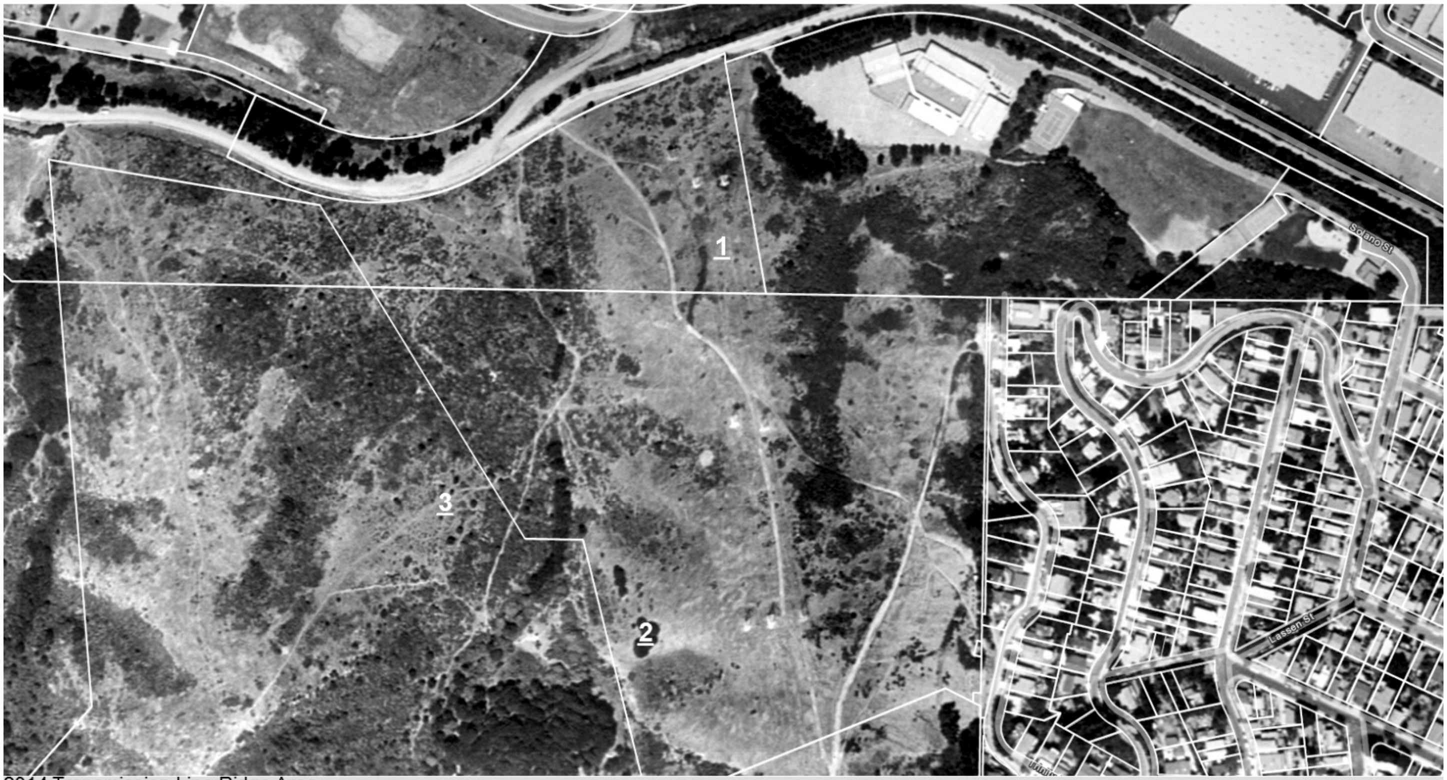

2014 Transmission Line Ridge Area

Disclaimer: Information displayed here is for reference. For precise boundary data or information, consult official records. Printed: Tue Sep 16 2014 11:45:47 AM.

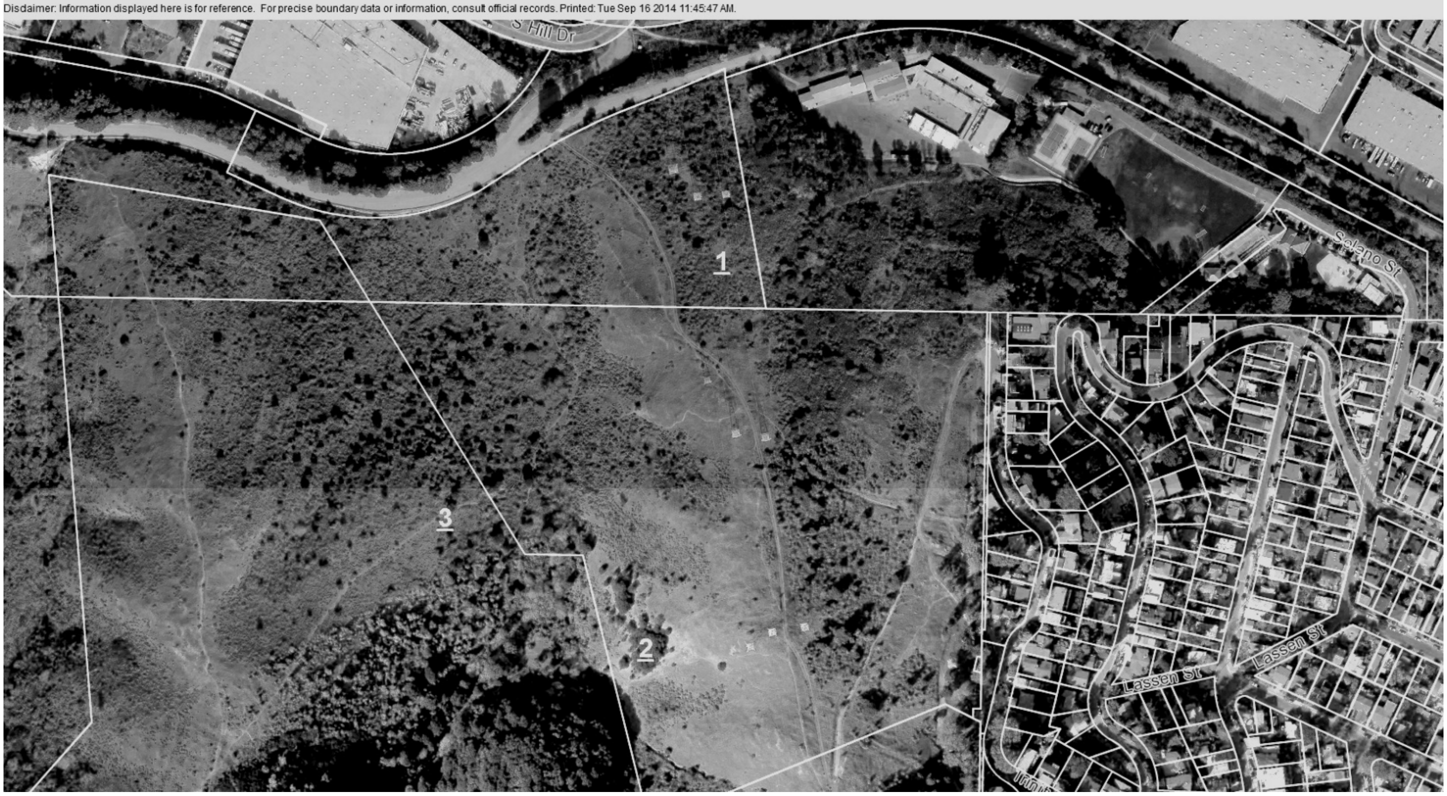

Figure 4- 5: Comparison of 2001 and 2014 aerial images of Transmission Line Ridge

For reference, we compare 1993 and 2014 images from the same Transmission Line Ridge area (Figure 4-6). Scrub encroachment on Transmission Line Ridge is evident.

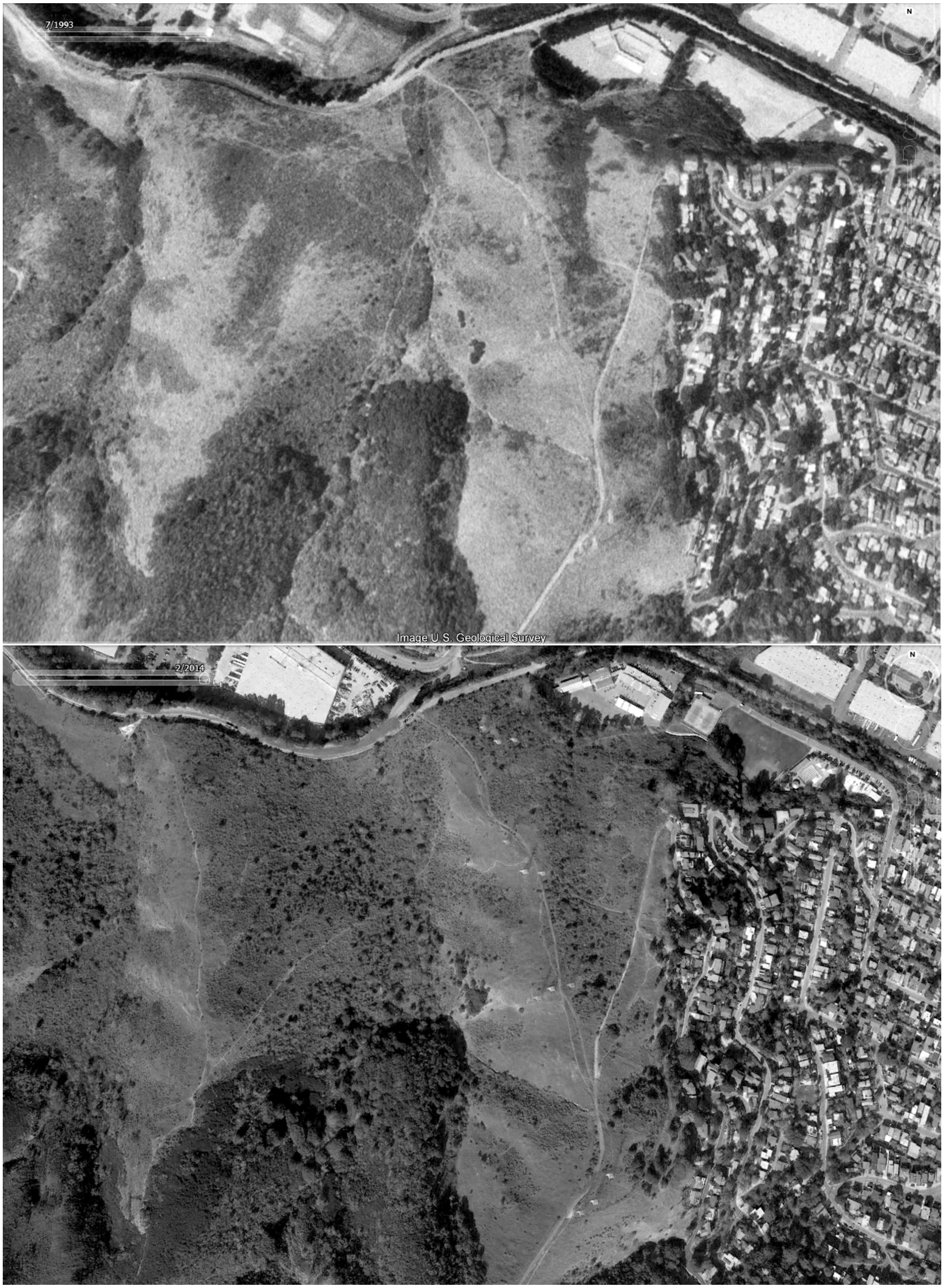

Figure 4- 6: Transmission Line Ridge area: 1993 and 2014 images extracted from Google Earth.

Rephotographing Analysis of Transmission Line Ridge

Transmission Line Ridge represents an important location for both CS and MB as well as high quality coastal prairie grassland. We present three photographs of this ridge, taken from the Northeast Ridge, which characterize the conversion of high quality grassland and CS/MB habitat to scrub (Figure 4-7). Over the 24-year period from 1982 to 2006, canyons and cooler slopes with a few shrubs filled in and eliminated grassland habitat (photographs from the 2007 Management Report). These changes are readily apparent although the photos are taken in two different seasons. From 2006 through 2014, a period characterized with below average precipitation and only one moderate El Nino year (09-10), lower rates of scrub encroachment are observed. Scrub encroachment is likely slowed by increased management in this area and volunteer efforts.

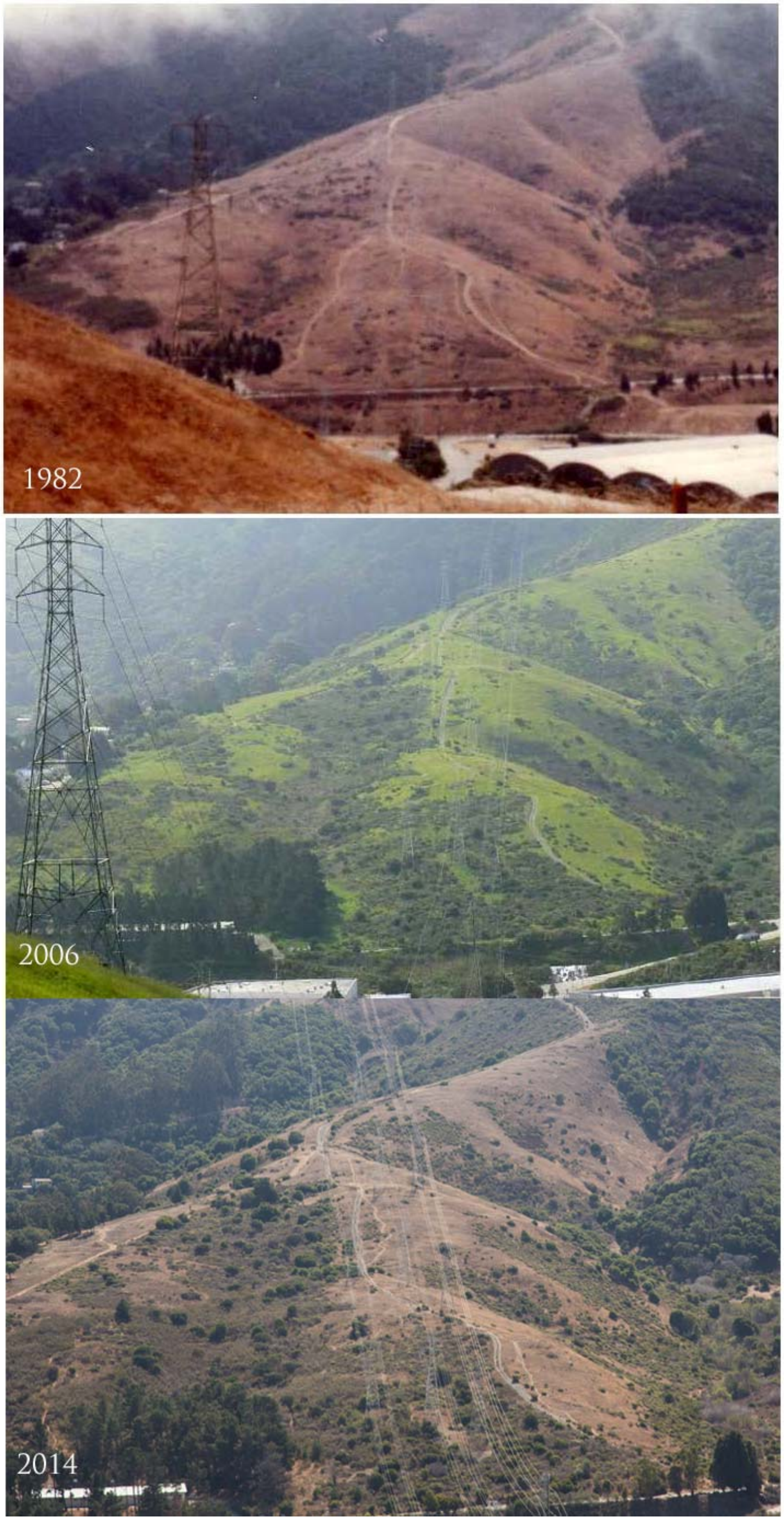

Figure 4- 7: Transmission Line Ridge Scrub Encroachment 1986-2014

Chapter 5. Priority Grassland Management Areas

Summary

High quality grassland habitat needs to be defended and restored at any reasonable cost. Grasslands provide habitat for three of the four listed butterfly species. It is clear that this vegetation community has been steadily decreasing since at least 1932 and species requiring this habitat are undergoing habitat loss. It is critically important to maintain large, contiguous patches of grassland to ensure that populations of CS and MB do not become reproductively isolated or even extirpated. Although the last mapping effort in 2004 reported 1296 acres of grassland, we believe that many of these areas are in imminent threat of scrub encroachment and could be converted to scrub after a good coyote brush recruitment year. Large patches of contiguous grassland with less than 2% scrub cover are quickly vanishing.

Grassland vegetation mapped in 2004 overestimates the total number of grassland acres, regardless of which definition of grassland one accepts (<10% scrub cover vs. <25% scrub cover). Areas mapped as grasslands in 2004 were re-evaluated qualitatively and we present one sample area which should be mapped as scrub, not grassland. Most grasslands on SBM are at least marginally invaded with scrub except for the Northeast Ridge, which contains a large contiguous grassland with relatively low scrub cover. Scrub encroachment needs to be slowed with management action.

A total of 943.7 acres within the San Bruno HCP boundary are categorized as **Priority Grassland Management Areas.** The Priority Areas Map is based on recent Viola surveys, CS and MB presence/abundance, and qualitative field data. High risk areas overlapping with high quality habitat are identified and prioritized for near term management: extant grasslands on north facing slopes in Owl-Buckeye/Transmission Line ridge areas, SE Ridge, Main ridge, certain south facing ridges (i.e. along transect 12), and the NE ridge are the highest priority.

Grassland Mapping

Most grasslands on San Bruno Mountain are designated as critical habitat for the CS, MB, and BCB. Historic images (see Chapter 4) and comparative mapping of grasslands from 1932 through 2002 clearly indicate that grassland habitat is on the decline (Table 5-1). A number of factors have contributed to the decline of grasslands, including, but not limited to removal of grazing animals, fire suppression, weed invasions, scrub succession, nitrogen deposition and climate change (McBride 1974, Williams et al. 1987). In this chapter we explore the decline of grasslands and identify some weaknesses in past mapping procedures.

The 1932 grassland acres were derived from a 1932 mapping effort known as the Wieslander vegetation type mapping project. The Wieslander Vegetation Type Map (VTM) collection is a dataset compiled in the 1920s and 30s, consisting of photos, species inventories, plot maps, and vegetation maps covering most of California (Wieslander 1935). Vegetation for map 82C (San Mateo Co which includes San Bruno Mountain) was mapped on a 15 minute USGS quadrangle map. Although these maps offer invaluable information, even the smaller scale maps (15 minute) have errors in spatial location that vary from 126 to 200m, with errors often greater in areas of high topographic diversity (Kelly et al. 2007). This level of error on a landscape as small as San Bruno Mountain should be considered significant when comparing past acreages of grasslands.

Grassland acreages from 1982 forward were derived from the digitization of aerial photographs. The source images are of varying photographic quality, record the mountain in various seasons and resolution. In 1982, the aerial imagery has become more resolved and sophisticated allowing for higher accuracy vegetation mapping, than occurred in 1932. Unfortunately, this leaves a 50 year gap where we have little vegetation information, and where we have a potential for propagating field mapping errors.

Table 5-1: Grassland Acres on San Bruno Mountain since 1932

Year of Aerial	Acres of Grassland	Ecological Notes
1932	1960	Large patches of contiguous grassland are present throughout the future HCP area. Grazing likely a factor in maintaining grasslands. Mapping is known to have significant error (Kelly et al. 2007).
1982	1419	Patches of large contiguous grassland still present although 1-2% scrub cover is apparent in many areas. Scrub encroachment and weed invasion is displacing grasslands.
2002	1297	Many weed invasions continue to impact grassland quality and scrub encroachment continues into high quality grassland with the aid of a few good wet years improving coyote brush establishment.
2014 (estimated from 82-02 encroachment rate)	1180	Although many weed invasions have been contained and treated with HCP effort, scrub encroachment continues to impact high quality grasslands.
2014 (corrected estimate based on overestimation of grasslands in 2002 mapping process)	944 ± 118 [826-1062]	Not only are the edges of distinct grassland patches being slowly invaded. Scrub is becoming more omnipresent and often grasslands contain significant patches of mature shrubs that are beginning to proliferate. Large continuous patches of grassland are uncommon, occurring only on Northeast ridge and south of the Southeast ridge.

Grassland acreage in 1932, as discussed above, is considered a rough estimate with significant actual errors. The 1982 acreage is considered the first high resolution mapping effort working from an aerial image. The 2002 mapping effort (TRA 2004) redigitized the extent of grassland vegetation on SBM. This GIS layer was made available to us and our GIS analysis of the 2002 grassland mapping effort estimates an overestimation of grassland acres due to at least three factors:

a. Transitional grasslands were not mapped. We locate several areas (Figure 5-1) that we feel are clear examples of coyote brush scrubland, but they were mapped as grassland.
b. Mapping conventions such as minimum mapping units (MMU's) were not implemented in the analysis. Small (< 1 acre) patches of grassland are mapped, but areas of the same size of scrub are not excluded from larger grassland polygons.
c. Invading coyote brush scrub may be difficult to discern from grassland in the 2002 imagery.

Vegetation mapping is inherently difficult because it requires the surveyor (or digitizer in this case) to group an area into one classification or another. Often, patches of vegetation are undergoing transitions to varying degrees and mapping usually fails to memorialize these areas.

In order to account for this discrepancy, we have conducted a quick sensitivity analysis by sampling one area and calculating that grassland vegetation is over-estimated anywhere from 10-30%, averaged to 20% error. Therefore we offer two methods for estimating the current (2014) total acreage of grassland within the San Bruno Mountain HCP (Table 5-1).

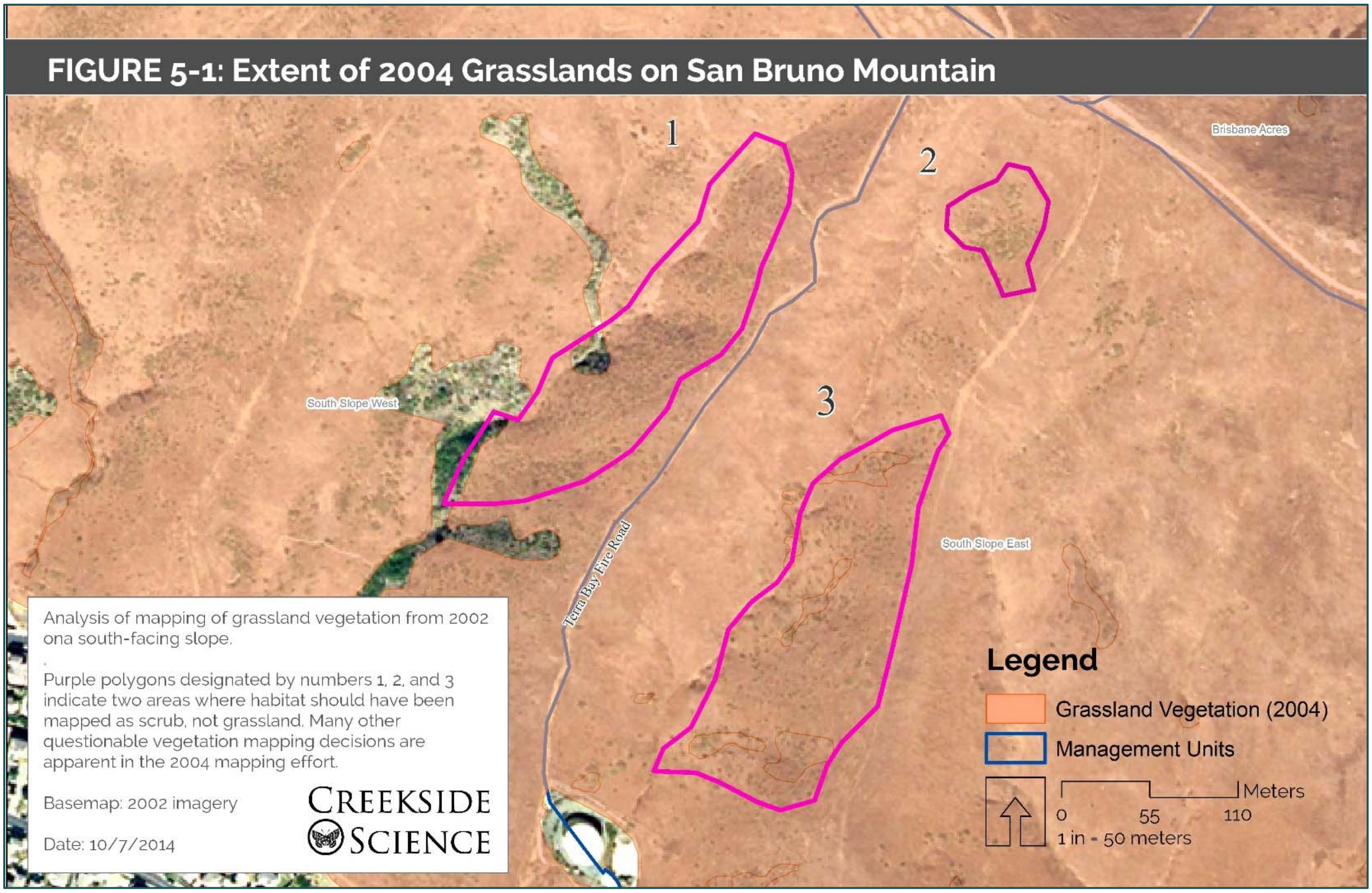

Figure 5- 1: Analysis of 2004 Grasslands Vegetation Mapping: The three purple polygons outlined above feature areas that have greater than 15% scrub cover and therefore should be mapped as North Coastal Scrub vegetation and not grassland. Creating smaller mapping units like this captures scrub islands that are driving scrub encroachment throughout the grassland, and reduces the total amount of grassland mapped.

Grassland Quality

The above mapping discussion is critical to our review for two reasons: a) nascent invasions of scrub can quickly convert good MB and CS butterfly habitat to low quality habitat and b) these nascent invasions are both the easiest and most cost-effective to control.

Although 2002 mapping efforts followed past protocol, prior maps of grassland vegetation failed to discern between pristine, high quality grassland habitat (0% mature scrub) and invaded grassland that may be scrub in a matter of a few years (2-10% mature scrub in an otherwise grass dominated polygon). We have yet to locate the classification rules for “grassland” and “scrub” vegetation, which may indicate that these classes were loosely interpreted. As stated above, this distinction is integral in identifying priority areas for management.

Although no vegetation manual definitively defines a grassland it is apparent many San Bruno grassland areas are in transition and may succeed to scrubland. The California Manual of Vegetation (Sawyer et al. 2009) offers the following key break for herbaceous vs. shrublands indicating that greater than 10% shrub cover is categorized as shrubland:

“III. Non-woody herbaceous vegetation, including graminoid and forb species, dominant throughout the stand. When total vegetation cover is greater than about 20%, the layers of shrubs, shrublands, and trees, if present, are of lower cover than herbs and less than 10%.”

Area #2 indicates an area mapped as grassland that should correctly be labeled as “shrubland” or more descriptively as coyote brush shrubland (Figure 5-1). Areas #1 and #3 on the map represent vegetation that is best categorized as diverse coastal scrub/North Coastal Scrub with a mix of herbaceous and woody vegetation.

Priority Grassland Management Areas

Based on available data from years of TRA monitoring, West Coast Wilds reports, GIS data, and other reports completed for the County of San Bruno, a map with the following base layers was compiled:

- Viola surveys from 2004,
- CS and MB presence/abundance from wandering surveys (1990-2001), and
- 2002 grassland vegetation

These layers form the foundation of our analysis (Figure 5-2). Additionally, interviews with community members, County staff, and site visits culminated in the creation of a Priority Grassland Management Areas map (Figure 5-3). A total of 943.7 acres of within the San Bruno HCP boundary are categorized as Priority Grassland Management Areas

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FIGURE 5-02: Criteria for Establishing Priority Grassland Management Areas on San Bruno Mountain

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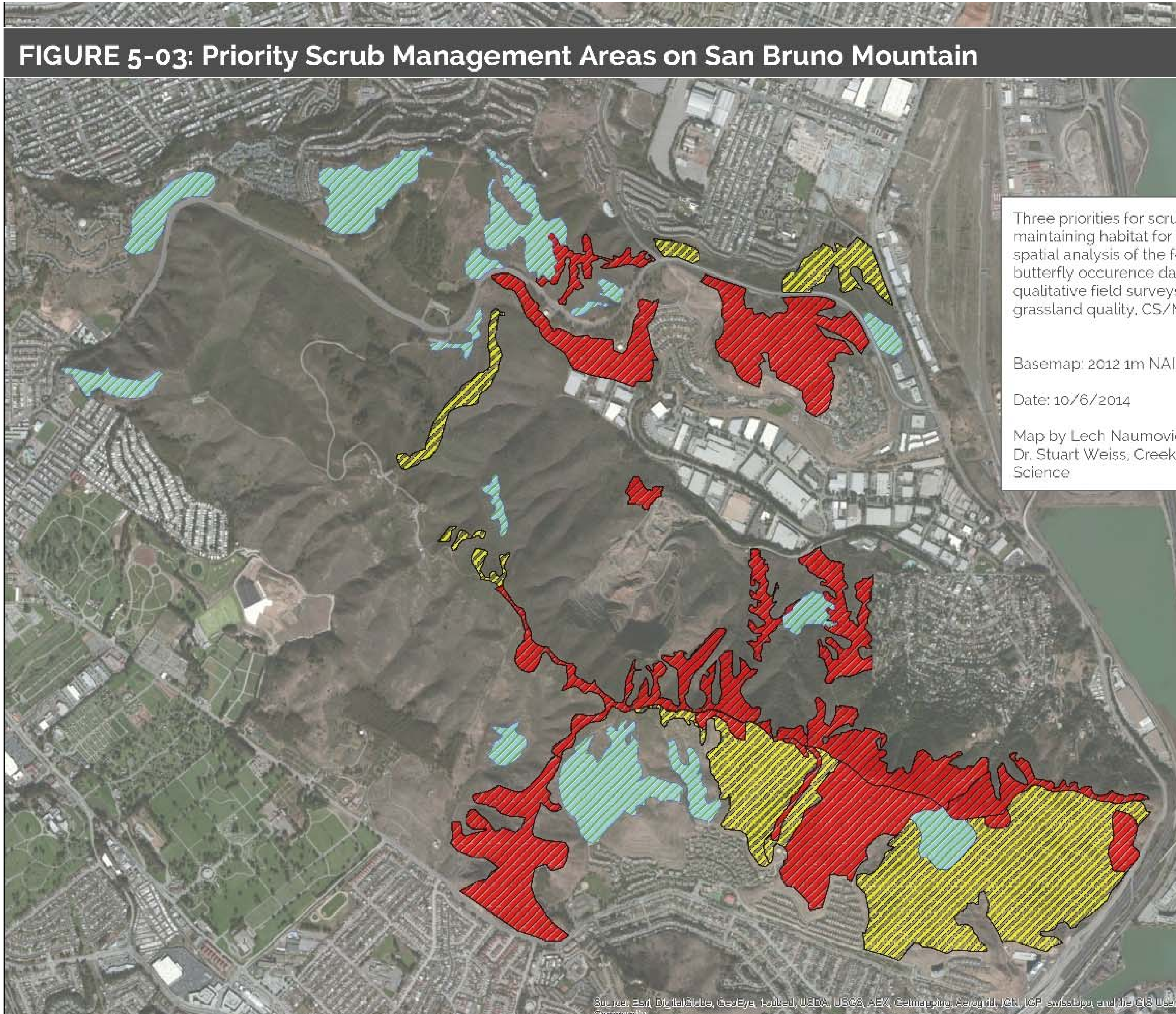
FIGURE 5-03: Priority Scrub Management Areas on San Bruno Mountain



Three priorities for scrub management are presented with the goal of maintaining habitat for MB and CS. These areas were derived from a spatial analysis of the following information: 2004 vegetation survey, butterfly occurence data from 1989-2001, viola maps in addition to qualitative field surveys in 2014. Priority was assigned based on existing grassland quality, CS/MB occurence data and presence of host plants.

Basemap: 2012 1m NAIP imagery

Date: 10/6/2014

Map by Lech Naumovich and Dr. Stuart Weiss, Creekside Science

Legend

Priority Scrub Management Areas

- 1 - Essential (431.2)
- 2 - Valuable (307.8)
- 3 - Potential Habitat (204.7)

0 437.5 875 Meters

1 in = 483 meters

CREEKSIDE SCIENCE

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Essential priority grasslands are locations where CS and/or MB continue to persist. Host and nectar plants are both abundant in Essential grasslands including Viola which is known to be difficult to establish (Figure 5-4). Essential grasslands are typically less invaded with invasive weeds and scrub. These sites can likely be managed for grasslands and butterfly habitat at the lowest per acre costs. As time passes, these sites too will degrade if scrub and weed management does not continue.

Figure 5- 4: Southeast Ridge Summit, an Essential Priority Grassland with *Lupinus formosus* and low density scrub (coyote brush) cover

Valuable priority grasslands are polygons that are one degree removed from the Essential areas. These sites may be degraded, are recently invaded, or CS and MB are in lower than normal densities at these sites. These site may be small patches of remnant habitat representative of habitat that was once more widespread (Figure 5-5). These locations have great potential to be restored, but will likely take more time and resources in the process.

Figure 5-5: Valuable Priority Grassland is well represented by this isolated remnant grassland which constitutes high quality coastal prairie habitat near Pacific Rock. Established shrubs encircle the priority area.

Lower Quality priority grasslands may have historically supported CS or MB but currently are not considered habitat (Figure 5-6). These are areas which may now contain closed canopy shrublands, dense monocultures of invasive weeds, or simply well establish non-native annual cover such as *Avena*, *Briza*, and *Raphanus* (for example) that directly compete with butterfly host and nectar plants. These locations will need well-crafted restoration plans that will require room for adaptive management and experimentation. At this point, these areas are likely very low quality habitat, although with proper attention they can regain their habitat value. Restoration will be expensive in these areas.

Figure 5-6: Lower Quality habitat in the Saddle area where gorse was once dense. This area is currently still undergoing gorse treatment. Grasses are dominated by invasive perennial velvet grass. This area will require more resources in order to bear host plants.

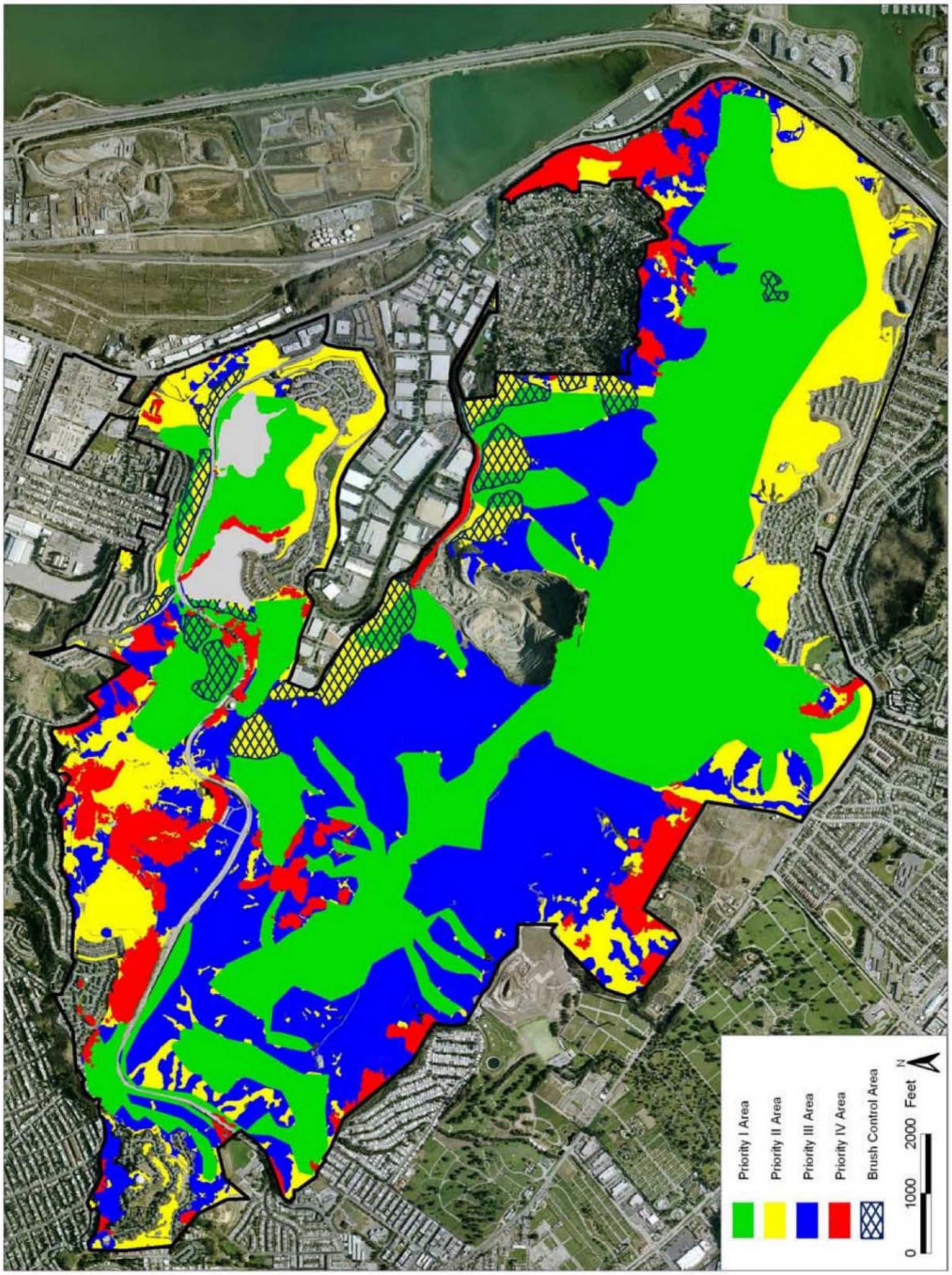
Control of both weed and scrub invasions is critical to maintaining high quality butterfly habitat for CS and MB. These two tasks need to be coordinated so that management actions can meet goals for maintaining and restoring grassland habitat. Our priority areas are intended to help direct management efforts so that limited funds are allocated to areas that will benefit covered species. To this end, we recommend treatment of Essential areas first, followed by Valuable areas, and finally the lowest of the priority areas: Lower Quality habitat. Annual stewardship planning should attempt to direct a significant share of funding towards Essential areas in order to maintain the core butterfly resources.

It is important to note that this map is restricted only to grassland habitat management. Other covered species will require different habitats and need different stewardship actions, and all covered species and unique resources deserve attention. Scrub removal should not be completed at the detriment of other covered species as possible. These conflicts need to be resolved on an individual basis.

2007 Habitat Management Plan Priority Areas

By first approximation, our Priority Grasslands coincide well with the Priority Areas mapped in the 2007 HMP (Figure 5-7), yet there are some notable areas where the two maps deviate.

Figure 1. Priority I, II, III and IV Management Areas on San Bruno Mountain



TRA Environmental Sciences March 2008

Figure 5- 3: Priority Management Areas Designated in the 2007 HMP (TRA 2007)

The HMP lists much of the known SBE habitat as a "Priority 1" area, and this is notably absent from our map since these areas area not grasslands and we are not currently recommending managing this area as an Essential Grassland. These areas should continue to be monitored for weeds, but scrub removal is not recommended for those habitats at this point.

The two maps notably deviate in where scrub management is prescribed. In the 2007 HMP, several areas of historic habitat with currently dense patches of scrub are identified as "brush control areas". We believe those areas are mostly lower priority, because we are prioritizing newly invaded areas where scrub removal can be completely quickly and reduce the rate of succession of high quality occupied grasslands to north coastal scrub (Figure 5-8).

Figure 5- 4: Grassland area on Tank Hill filled with lupines that are slowly being invaded by coyote brush. We recommend prioritizing areas that are currently occupied by MB and/or CS that have low (< 5%) coyote brush cover. This area was burned in 2013 so 2014 is an ideal time to manage for scrub. April 2014.

Another notable deviation is that our map only highlights a portion of the Mountain as critical. Given funding constraints, we wanted to produce a map that would allow for work to be focused into specific high priority butterfly habitat areas. Although our total map prioritizes almost 944 acres, the Essential areas (431.2 acres) should be treated as soon as possible for scrub encroachment.

Chapter 6. Stewardship Tools for Managing Habitat on San Bruno Mountain

Summary

Grasslands require a degree of regular and heterogeneous disturbance in order to maintain their diversity and reduce scrub succession. Future management efforts need to strategically target invading scrub in Priority Grassland areas, while continuing to contain weed infestations. Additionally, thatch buildup in grasslands is impacting habitat quality.

Scrub removal and stewardship of San Bruno Mountain can occur through a diversity of methods. This chapter highlights many of those methods and offers insights to collaborative management that may meet multiple goals. For instance, fuels management activities can be planned to complement scrub removal in designated areas.

Since fire is a powerful grassland management tool, creating dynamic management that focuses on opportunistic treatment of post fire landscapes will provide significant management benefits. We recommend initiating a post-fire action fund (Fire Fund) that will draw 5-10% of annual funds into an account reserved for post-fire stewardship, up to $15,000 annually. If a fund cannot be rolled over from year to year, we recommend opportunistically shifting annual project activities to leverage habitat gains made after an unplanned fire.

Grazing can also be used to limit scrub establishment and reduce the dense grasses and resultant thatch that directly reduce host plant density. The Northeast Ridge is a feasible location for an operational scale grazing trial. A trial with intensive monitoring to document positive and negative impacts is essential. Supporting research elsewhere in the Bay Area indicates that grazing can be beneficial for Callippe. The prior, unimplemented grazing plan was overly complicated and expensive for the needs of the target species.

We identify several areas where additional research can provide critical guidance for future management.

In Chapter 5 we established a set of Priority Grassland Management Areas that are critical for the continued survival of CS and MB on San Bruno Mountain. These Priority Grasslands total 944 acres, or approximately one-third of San Bruno Mountain. A subset of these areas is categorized as Essential Grasslands totaling 431 acres. Removing scrub, securing perimeters, and containing prioritized invasives within these Essential Grasslands must be a priority for the next 5 years.

Grasslands require a degree of regular and heterogeneous disturbance in order to maintain their diversity and to reduce scrub succession (Stromberg et al. 2007). A set of strategies and tools will be needed for protecting and enhancing 431 acres of Essential Grasslands in the next five years, 309 acres of Valuable Grasslands in the next 30 years, while balancing other annual obligations such as reporting, monitoring, administration, fuels management, and work directed towards other resources.

2007 Habitat Management Plan

The 2007 Habitat Management Plan (HMP) provides a rich palette of ideas for stewardship, while also reporting that a limited number of activities have dominated the management activity to date (TRA 2007):

> "Techniques are used that can reduce and control invasive plant infestations and brush, reduce thatch and dense annual grasses, and restore native plant communities. Techniques described include hand removal, herbicide application, pile burning, prescribed burning (when permissible), grazing, mechanical clearing, mowing, mycorrhizal inoculation, nutrient fixation, seeding, and planting. The sequence and timing of implementation of these management tools is critical to the success of grassland habitat protection and restoration. To date (2007), the habitat management methods utilized on San Bruno Mountain have been primarily herbicide treatment, mowing, hand removal and replanting (Table 4)" (page V-1).

2007 Management Plan Priority Areas

The 2007 San Bruno Mountain HMP begins to communicate the importance of scrub control on the mountain (Figure 5-7, previous Chapter). The Priority 1 and 2 areas correspond with high quality habitat for CS and MB as well as SBE: these roughly equate to our Priority Grassland management areas. Where our recommendations differ significantly is that our prescription to remove scrub is much more widespread, including south-facing slopes and critical grasslands around the ridgeline. Our recommended scrub control areas are critical for maintaining extant Viola and lupine populations that will otherwise be outcompeted by encroaching scrub.

The Management Toolbox (1982 HCP, 2007 HMP, & Novel Techniques)

The HMP, like the HCP and this document, urges the use of a variety of management techniques and tools because they help create a heterogeneous landscape that promotes native plant diversity. A number of the tools available for management of the Mountain have been underutilized. We list a number of techniques (Table 6-1) and recommend them to improve covered species management. Management actions need to be analyzed for impact to natural resources on the Mountain, not only special status taxa. All management activities need to comply with federal and state regulations and minimize impacts to listed species. The *Habitat Management Impact Minimization Measures* described in 2007 HMP must be used for guidance (see Page V-1).

Table 6-1: Management Tool Review

Management Tool	Utilization Notes	Limitations and Concerns	Relative Cost
	Removal		
Hand work – manual removal of plants by mowing and uprooting	Allows for removal of plants without use of chemicals. Biomass can be removed from site. Manual removal has proven to be successful on San Bruno Mountain especially for trials with coyote brush. This technique may be most appropriate for small populations.	Causes local soil disturbance. Can be labor and time intensive.	Varies depending on degree of invasion and treatment goals. Cost can be as low as a few hundred dollars/acre for nascent infestations, to upwards of $5000/acre for larger colonies.

Herbicide application	Useful for initial attack of large established populations of invasives as well as followup treatment.	Requires certified applicator, involves use of chemicals and potentially several applications over the course of the season. Can cause buildup of dead material in treatment areas.	$1000/acre for medium to high density control areas. Follow up in year 2 cost is 50% original. Further follow-up cost can decrease to 25% of original.
Grazing (cattle)	Used as a management tool on San Bruno Mountain until 1960s, grazing inadvertently maintained covered species habitat on a large scale with limited cost. With proper stocking rate, cattle can prevent scrub establishment, reduce thatch, control non-native annual grass growth, and favor annual forbs and native perennial grasses.	Improperly managed cattle can cause damage to a sensitive landscape including, but not limited to: erosion, overgrazing, soil compaction, and spread of non-natives. Current infrastructure for cattle is absent and will require a start-up cost.	Cost estimates for a 40-acre site are offered later in this chapter. Establishment Costs costs near $1500/acre at a scale of 40 acres, ongoing costs drop dramatically.
Grazing (goats/sheep)	Intensive grazing or mob grazing can be utilized in specific situations where low quality habitat occurs. Goats (and to a lesser extent sheep) can target woody vegetation.	Efficacy on San Bruno Mountain of this technique is inconclusive. A 2003-2004 goat grazing experiment was ceased after only a two year trial. Goats can be very destructive and non-discriminatory. Should be confined to poor habitat quality areas.	Often costs exceed $1500/acre. Cost is scaled.
Prescribed burn (large scale)	Removal of thatch and residual dry matter favors forbs over grasses. Fire creates nutrient flush and bare ground ideal for seed germination. Fire can kill or damage woody vegetation, especially small individuals. Ideal for maintaining grassland habitat.	Coordination of prescribed burning can be notoriously difficult. Risk of fire escaping prescribed area.	Event specific. Likely majority of costs will be absorbed by agency conducting prescribed burn (if considered a training activity).
Prescribed burn (pile burns)	Removal of thatch and residual dry matter favors forbs over grasses. Fire creates nutrient flush and bare ground ideal for seed germination. Fire can kill or damage woody vegetation, especially small individuals.	Fires are highly localized, often impacting a small area with soil sterilization. This may be desirable in gorse and other scrub reclamation areas. Fires are typically ignited during wet season, which may have negative impacts on soil fertility/seedbank of natives and newly germinating plants.	Coordinated with CDF historically. Prison crews cost approximately $500 per acre.
Microburns	Utilization of fire in burn boxes and other approved	A “boutique” management technique	Needs to be estimated, likely very

	techniques that enclose a small burn safely. Removal of thatch and residual dry matter, same as above. Works on small scale and could be beneficial for host plants such as Viola.	that is expensive and may stir discontent over the use of fire.	high costs per acre ($5,000 - $10,000), although much smaller areas would be treated with this method.
Hydro-mechanical Obliteration (HMO)	Removal of annual vegetation and thatch in targeted areas. This technique has been shown to be effective in grassland restoration in San Mateo County. HMO is ideal for benefiting existing perennials in an annual grassland by setting annuals back with the physical force of the treatment.	Creates physical disturbance of the entire top inch of soil. Treatment areas must be within 300 feet of road accessible by 4x4 with water tank. Water is required for the technique.	$2000/acre in addition to the cost of water.
Flaming	Direct mortality of plants at cotyledon stage. Ideal for large infestations and monocultures of weeds. Flaming is ideal for treating French broom and fennel seedlings. Established perennials can resprout after losing emergent leaves.	Treatment can be slow. Treatment is non-specific. Treatments should be limited to rainy or moist days to limit fire risk.	$500-$2000 per acre depending on density of treatment.
Soil Solarization	This technique which covers soils with a clear tarp directly impacts annuals and many perennial plants by elevating local soil temperatures. Seed banks are reduced with this technique often leaving a blank slate. This technique is ideal for small weedy patches with limited native resources.	Treatment is non-specific and impacts all living things equally. Soil sterilization in the top horizon can occur. This technique cannot treat large acreages and often is not aesthetically pleasing.	$2000 per acre, but sites are usually much smaller.
Soil scraping	Removal of thatch and typically O layer and some A layer of the soil, including seeds stored in those horizons. Scraping is ideal for removing seed banks of non-native species in weedy grasslands or converted scrub.	Method typically is completed with heavy equipment which can be considered "heavy handed". Local soil disturbance is significant.	Scraping can be completed in early winter or early spring when soils are wet but not saturated with water. Heavy equipment rental applies, therefore, scraping may be combined opportunistically with other projects using dozers.

	Plant Establishment		
Restoration Plantings	Restoration plantings are ideal for areas with low host or nectar plant resources. They can usually be used by the target species within a year.	Plantings are more time intensive than seeding methods and have historically been only partially successful on SBM. Careful planning of planting locations is key since many new plants can become overgrown with non-natives quickly. Supplemental watering may be needed.	Highly variable.
Broadcast Seeding	Seed availability is often a limiting factor for native plant recruitment. Seed collection and dispersal into sites with low native cover can be used to increase host and nectar plants. Some initial treatment is necessary to reduce weed competition and produce a good seedbed.	Seed collection should be local, preferably from SBM, but seed from anywhere on the peninsula is likely acceptable. Seed collection needs to be timed with seed maturation, which is often spread over 4-6 months for California natives.	$1500-3000 per acre depending on seeding rate and seed sourcing. Local seed is usually more expensive.
Drill Seeding	Drill seeding has a higher success rate than broadcast, and the heavy machinery makes it appropriate on larger scales.	Sites usually need to be relatively flat to allow for machinery to access the area. Larger volume of seeds need to be available.	With machinery rental and seed purchase, this technique will likely cost $3000-5000 per acre.
Transplanting Roots and Rhizomes	Viola on SBM seems to be predominantly spreading through rhizomes. Transplantation of rhizome and root fragments during the active growing season may help establish new Viola populations. Viola cores can be moved where rhizomes and soil are extracted and moved to a new location. The benefit of coring is that soils are likely slightly less disturbed than with a shovel.	This technique is labor intensive and requires prior planning in order to identify good transplant (donor) areas. Transplanting may impact larvae in diapause.	Unknown.
Mycorrhizal Innoculation	Fungi can be critical for aiding native plant establishment and survival. Mycorrhizal inoculation can be combined with various plant establishment methods.	Mycorrhizae specific to SBM may be difficult to isolate, identify and purchase. But use of native soils as inoculant is feasible.	About $500-1000 per acre depending on inoculation rate.

An effective management scenario utilizing a number of these tools is presented in Chapter 10.

Research indicates that a technique can be successful in one location, but not necessarily in another topoclimate or on another soil type. It is essential to evaluate each technique at a topographic scale to evaluate whether or not they can meet the prescribed goals when applied locally. Monitoring new techniques and even well proven ones is essential to understanding the value of each treatment type at San Bruno Mountain. This evaluation can be completed on a qualitative basis with photo point monitoring in order to offer a first approximation of efficacy. Detailed quantitative monitoring of new experimental treatments (such as the grazing trial or outplantings/seeding) is most important during the initial experiments, and can be relaxed to less intensive methods when scaling up proven treatments. There is a balance between monitoring intensity and evaluation needs – if the story can be told with photo points (which is especially appropriate for scrub management) then that may be sufficient.

Scrub Encroachment and Management

Shrublands in coastal California are expanding into grasslands with the absence of fire. California grasslands can be maintained with frequent fire and/or grazing (Adam 1984, Tyler et al. 2007). Callaway and Davis (1993) used aerial photographs to measure shifts in grassland, coastal sage scrub, chaparral, and oak woodland communities between 1947 and 1989 in central coastal California (Gaviota State Park near Santa Barbara). The highest transition rate was in unburned, ungrazed plots shifting from grassland to coastal sage scrub. Burning or grazing reduced transition rates. Burned plots showed a higher transition rate from coastal sage scrub to grassland.

McBride and Heady (1968) showed that coyote brush (*Baccharis pilularis*) increased from 7% to 22% of the areal extent of East Bay Regional Parks in less than 37 years since grazing was eliminated. They experimentally linked this expansion to grazing cessation and fire suppression. In Contra Costa, Alameda, and Santa Clara Counties, widespread loss of grasslands to scrub typically begins with establishment of coyote brush (Keeley 2005).

Shrub colonization may have positive feedback loops that increase rate of establishment. Herbivores, such as brush rabbits, use the shrubs as shelter and can reduce cover of herbaceous plants in the immediate vicinity of the shrubs. Some shrubs may produce allelopathic volatile compounds that inhibit germination around the shrubs. Reduced light may also inhibit growth under the shrubs (Tyler et al. 2007). Disturbance (such as grazing or fire) is required to maintain most grassland in the Bay Area (Keeley 2005).

Coyote brush accounts for the majority of the scrub encroachment observed on San Bruno. It seems to follow the well documented pattern of episodic establishment in wet seasons when roots can more quickly tap into needed soil water. Once seedlings have survived the first critical year, mortality drops quickly and full establishment plays out over the next 5-7 years (Williams et al. 1987). During this process of establishment, grassland resources decline and eventually disappear. Soil changes such as increased nitrogen and allelopathic compounds often follow scrub encroachment (Zavaleta and Kettley 2006, Weidenhamer and Callaway 2010) reducing the ability of grasslands to successfully re-establish without an intermediate disturbance such as a fire or intensive browsing (Hobbs and Mooney 1986). Our recommendations are to limit the establishment process as much as possible by removing invading scrub when it is young (1-2 years old). Our Priority Grassland Management Areas are ideal areas to enact early treatment of nascent scrub invasion. When considering specific sites for scrub management, we offer the following decision making chart (Figure 6-1) to determine where scrub management is appropriate.

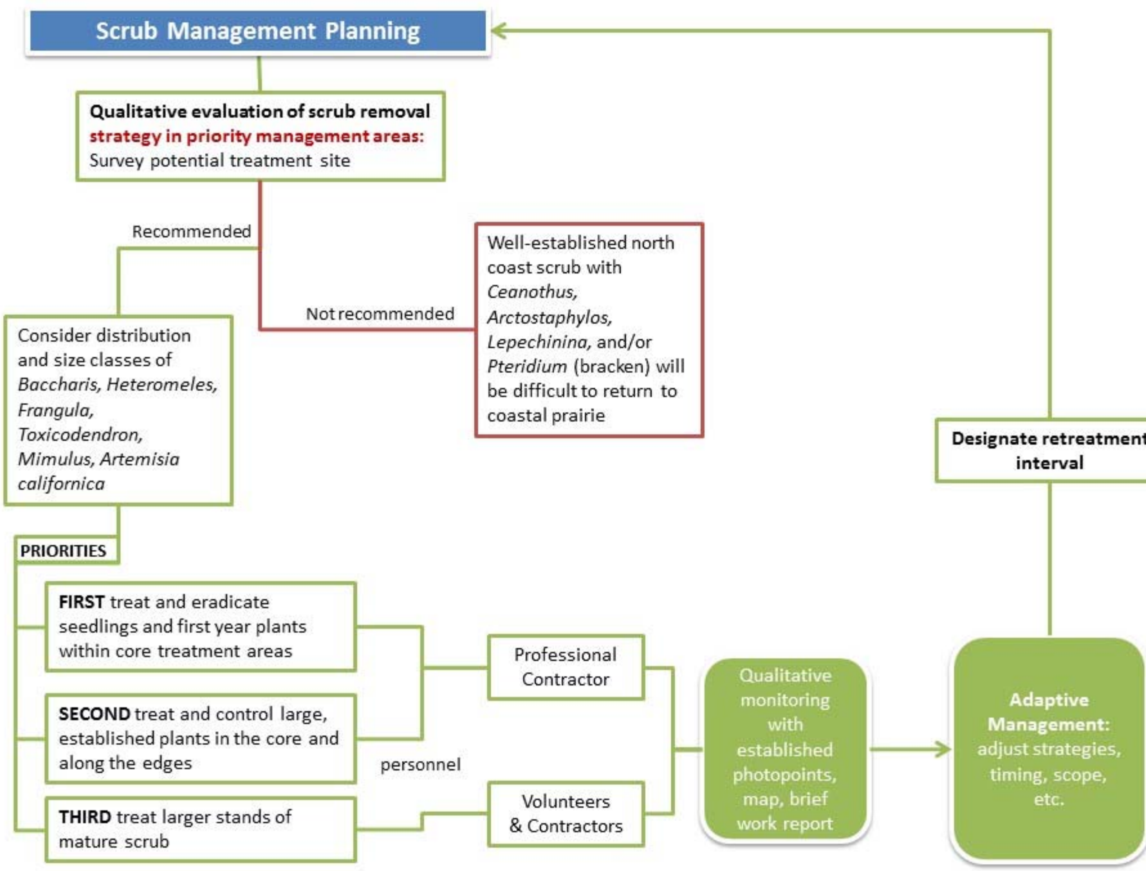


Figure 6-1: Scrub Management Decision Chart

In this chart, we conceptually outline the scrub removal process. Species not recommended for removal can be rare, difficult to remove, and indicative of mesic soils that may not be suitable for grassland establishment. The chart also offers guidance to what may be completed with a professional contractor and volunteers (discussed further in Chapter 9).

In addition to providing species-specific guidance, it is critical to determine the stage of invasion and how that will impact budgetary needs for the project as well as chances for success. Simply speaking, the more established scrub is, the more costly and difficult removal will be. Many of these increased costs stem from time and equipment for scrub removal and disposal of established scrub. Additionally, established scrub can quickly change soil properties (Haubensak et al. 2012, Zavaleta and Kettley 2006) as well as reduce germination of existing seedbanks (Corbin and D'Antonio 2012).

It is important to treat new invasions early. Moody and Mack (1988) showed overall effectiveness of control measures was greatly increased when satellite populations were targeted. This was based on relatively larger growth potential of outlier colonies compared with established core colonies.

Treatment of new invasions should be prioritized over the next 5 years in order to preserve extant grassland habitat. We offer guidance on 6 stages of invasion and prioritization of management of specific stands of scrub (Figure 6-2).

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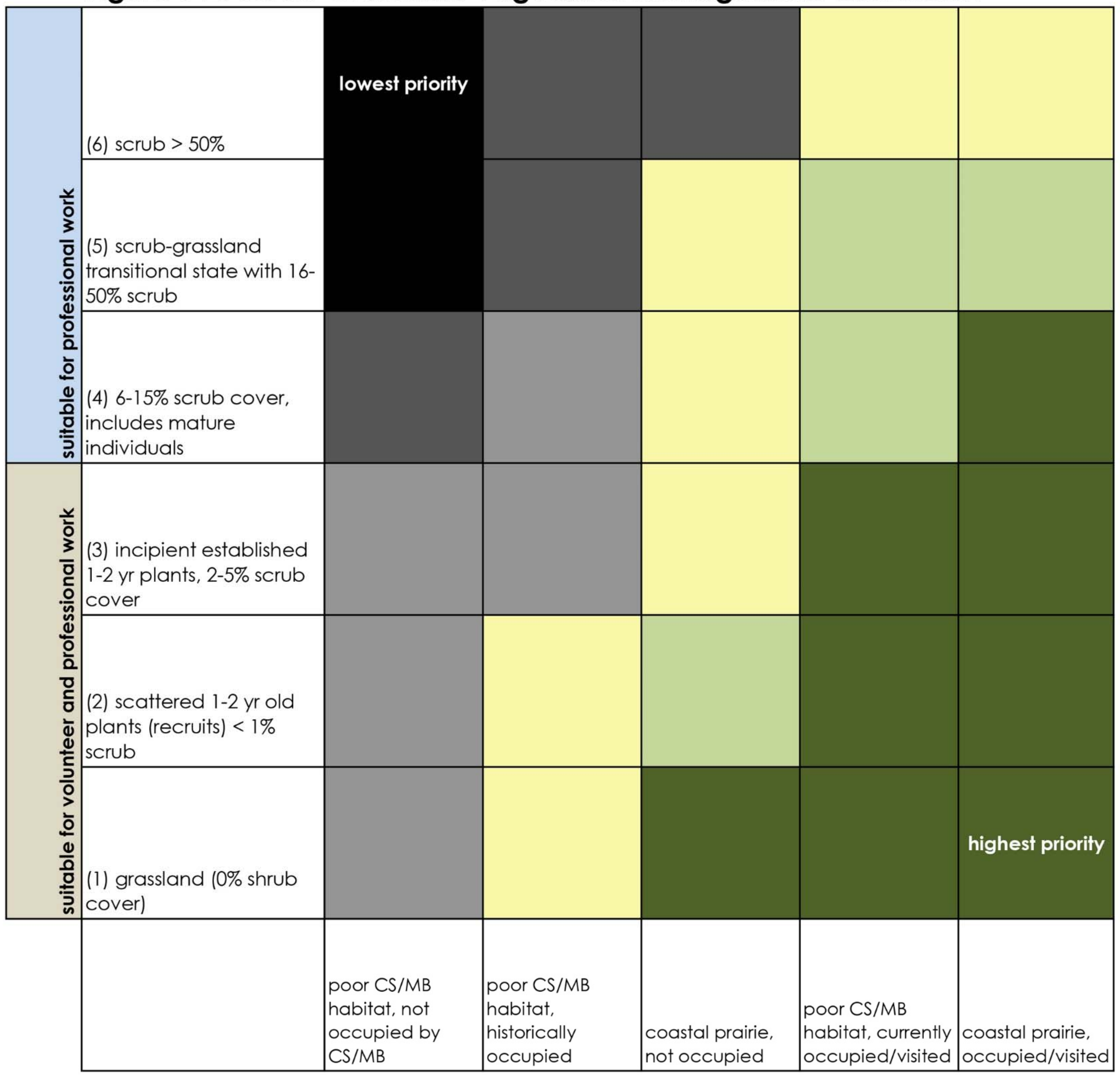
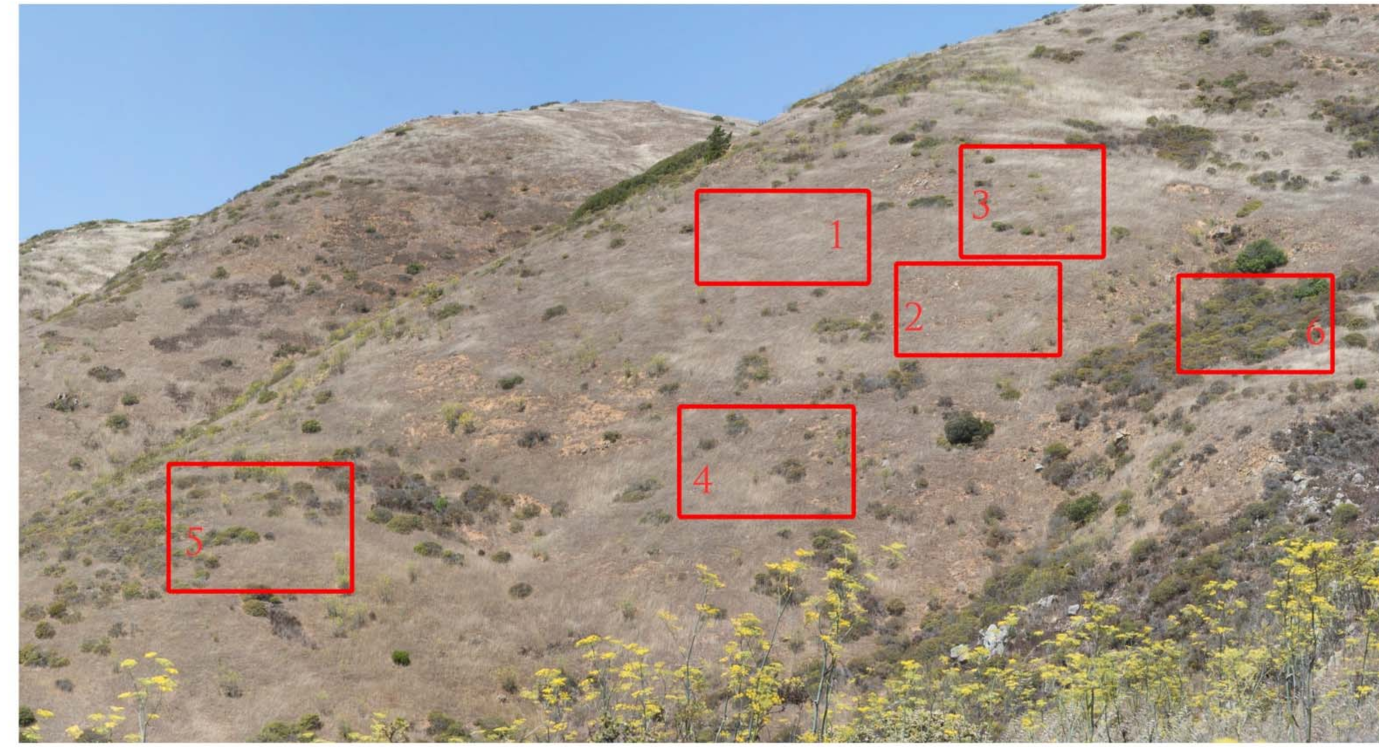
Figure 6-2: Scrub-Grassland Vegetation Management Continuum





Coastal grassland and north coastal scrubland vegetation communities often compete. With a lack of disturbance, the scrub will usually succeed the coastal grassland. This process can occur slowly or very quickly depending on soil, aspect, seed sources, and climate. Blocks of the chart filled with shades of green are high priority management targets, with high quality grassland and/or occupied CS/MB habitat. Priority is reduced as the colors fade to black where conditions are typically mature scrublands with no CS/MB. Historically occupied habitat in high quality grassland is an intermediate priority.

Figure 6-2: Scrub-grassland vegetation management continuum. The above plate offers representations of each of the 6 scrub vegetation treatment classes in one constrained area. Typically, this entire area would be treated as one class for management purposes.

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New invasions and low density scrub in high quality, occupied grassland need to be treated immediately. Every year that passes allows for greater establishment of seedlings and development of a seedbank. This makes management more expensive, less effective, and less likely to allow for successful passive re-establishment of desirable grassland species. The diagram above shows these areas in green. Moving towards the black end of the spectrum (top left), management activity is discouraged in highly invaded scrub with no historic butterfly habitat. The center of the diagram allows for the most discretion where biologists, land managers, the TAC and others can discuss and create an informed plan of action (Figure 6-2).

Tactical scrub removal by WCW has been effective in the past. A timely coyote brush removal project along the south face of the Southeast ridge shows the before and after results of treatment of scrub with cutting and manual painting (Figure 6- 3). Eight person hours were dedicated to this particular treatment. This area should be rephotographed annually for three years to document the medium range success of this approach.

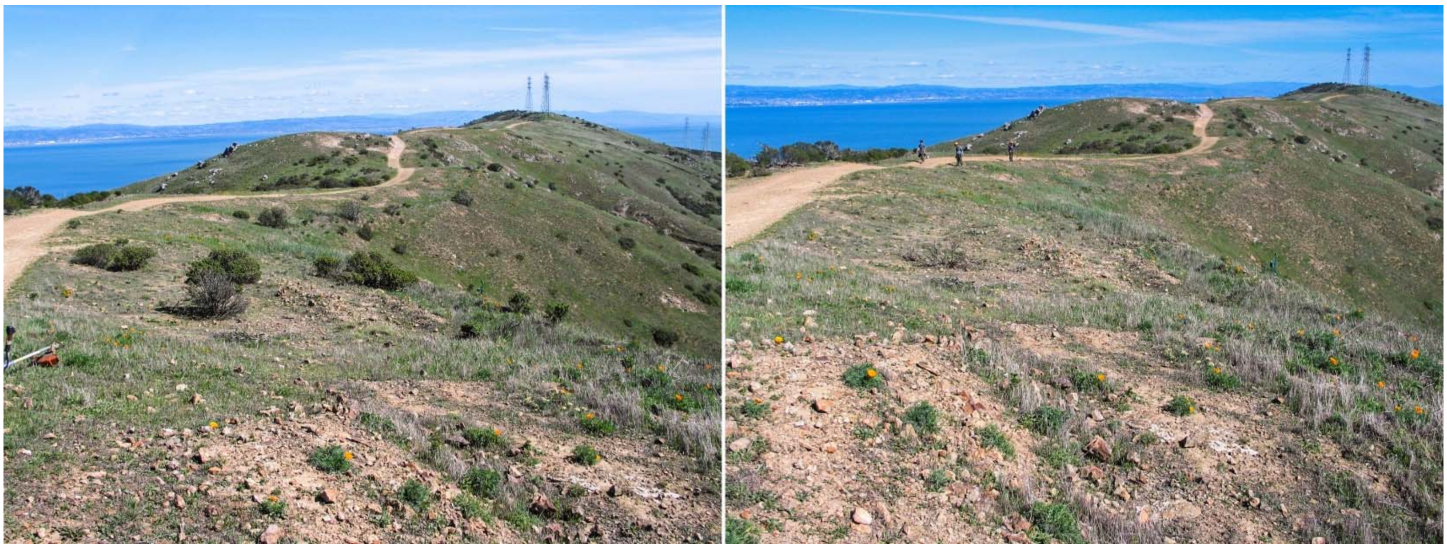

Figure 6-3: Manual scrub removal and stump painting on the Southeast ridge. March 2014.

Another set of photos below shows Essential Grassland cleared of scattered scrub at the top of Buckeye Canyon (Figure 6-4). The top left photo illustrates high diversity grassland after treatment. The top right photo is taken from the scrub edge; note the high cover of "soft-scrub" species like red pitcher sage (*Salvia spathacea*) and beeplant (*Scrophularia californica*), including some native grassland species in between, a few remaining coyote brush (*Baccharis pilularis*), and large blue blossom (*Ceanothus thyrsiflorus*) in the background. Habitat edges like this will require heavy treatments to fully convert to grassland, and perimeter containment is the appropriate treatment until all Priority Grasslands have been treated.

The bottom left photo shows the Essential Grassland at mid-elevations on Transmission Line Ridge, core CS and MB habitat. Note the small coyote brush among the scattered larger shrubs, and the thickening of scrub cover toward the grassland edge. This area is similar to the pre-treatment site on the South Slope (Fig 6- 3 above) and could be rapidly cleared with professional cut and paint for large plants, coordinated with professional/volunteer hand removal (weed wrench, hand pull) for the smaller plants.

The bottom right photo shows a north-facing slope in Brisbane Acres with an incipient scrub invasion. Without immediate treatment, scrub will fill in within a few years and this Essential Grassland will be lost.


Figure 6- 4: Desired state of essential grasslands compared with invaded grasslands. Spring 2014.

Grazing and Fire

Scrub invasion of grasslands in the East Bay (as well as other areas in coastal California) has been historically moderated by two factors: wildfires and grazing (McBride and Heady 1968). Both of those elements are rare on San Bruno Mountain and they do not occur at the same frequency as pre-European settlement of the area. Yet these tools have been shown to be extremely effective in managing grasslands at a large scale (Menke 1992, Stromberg et al. 2007, Weiss 1999). If misapplied, any tool can cause a detriment to the environment. We present our reasoning and approach to investing in an experimental approach to using these two tools.

Grassland Quality and Residual Dry Matter

Although presence of grassland vegetation is the first determinant of butterfly habitat, grassland quality determines whether the density and diversity of host and nectar plants are high enough to maintain butterfly populations. In high quality grasslands on San Bruno Mountain, Viola and lupine are present at high densities, lupines occupy rock outcrops and locally disturbed areas, and diverse native forbs and grasses are established and reproducing at high cover. In other areas, grassland quality is lower –annual grasses and non-native forbs dominate, thatch has built up, native species are limited to areas of thin soils, Viola and lupine are absent or present only at low densities.

One method for measuring grassland quality is to assess residual dry matter (RDM) (Bartolome 2006). Higher RDM indicates a larger amount of thatch, which typically precludes high density forbs (Bartolome 2007) including Viola or lupine. Some RDM is recommended to protect against erosion (Sotoyome RCD 2006).

In August 2014, we visited three locations with certified rangeland ecologist Larry Ford, Ph.D. and collected 12 representative RDM samples along with obstruction heights and ecological site information (Table 6-2). These results indicate that portions of San Bruno mountain grasslands have very high thatch cover that will negatively impact vegetation diversity and host plants (Ford 2007). Grazing is an effective tool for reducing thatch and residual dry matter.

Table 6-2: Residual Dry Matter (RDM) Measurements on Three Locations, August 2014

Location	Vegetation Description	Point #	Adjusted Dry Weight (lb/acre)	Obstruction Height (In)	Thatch Height (in)	Bare Cover (%)
NE Ridge	tall Avena	1	3300	21	<1	0
	low Briza minor	2	3900	8	<1	0
	low Agrostis sp.	3	5900	8	<1	0
	Viola, better butterfly site	4	2850	7	<1	0
	Viola	5	2750	10	<1	5
	very tall Avena	6	6400	18	0	0
South Slope - Terra Bay Water Tank Area	tall Avena	7	6400	29	1	10
	medium height Avena	8	4200	7	<1	0
	large silver lupine	9	4200	22	<1	0
Hillside Juncus Ravine Burn	post fire forbs and grasses	10	3500	15	<1	25
	silver lupine	11	1000	9	<1	30
	coyote brush shrubs invading	12	750	13	0	50

RDM values in 2014, a drought year, can be compared to values from 2003 in the Hillside/Juncus area (Figure 6-5). Peak RDM values in 2003 (9300 lb/ac) were nearly 50% higher than the highest observed values (6400 lb/ac) in 2014. Drought typically reduces primary productivity, thus numbers across SBM are likely lower in 2014 than a typical year. Locations with known Viola had 2850 and 2750 lb/ac RDM.

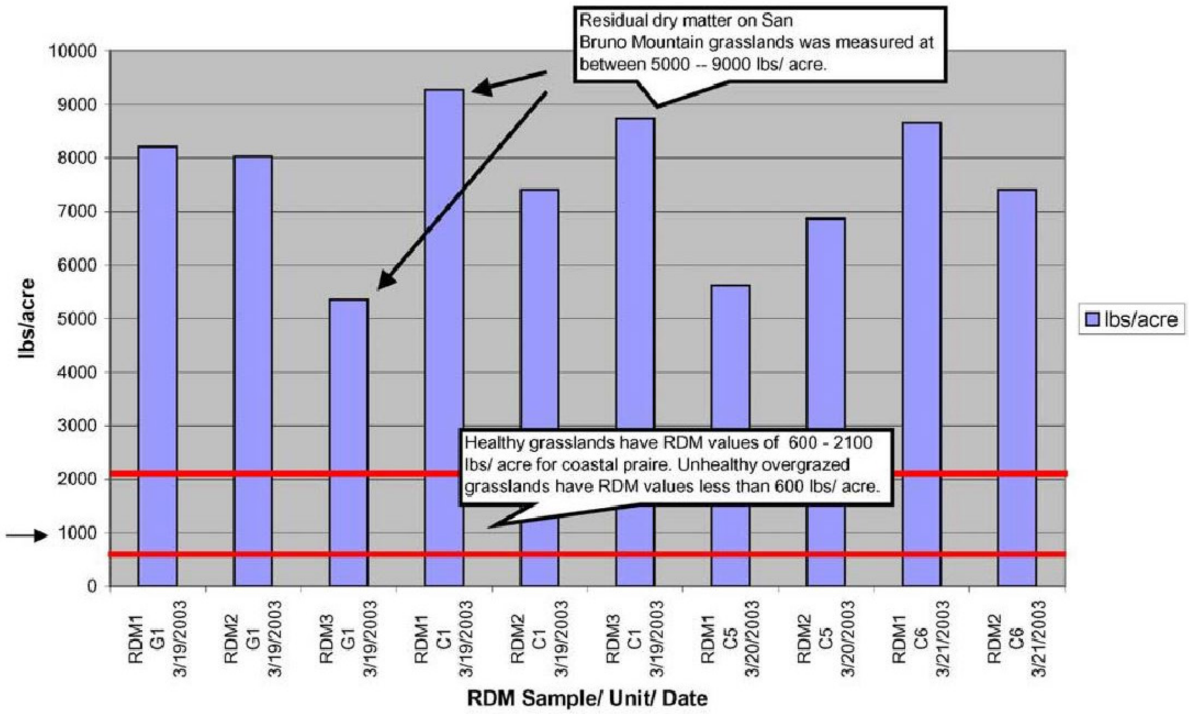

Figure 6- 5: 2003 RDM measurements from Hillside/Juncus Area (source: 2007 HMP).

Bartolome (2006) provides minimum RDM standards of 1200-2100 lb/ac for coastal prairie (with higher values on the slopes). We recommend an initial goal of 1200 to 2500 lb/ac throughout the mountain. This target should be compared with Viola and lupine monitoring, and adjusted as needed.

Grazing Trials in the Guadalupe Hills

From the 1884 purchase of the now HCP lands by Charles Crocker through the mid twentieth century, San Bruno Mountain was primarily used for cattle grazing (County of San Bruno 1982). Historic photos investigated in Chapter 4 show large expanses of contiguous grassland that was likely maintained by grazing.

Although results of grazing experimentation on grasslands does not show benefits across all guilds (Harrison et al. 2003), grazing has a pronounced benefit in reducing non-native annual grass cover while increasing annual forb cover and native grass cover (Edwards 1992, Hayes and Holl 2003, Hatch et al. 1999). These responses are beneficial for our covered grassland species.

Grazing animals have different preferences and patterns, and each must be analyzed for impacts to covered species. Goats, for instance, prefer woody species and can be used to remove nearly all vegetation in an area (Sotoyome RCD 2006). They have been used historically on the Mountain to remove biomass and browse invasive weeds including fennel and French broom. This form of grazing is very intensive and occurs over a short time scale. Goat grazing could be appropriate in lower quality priority areas (such as the Owl-Buckeye – Transmission Line grassland connection) filled with woody species and few butterfly host plants.

Figure 6- 6: Comparison of grazed (right of fence) and ungrazed grasslands in spring.

Cattle prefer eating grasses (Sotoyome RCD 2006), and at moderate stocking rates they leave about 3”- 5” of cover (Figure 6-6). There is much research supporting the effective use of cattle for long term habitat management (Weiss et al. 2014, Weiss 1999).

We predict responses of butterfly host plants (Viola and lupine species) to cattle grazing will be highly beneficial (in the case of Viola), and low to moderately beneficial to lupines species that are typically avoided by cattle due to their toxins. Grazing has been shown to reduce thatch and thus benefit Viola in Solano County (Solano Land Trust and Pacific Gas and Electric Company 2007). Livestock grazing that favors native bunchgrasses and reduces the height and density of the non-native annual grasses is also expected to maintain existing Viola (Ford 2007). Data collected on paired grazed and ungrazed plots in Point Reyes National Seashore had higher densities of Myrtle’s silverspot and higher frequency of its host plant *Viola adunca* (Murphy and Launer 1992, in Sotoyome). Because cattle preferentially target grasses, we expect little direct herbivory damage to either Viola or lupine, although it is possible some will be trampled. At low stocking rates, trampling should be minimal and may benefit germination of new plants by causing local soil disturbance.

We recommend a ~40 acre fenced paddock with two gates located in the Guadalupe Hills area (Figure 6-7). A total of 56 acres of Essential Grasslands are identified there that would serve as an optimal experimental location. We recommend designing an experiment that will monitor residual dry matter (RDM), Viola and lupine density, native and non-native plant cover, and butterfly adult densities over the course of several years. Ideally, we would be able to maintain areas habitat outside of the paddock would serve as a control sites. The basic design would be a “Before-After/Control/Impact” (BACI) experiment, with at least one year of pre-treatment data collected. It is premature to set up an exact experimental and monitoring design at this point, except to re-emphasize the important of a rigorous scientific assessment of grazing effects, positive, neutral, and/or negative.

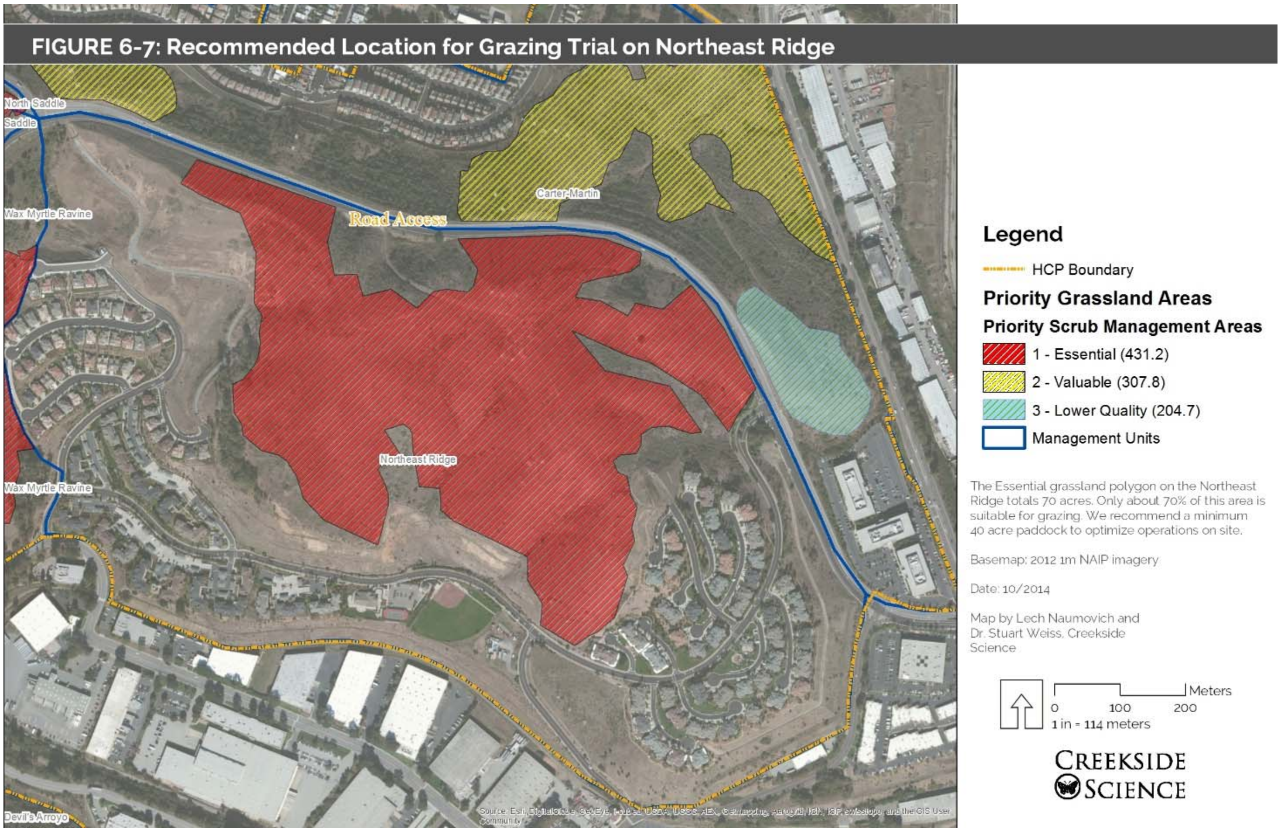

Figure 6- 7: The Northeast ridge Area is recommended for a cattle grazing trial. We recommend a minimum 40 acre paddock in the Essential Grasslands, which would occupy roughy 70% of the Essential grassland.

The 2002 grazing plan (Amme, 2002) is considered to be far too intricate and overbuilt for this environment (Ford, 2014). Although well-defined paddocks have value, the plan is over-engineered and costs are excessive. Larry Ford offers this cost approximation for the initial set-up:

Using the rates (for a grazing cooperator like Renz Ranches), and assuming the field will be one square 40 acres on an accessible but moderately-sloped hillside with a municipal water source available, the estimated costs would be:

Fencing and two gates (40 acres square = 5280 feet perimeter)

5280 feet x $9/foot = $47,520

One watering trough (4x10 feet concrete) delivered and installed with meter, plumbing hardware, foundation, gravel apron, source to trough buried pipeline (1000 feet), and back-filled trench, including labor = $9072

Total Cost: $56,592

Ongoing costs will include maintenance, and will drop substantially. Monitoring and analysis costs of the experiment can only be estimated once an exact design is considered and adopted. The infrastructure for this project may be an appropriate target for outside funding with internal operating costs an effective match.

Fire on the Mountain

Fire may be the single most effective landscape scale tool for managing grasslands (Niederer 2014). Prescribed burns can restore grassland quality and halt scrub invasion, generally shifting community structure towards annual forbs, both native and non-native (Harrison et al. 2003, Rice 2005, D'Antonio et al. 2006, Reiner 2007, Zouhar et al. 2008). Germination of forb seeds is enhanced by increased light availability and temperature at the soil surface. Seedling survivorship may be favored by increased light, increased nutrients, and decreased pathogens. The increased light generally increases flowering in geophytes (bulb plants). Germination in legumes and other species with physical seed dormancy may increase as a result of the direct effects of fire (heat scarification) rather than secondary effects such as light. Wildflower displays are common after grassland fires in California. Direct mortality of woody species may also shift the community toward forbs (D'Antonio et al. 2006, DiTomaso and Johnson 2006, Reiner 2007).

Members of Fabaceae (pea family) or Geraniaceae (geranium family) tend to be most favored fire followers (DiTomaso and Johnson 2006). Most native annual legumes (Acmispon [Lotus], Lupinus, Astragalus, and Trifolium) increase after fire (D'Antonio 2006). Erodium spp. are a common fire follower (DiTomaso and Johnson 2006). D'Antonio et al. (2006) saw Erodium increase with spring and early summer burns, regardless of repeated burning. Fall burning generally had no effect on Erodium abundance.

Harrison et al. (2003) examined the variation in effects of fire and grazing on native and exotic species diversity in California grasslands. They compared various serpentine and nonserpentine grassland sites throughout California. Fall fire tested two years before and two years after at McLaughlin Reserve in Napa, Lake, and Yolo Counties.

Fire increased exotic species richness (especially exotic annual forbs) more than that of native species in nonserpentine grasslands. On nonserpentine soils, where nonnatives generally outcompete natives, nonnative annual forbs may more quickly and effectively utilize the available space and light created by disturbance and thus reduce the response in the richness of native species. Their conclusion was "The rich get richer and the poor get poorer."

Reiner (2007) agrees: "Most likely, plant community composition before burning plays an important role in determining whether fires help promote native diversity." He counsels managers to consider the pool of both native and nonnative species that are present to respond to fire. DiTomaso and Johnson (2006) also point out that new invaders, such as tocolote, can establish after fires. (Fire may also stimulate long-dormant seed banks, allowing unexpected natives to emerge (Reiner 2007).)

Also in agreement are Zouhar et al. (2008), who state "Generally speaking, if a fire occurs in a plant community where nonnative propagules are abundant and/or the native species are stressed, then nonnative species are likely to establish and/or spread in the postfire environment." Burning alone is unlikely to shift dominance from nonnative to native if the native species are sparse or low in vigor.

Due to SBM's close proximity to urban areas, high fuels loads and air quality restrictions, prescribed burns need careful planning and execution. We highly recommend the use of fire as a management tool, although we understand burns a great deal of preparation and planning, but we still believe the benefits likely outweigh the costs. On San Bruno Mountain, Viola has shown to benefit from fire (Figure 6-8), and butterfly abundance quickly recovered after the fire (see Chapter 3).

Figure 6- 8: Viola near Buckeye canyon rebounding and growing vigorously after the 2008 fire. (M. Forbert)

Areas of dense scrub are "opened" and become accessible to management by hand tools after a fire (Figure 6-9). These scrub dominated areas would otherwise require a great deal of manual labor and leave an unsightly scar on the landscape.

Figure 6- 9: Owl-Buckeye area after the fire. Scrub management is more effective immediately following fire. July, 2008. (M. Forbert)

A Fire Endowment

Prescribed fire is difficult to implement as a management tool. Prescribed burns are costly to implement and often are politically unpalatable. Wildfires do occur on San Bruno Mountain occasionally and they provide access to a critical management tool. Often, in the six months after a fire, management actions can be more cost effective and have a bigger impact on species conservation.

After the 2008 fire, Viola is seen rebounding the following spring in high density (Figure 6-8). Deploying management crews during this time period can greatly improve Viola regeneration and further reduce competition from scrub and weeds by continuing to knock back and remove scrub in burned areas. Additionally, early weed management can play a critical role in shirting grasslands back to more native-dominated vegetation. Direct seeding in areas of intense, hot burns may allow land managers to create high density patches of host and nectar plants, especially if soils have been sterilized from the fire.

We recommend a post-fire action fund that will annually draw some regular funding saving up resources for a stewardship actions after a fire event.

Fuels Management and Scrub Removal

Managing high fire risk vegetation is called fuels management. A typical fuels management action is the reduction of biomass along a wildland/urban interface. Usually these actions are completed on public lands by fire protection agencies like CALFIRE. The fuel reduction creates a fire break and defensible space between structures and wildlands.

Coordinating fuels management with habitat restoration has not always been successful (LSA 2009). Fuels work and habitat restoration goals do not always coincide, and all too often, public safety goals take precedence over habitat protection (Sierra Club et al. 2009). We offer a preliminary buffer area where fuels management may be appropriate (Figure 6-10). Potential areas where habitat restoration and fuels reduction may overlap are highlighted. These are areas where shared funding can create significant habitat restoration opportunities.

We are not endorsing this map (Figure 6-10) as a specific management plan, as the entire site needs to be reviewed on the ground with qualified biologists, the Fire Marshall, and the action may be subject to CEQA consultation.

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FIGURE 6-10: 100 Foot Buffer: Urban-Wildland boundary for Fuels

Legend

Vegetation Edge (WUI)

100 foot buffer from centerline

Priority Grasslands

Priority Scrub Management Areas

1 - Essential (431.2)

2 - Valuable (307.8)

3 - Potential Habitat (204.7)

A 100 foot buffer from the urban boundary (Wildland Urban Interface) is drawn in purple. This line represents where possible fuels activities would be considered. This map is not a fuels management recommendation.

Basemap: 2012 1m NAIP imagery

Date: 10/2014
Map by Lech Naumovich and Dr. Stuart Weiss, Creekside Science

Meters
0 460 920
1 in = 508 meters

CREEKSIDE SCIENCE

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Once a fuels management plan is vetted and approved with recent information (see 2005 Draft San Bruno Mountain Community Wildfire Protection and Fire Use Plan), further recommendations for habitat restoration can be completed. Fuels management and habitat restoration can likely be combined to reduce costs for San Mateo County Parks.

The Carter-Martin Area is used to illustrate a possible collaboration between fuels and habitat management. In the Carter-Martin management unit, two different objectives fall within the 100 foot fuel buffer: a green gorse polygon extending from Carter St eastward, and a yellow Valuable Grasslands polygon (Figure 6-11). Fuels management can thus be conducted here with two different, but linked goals: 1) reducing fuel loads in the present by removing/mowing vegetation, and 2) by creating grassland habitat that benefits covered species and helps reduce future fuels maintenance costs. The gorse polygon can be treated solely for reducing gorse cover. The Valuable grasslands polygon could be treated for fuels with an eye on the goal of restoring grassland quality (for example scraping the area and reseeding with natives where appropriate).

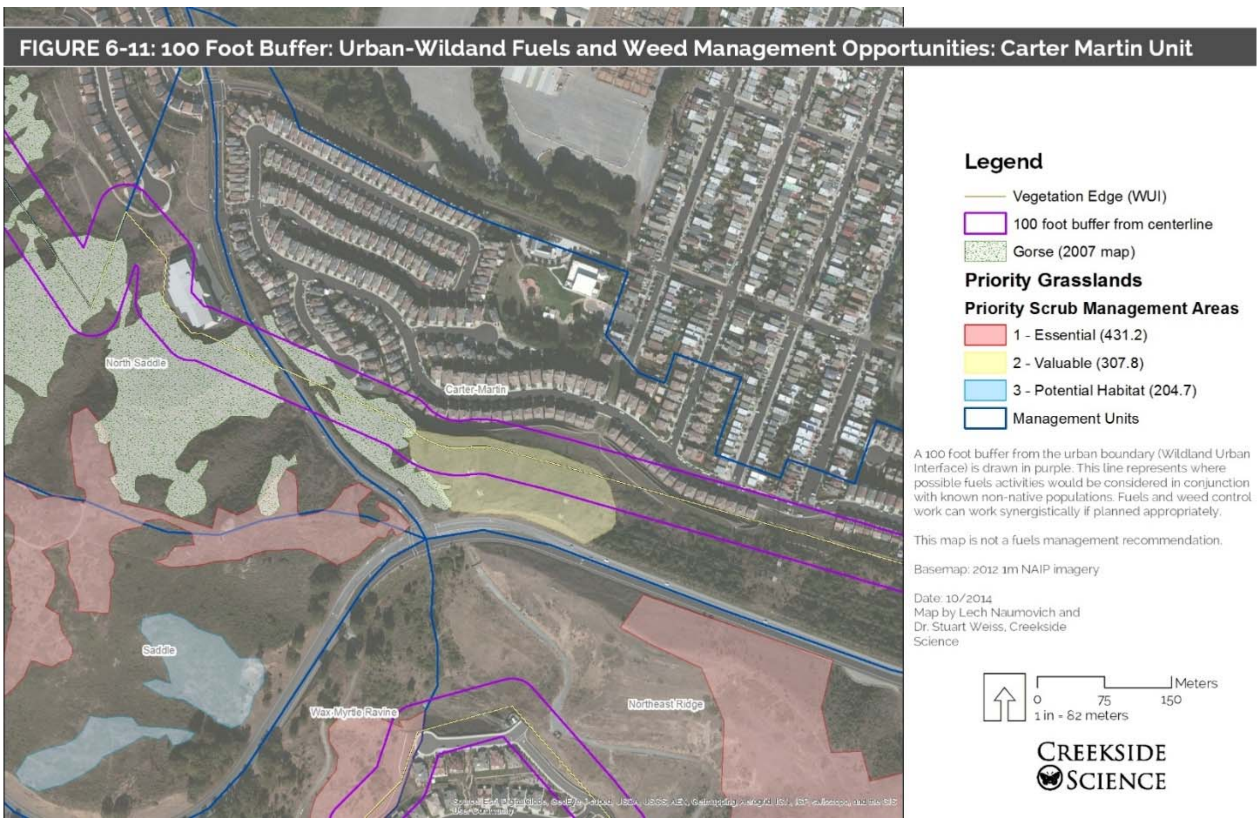
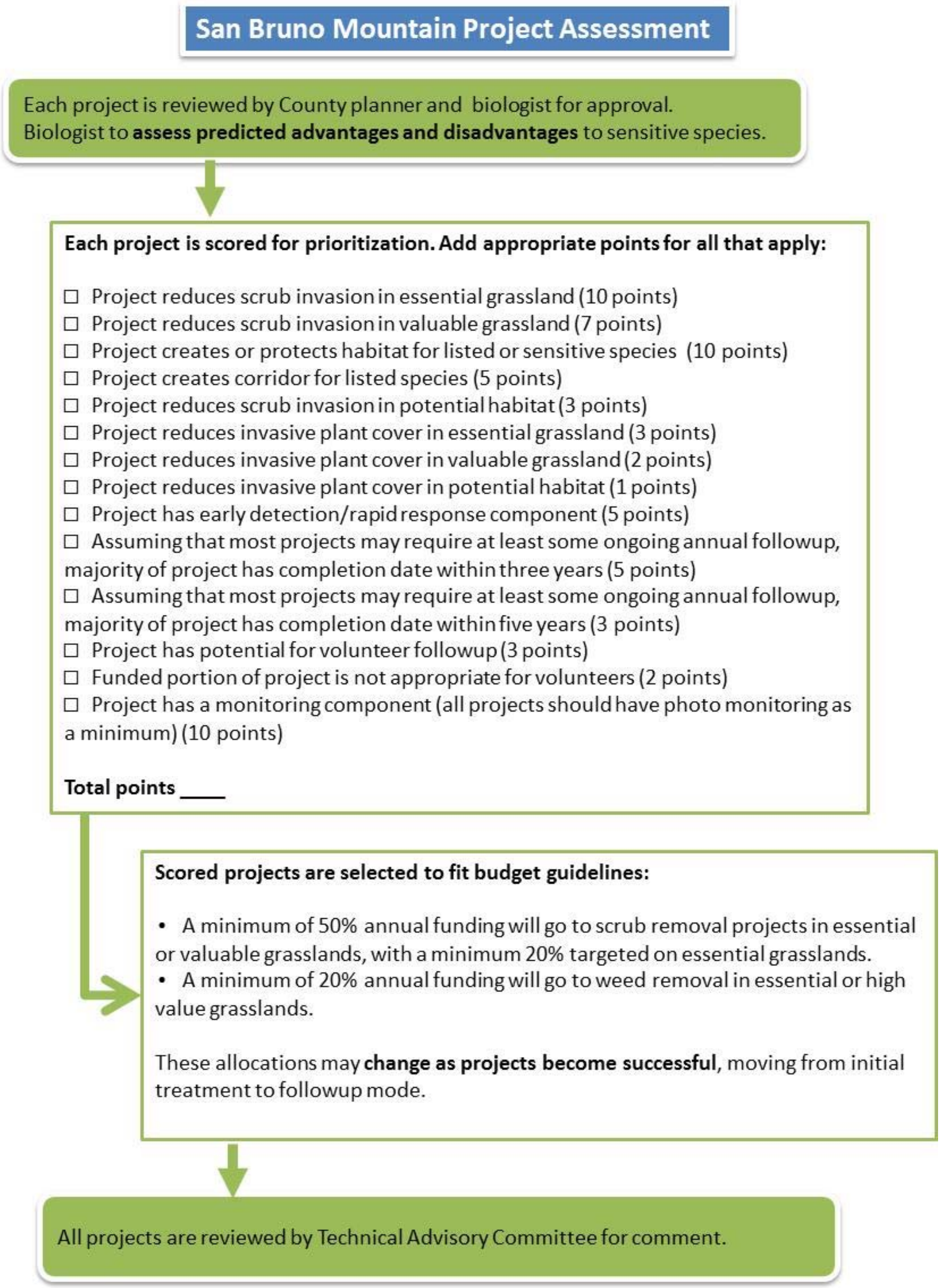


Figure 6- 11: Fuels and habitat management in the Carter-Martin unit

Project Prioritization

The following flowchart offers a tool to select and prioritize resource management projects on San Bruno Mountain (Figure 6-12). Since the original HCP was written, scrub control has consistently been identified as a key issue that needs to be addressed. In practice, however, scrub control has been a much lower priority than invasive plant control. As such, it appears at least 780 acres of grassland (40%) have been lost since 1932, and further loss is expected if the current trajectory continues. The perimeter and cores of essential grasslands should be secured within the next five years (by 2020). The flow chart offers a concrete tool to ensure scrub control projects in essential grasslands are made a priority. The point values and budget targets have been arbitrarily selected as a discussion starting point. They may be altered in the future as conditions change and/or to make this tool as useful as possible.



San Bruno Mountain Project Assessment

Each project is reviewed by County planner and biologist for approval.
Biologist to **assess predicted advantages and disadvantages** to sensitive species.

Each project is scored for prioritization. Add appropriate points for all that apply:

☐ Project reduces scrub invasion in essential grassland (10 points)
☐ Project reduces scrub invasion in valuable grassland (7 points)
☐ Project creates or protects habitat for listed or sensitive species (10 points)
☐ Project creates corridor for listed species (5 points)
☐ Project reduces scrub invasion in potential habitat (3 points)
☐ Project reduces invasive plant cover in essential grassland (3 points)
☐ Project reduces invasive plant cover in valuable grassland (2 points)
☐ Project reduces invasive plant cover in potential habitat (1 points)
☐ Project has early detection/rapid response component (5 points)
☐ Assuming that most projects may require at least some ongoing annual followup, majority of project has completion date within three years (5 points)
☐ Assuming that most projects may require at least some ongoing annual followup, majority of project has completion date within five years (3 points)
☐ Project has potential for volunteer followup (3 points)
☐ Funded portion of project is not appropriate for volunteers (2 points)
☐ Project has a monitoring component (all projects should have photo monitoring as a minimum) (10 points)

Total points ____

Scored projects are selected to fit budget guidelines:

- A minimum of 50% annual funding will go to scrub removal projects in essential or valuable grasslands, with a minimum 20% targeted on essential grasslands.
- A minimum of 20% annual funding will go to weed removal in essential or high value grasslands.

These allocations may **change as projects become successful**, moving from initial treatment to followup mode.

All projects are reviewed by Technical Advisory Committee for comment.

Figure 6-12: Project assessment sheet. We envision using a scoring methodology for ranking different stewardship actions. With limited budgets, often difficult decisions need to be made over which projects to fund.

Adaptive Management and Applied Research

Resource management at San Bruno Mountain should be undertaken within the adaptive management model. Under this model, problems are assessed using existing information. Management regimes are designed and implemented in order to achieve stated objectives. Results are assessed through monitoring, and information gained is used to assess and adjust the management regime. Through each iteration of the cycle, information is gained that further refines the optimal management regime (Figure 6-13).

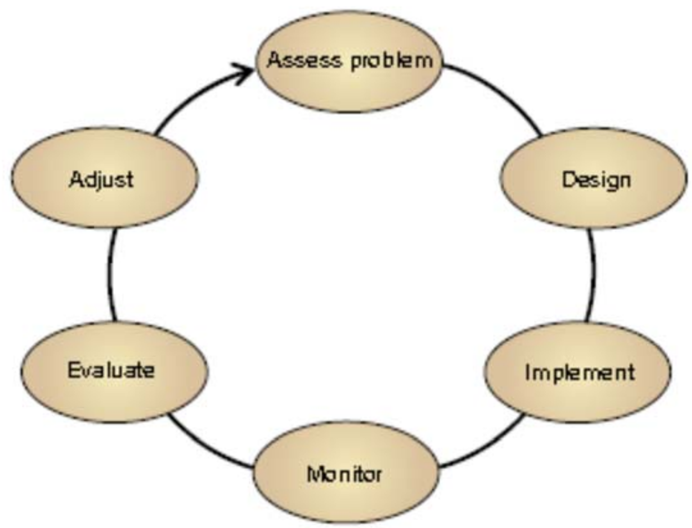


Figure 6-13: The adaptive management process. Taken from Williams et al. 2009.

Literature review, experimental research, and monitoring data can provide critical feedback that can be used to trigger management changes that further improve resource management goals. Such information can be used to form more powerful integrated management techniques (Matzek et al. 2013).

Suggested questions that can be answered through research and adaptive management:

- How does cattle grazing affect listed butterfly host plants?
- Can top soil removal aid in the restoration of high quality grasslands from gorse infested areas?
- Can direct seeding be more cost effective than planting?
- What role can burn piles/burn boxes play in reinvigorating declining Viola habitat?
- How long do post-fire effects last at the 2013 Juncus/Hillside fire site?
- Can extant rare plants on the Colma Dunes be restored (dispersed) to adjacent sandy sites that have become dominated with scrub?

Chapter 7: Evaluation of Other Covered Species

Summary

Limited effort has been spent on monitoring species other than listed butterflies on SBM. We and others (Nelson et al. 2015) believe this data gap needs to be addressed.

We provide the most recent information on species (not including CS, MB, and SBE) that are covered by the HCP. We recommend compilation and review of all the existing information on other covered species to ensure they and their habitat are being maintained as much possible. Some covered species that were included in the HCP have not been observed on SBM since 1982. We recommend a recurring 5-year survey of perennial rare plants including collection of demography and recruitment data. Annual plants should be monitored at least once every 3 years. All results should be reported to the CNDDB. Because other listed animals are not currently known from the mountain, we do not recommend surveying them.

The San Bruno Mountain Habitat Conservation Plan was approved to protect populations of the following federally and state-listed species (excluding rank 4 listed plants by the CRPR):

Table 7-1: HCP Covered Species on San Bruno Mountain (Federally listed and/or State listed 1B)

Taxon	Status*
Mission Blue Butterfly (*Icaricia icarioides missionensis*)	FE
Callippe Silverspot Butterfly (*Speyeria callippe callippe*)	FE
San Bruno Elfin (*Callophrys mossii bayensis*)	FE
Bay Checkerspot Butterfly (*Euphydryas editha bayensis*)	FT
San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*)	FE, CE
California Red-legged Frog (*Rana aurora draytonii*)	FT
San Bruno Mountain manzanita (*Arctostaphylos imbricata*)	CE, CRRP 1B.1
San Francisco lessingia (*Lessingia germanorum*)	FE, CE, CRRP 1B.1
White-rayed pentachaeta (*Pentachaeta bellidiflora*)	CE, CRPR 1B.1
Pacific manzanita (*Arctostaphylos pacifica*)	CE, CRRP 1B.2
San Bruno Mountain manzanita (*Arctostaphylos imbricata*)	CE, CRRP 1B.1
Montara manzanita (*Arctostaphylos montaraensis*)	CRRP 1B.2
Diablo helianthella (*Helianthella castanea)*	CRRP 1B.2
San Francisco spineflower (*Chorizanthe cuspidata var. cuspidata*)	CRRP 1B.2
San Francisco campion (*Silene verecunda* ssp. *verecunda)*	CRRP 1B.2

*FE federally endangered; FT federally threatened; CE California endangered; CRRP 1B.1 California Rare Plant Ranking (formerly CNPS list) for plants rare, threatened, or endangered in California and elsewhere, seriously endangered in California; CRRP 1B.2 California Rare Plant Ranking for plants rare, threatened, or endangered in California and elsewhere, fairly endangered in California.

Covered Animals

MB, CS, and SBE butterflies are monitored regularly and results are presented in Chapter 3. The BCB has not been observed on San Bruno Mountain since the early 1980s and is considered extirpated from the Mountain. This taxon is also discussed in Chapter 3, including reintroduction potential. The SFGS and CRLF were identified in the HCP as having potential habitat on San Bruno Mountain. Neither species has been reliably observed in 30 years. There is no evidence pointing towards the need to survey for those two taxa. Two rare but unlisted animals known to occur on San Bruno Mountain include a rare solitary bee (*Dufourea stagei*) and the incredible harvestman spider (*Banksula incredula*). We recommend the County consider current surveys for these two taxa.

Covered Plants

The plants and vegetation communities of San Bruno are unique (McClintock 1980, Edwards 1990, Allshouse and Nelson in preparation) and efforts should be made to maintain both rare plants and vegetation communities. Currently, no HCP funds are used to monitor rare plants (TRA 2013). Previous annual reports by TRA from 1999-2006 have limited distribution information on a selection of rare plants located on SBM. Two of the rare plants only grow on unique sandy substrates (San Francisco lessingia and San Francisco spineflower) and are therefore limited in their potential distribution (Figure 7-1). These two plants co-occur on the rare Colma sands found on the western end of the HCP lands. The rare manzanitas occur on cooler slopes near the summit. San Francisco campion tends to prefer rocky outcrops and thin soils near the summit. The Diablo helianthella is known from a small north-west facing slope on the eastern end of the mountain. Little to no demographic or population information is available for these rare plants.

Figure 10- 4: *Lessingia germorum* on Colma dunes. This plant is restricted to sandy soils and thrives in open sand. August ,2014.

Current efforts to track HCP-covered plants are inadequate, and funding should be dedicated for monitoring them. The seven covered species need to be regularly monitored to ensure they are continuing to persist through weed invasion, scrub encroachment, and environmental change.

We recommend the following steps for monitoring these taxa.

1) Resurvey presence at historical locations: map populations on GPS, photograph the habitat, and file a California Natural Diversity Database (CNDDB) form for each historic occurrence, even if no plants are found.
2) Develop a log-scale abundance estimate using an appropriate sampling design for the taxon
3) Assess any local threats from invasives, succession, and other factors
4) If local populations are small or appear to be declining, consider a complete census and/or a demographic study
5) Perennials should be re-surveyed every 5 years
6) Annuals should be resurveyed every 3 years

Many surveys can be completed with CNPS and other volunteer botanists under professional supervision. Surveys can secondarily serve as training opportunities or workshops for amateur botanists.

Plant populations can often be maintained with simple, timely stewardship actions, informed by regular surveys. Although the HCP lists no triggers for stewardship action, we provisionally recommend that a 50% decline in individuals from the prior survey should trigger a management discussion with the TAC and a knowledgeable botanist. Stewardship triggers should be evaluated on an individual species basis in order to assess if a 50% decline is appropriate. Management recommendations should be drafted, reviewed externally, and implemented as soon as possible. Each species will require a species-appropriate population reporting technique (e.g. census, macroplot, etc.) to be completed within the proper phonological window. These techniques need to be developed in a separate document.

Chapter 8: Environmental Change: Climate and Nitrogen Deposition

Summary

Climate change will cause systemic change on SBM on decadal time scales and intensify through the 21st century. Detailed analysis of two representative climate futures shows a general trend toward drier summer-fall conditions, even if precipitation stays the same or increases. But in next 30 years, trends will be difficult to detect from interannual noise. Key predictions include:

- Fire risk will increase concomitantly with increased climatic water deficit (water stress).
- Likelihood of intermittent brush establishment events should decline but not disappear.
- Vegetation productivity is relatively stable, and even increases a little, except under driest future climate prediction at end of century, when productivity declines.
- Phenology of plants advances with warmer winter/spring temperatures, and butterflies emerge earlier.

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Nitrogen deposition will continue to impact SBM through fertilization. Key points include:

- Deposition rates and impacts are greatest at low elevations closer to urbanization and can be observed in the field as increased biomass of grasses and thistles.
- We coarsely mapped high N-deposition areas based on distance from development and elevation, which delineates a zone where rapid growth of grasses/weeds will inhibit habitat restoration.
- Special attention/effort will be necessary to maintain habitat for Mission Blue and Callippe Silverspot in high N-deposition areas through grass control primarily.
- The upper slopes of SBM are less affected because they are exposed to relatively clean marine air.
- A slow reduction in N-deposition from NO_x is expected over the next decades; no trend in NH_3 is predicted.
- Elevated soil nitrogen will remain for several decades and will increase productivity of annual grasses, thistles, other weeds, and scrub.

We are in an era of unprecedented environmental change. Two major factors, climate change and atmospheric nitrogen deposition, will continue to affect SBM ecosystems over the next century, and need to be considered in short and long-term management planning.

Climate Change

On a global scale, climate has been changing rapidly with the accumulation of greenhouse gases and is projected to accelerate through the century in the absence of drastic reductions in emissions (IPCC 2012). The local manifestation of global climate change is complex in the Bay Area, especially in the fog belt with its tight coupling to Pacific Ocean temperatures. It is important to remember that climate is reflected in long-term (30-year periods are standard) averages and trends, and that directional change can be masked by short term variability driven by El Nino-La Nina cycles and the Pacific Decadal Oscillation. Longer-term (20+ years) increasing trends in temperatures are robust across all climate futures; the question becomes the rate of change which varies among models and emissions scenarios. California has wide interannual variability in precipitation, and future projections span a wide range of wetter and drier regimes.

The primary data source is the Conservation Land Network Explorer (www.bayarealands/explorer/#) which delivers site-specific fine-scale (270 m grid) climate data as 30-year averages, and calculates a spatial average over the area of interest, and as maps of the gridded data. Monthly downscaled climate data from the historical period (1895-2010) and for four climate futures (2010-2099) are run through the Basin Characterization Model (BCM), a hydrologic model that calculates a water balance at each 270 m cell, partitioning precipitation into soil storage, evapotranspiration, recharge, and runoff. The BCM includes soils (water holding capacity) and bedrock geology (permeability to water flow in fractures), as well as topography (solar radiation across aspect and slope), and represents a more full complexity of our landscapes.

The BCM calculates "Climatic Water Deficit" (CWD), a robust measure of drought stress. CWD is an integrated measure of drought stress over the dry season. As soil water is depleted at the end of the rainy season, drought stress builds through the dry season as the evaporative power of the atmosphere exceeds available soil water. CWD accumulates month by month until the end of the water year (September 30 or beyond) when precipitation replenishes soil water. Higher spring-summer-fall temperatures are the primary determinant of increased CWD across all climate futures; this is the most robust trend in future climate. Increased precipitation, especially in spring, can partially ameliorate increased CWD, but the dominance of the dry season evaporative demand is consistent. The increase in CWD drives a process of vegetation *aridification*.

Actual Evapotranspiration (AET) is the amount of water used by vegetation, with a small increment being direct evaporation from soil. AET effectively translates into vegetation productivity, and will be treated as such in discussions. AET peaks in spring, when high temperatures and high soil moisture coincide, and is reduced to zero during the summer when soil moisture is depleted. Increasing winter temperatures also increase AET, and mid-winter growth will accelerate. Spring precipitation leads to the greatest increase in AET.

Recharge and runoff are excess water above soil water capacity and AET, and typically only occur from November through March. Recharge is percolation below the rooting zone and is limited by bedrock permeability. Recharge and runoff have a more direct relationship with total precipitation than AET and CWD. Recharge and runoff are important for wetlands and riparian zones, less so for uplands.

For this analysis, we consider two climate futures that have been extensively used in California climate change assessment. Two models (GFDL and PCM) provide a drier future and a wetter future, and only the "Business as Usual" high emissions scenario (A2) is considered. Two historical 30-year periods (1951-1980 and 1981-2010) document baseline conditions and historical climate change. Three future periods (near-century 2010-2039, mid-century 2040-2069, and end century 2070-2099) are reported. We note that the emissions scenarios do not create large divergence until mid-century, and because the scope of this review is primarily the next 30-years, most focus will be on near-century projections.

For more detail of the BCM output see www.TBC3.org and

http://www.bayarealands.org/upload/page.php?pageid=34#factors

BCM Results

The results in Table 8-01 show the following trends. All units are in Celsius and millimeters. 1°C = 1.8°F, and 25.4 mm = 1" for quick conversions. Note that these 30-year averages mask large interannual variability. All results will be reported as the range between the two futures.

1) There has been historical warming from the baseline 1951-1980 to recent 1981-2010 periods of 0.7°C in summer T_{max}, and 0.8°C in winter T_{min}. Precipitation increased by 44 mm, and AET by 12 mm, with the remaining PPT going to recharge (6 mm) and runoff (26 mm). The increase in temperature drove an increase in CWD of 19 mm, indicating a slight aridification of SBM combined with a trend toward greater productivity (AET). There was a notable increase in interannual variability in precipitation.
2) In the near century (2010-2039), temperature increases at greater rates (+1.2 - 1.3°C summer, +0.7 - 1.4°C winter), and CWD increases by 19-29 mm (a bit above the historical rate). AET increases by 15-17 mm. Therefore, aridification continues and productivity increases. This time period is the main focus of discussion below.
3) In the mid-century (2040-2069), temperature increases further, and the futures diverge on AET (-13 - +9 mm). CWD increases substantially (+50 - 83 mm). This time period is when decisions made over the near century will play out in an increasingly arid climate.
4) In the end of century, temperatures are 2.7 – 4.5° C warmer, and the precipitation uncertainty increases (-109 - +69 mm). AET decreases or remains similar (-50 - +6 mm). This period is well beyond the planning horizon, but is included for informational purposes.

Table 8-1: Climate trends for San Bruno Mountain

Model	Time	Summer (JJA) Tmax C		Winter (DJF) Tmin C		PPT mm/yr		AET mm/yr		CWD mm/yr		Runoff mm/yr		Recharge mm/yr	
Baseline	**1951 - 1980**	20	-	6.4	-	674	-	390	-	715	-	89	-	196	-
Recent	**1981 - 2010**	20.7	+0.7	7.2	+0.8	718	+44	402	+12	734	+19	115	+26	202	+6
GFDL-A2	**2010 - 2039**	21.3	+1.3	7.8	+1.4	728	+54	405	+15	744	+29	112	+23	211	+15
	2040 - 2069	22.5	+2.5	9	+2.6	676	+2	377	-13	798	+83	112	+23	188	-8
	2070 - 2099	24.5	+4.5	10.4	+4.0	565	-109	340	-50	881	+166	72	-17	153	-43
PCM-A2	**2010 - 2039**	21.2	+1.2	7.1	+0.7	725	+51	407	+17	734	+19	109	+20	209	+13
	2040 - 2069	22	+2.0	7.9	+1.5	706	+32	399	+9	765	+50	111	+22	196	0
	2070 - 2099	23.5	+3.5	9.1	+2.7	743	+69	396	+6	797	+82	145	+56	202	+6

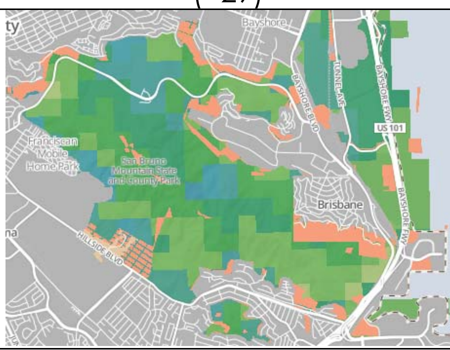
Maps of CWD are shown for all time periods to illustrate spatial patterns and temporal trends (Figure 8-01). The spatial patterns show differences between the south-facing slopes and north-facing slopes on the main ridge, as well as some soil differences between the Saddle and adjacent areas. Across SBM in the recent 1981-2010 period, CWD varies from 650 to 900 mm, with the largest CWD on the eastern part of the SBM and the lowest in the Saddle and on some deeper soils. Note the 50-100 mm differences between the South Slope and Owl-Buckeye area.

The spatial pattern remains through future projections, but the absolute magnitude changes. Changes in near century 2010-2039 are subtle in both futures, but by mid-century 2040-2069 there is a definite shift to higher CWD across the entire landscape, more pronounced in the GFDL-A2. By end of century 2070-2099, GFDL-A2 produces CWD >900 mm across more than 50% of the mountain.

1951-1980 Baseline CWD = 715 mm

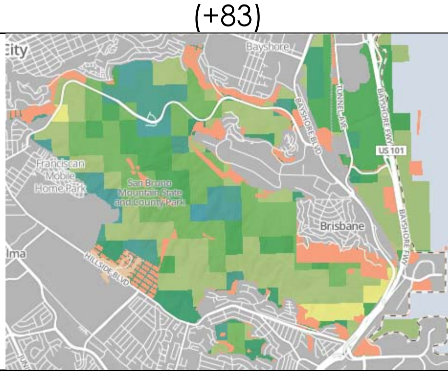
1981-2010 Recent CWD = 734 mm (+19)

2010-2039 GFDL-A2 CWD = 744 mm (+29)

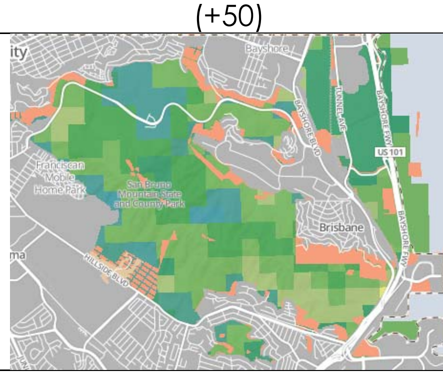


2010-2039 PCM-A2 CWD = 734 (+19)

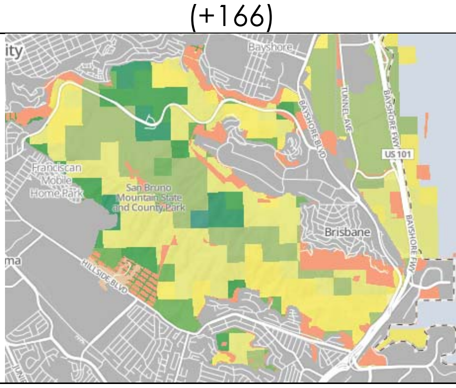
2040-2069 GFDL-A2 CWD = 798 mm (+83)



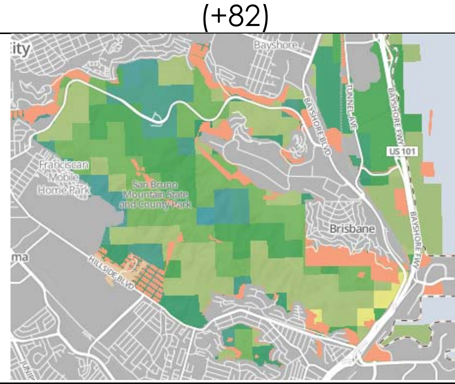
2040-2069 PCM-A2 CWD = 765 mm (+50)



2070-2099 GFDL-A2 CWD = 881 mm (+166)



2070-2099 PCM-A2 CWD = 797 mm (+82)



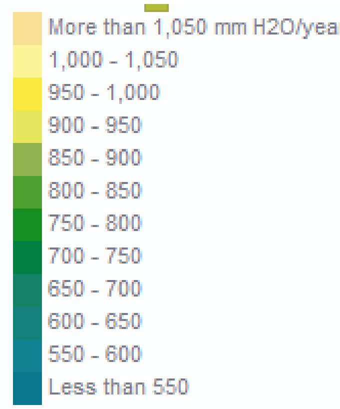


Figure 8-1: Climatic Water Deficit Maps

Cal-Adapt Extreme Heat Analysis Results

The increases in temperature projected by GFDL-A2 greatly affect the frequency of extreme heat days (defined as the 98th percentile of historic 1960-1990 baseline). In the near century frequency is about double that of the recent period, and rapidly rises mid-century and beyond. Extreme heat days are high fire risk, and exacerbate high seasonal CWD.

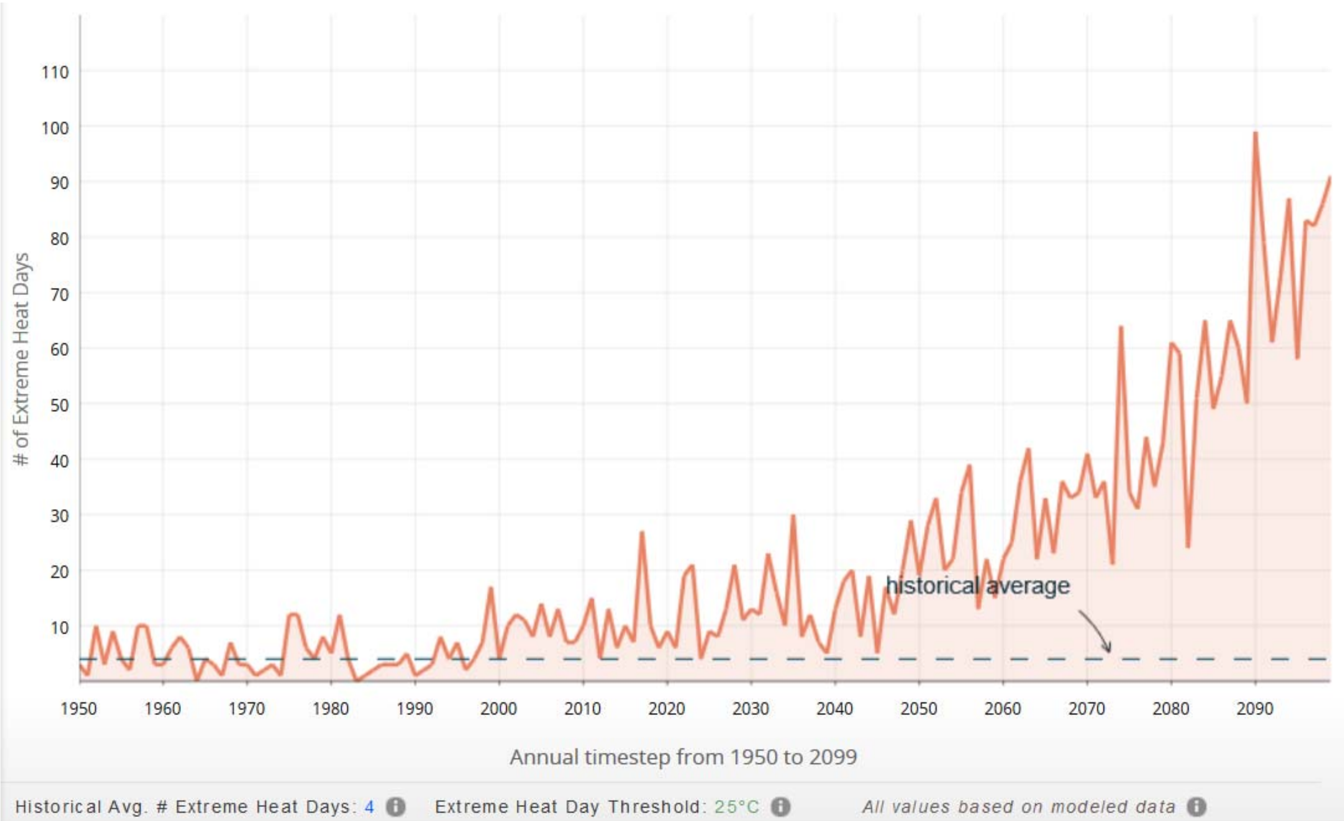


Figure 8-2: Extreme Heat Days Average >25°C (77°F) from Cal-Adapt (http://cal-adapt.org/temperature/heat/)

Fog

Summer fog is a fundamental feature of the SBM climate. Summer fog reduces and diffuses solar radiation, increases humidity, and can provide local fog drip. Fog reduces evaporative demand and cools the air. Many plants can directly absorb fog water into their foliage. Fog drip can contribute some soil moisture depending on the vegetation cover, slope, wind, and other environmental factors. At present, no good fog climatology is available (but one is being developed by USGS and will be available in 2015). Long-term coastal airport observations (Arcata and Monterey, averaged into a Northern California Index) are used to indicate broad trends in fog along the coast from 1951 to 2009 (Johnstone and Dawson 2010).

Fog has decreased by about 5% since 1951, with a statistically significant trend through 2009. There has been high variability, with frequency ranging from >60% (1951) to < 30% (1997). The 10-year moving average shows variation between 45% and 38%. We note that two recent years not in this study (2010 and 2011) were the foggiest in several decades and that trends are hugely dependent on the Pacific Decadal Oscillation and broad-scale atmospheric circulation features like the exact position of the Pacific High.

Longer term-reconstructions from 1900 to 2009 based on temperature patterns indicate a 33% reduction in fog over the 20th century (Johnstone and Dawson 2010). Future fog frequency is an unknown, but SBM will remain one of the foggier spots on the California Coast because of its exposure and proximity to major gaps in the Coast Range. High year to year variability will remain the rule. There are some initial indications from regional climate model simulations that the strong forcing by the end of century will reduce fog frequency (O'Brien et al 2012), but huge uncertainties remain both about historical and future fog.

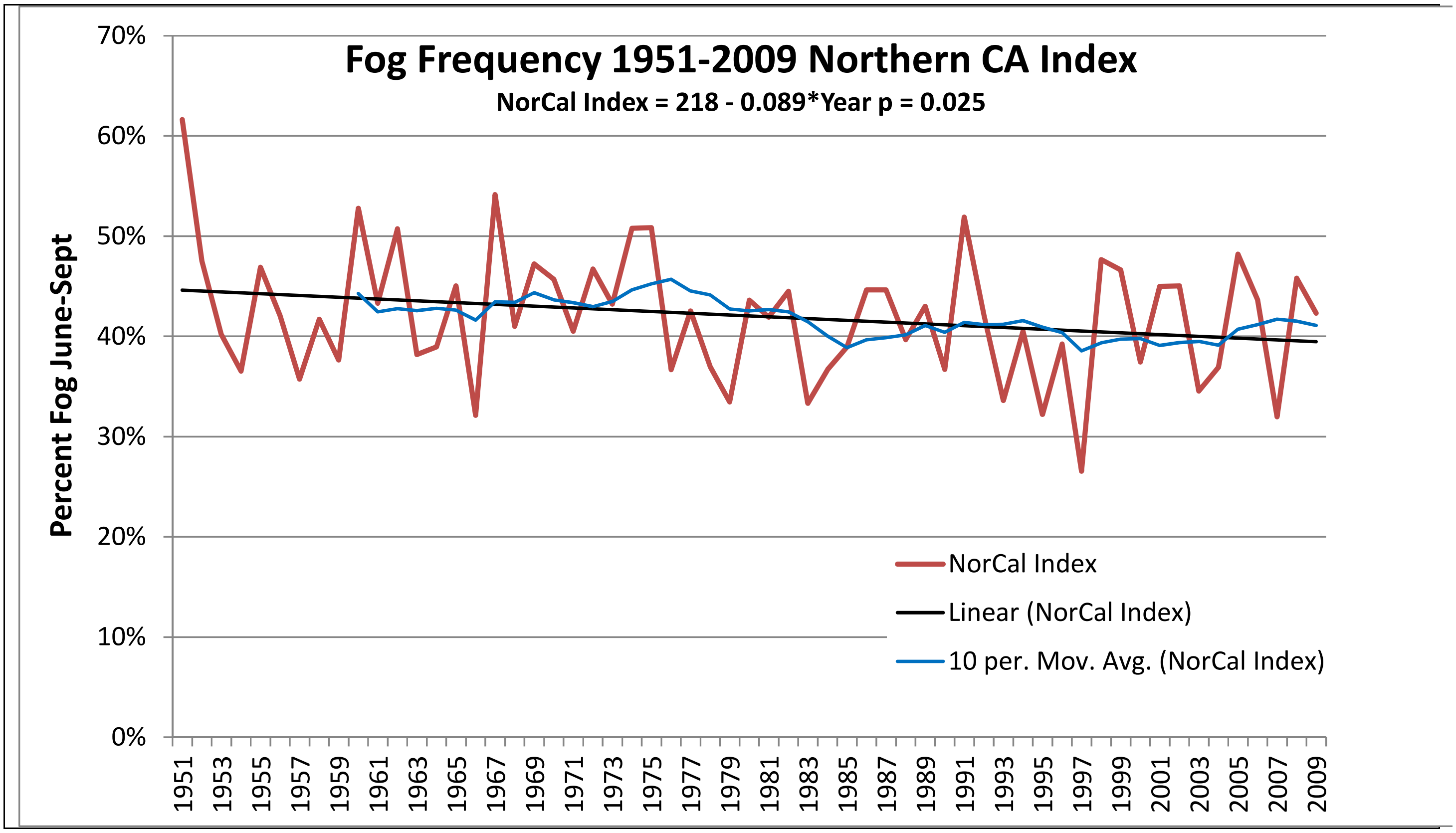


Figure 8-3: Fog Frequency data from Johnstone and Dawson 2010 supplemental material.

Impacts of Climate Change on Vegetation and Management

Vegetation responds to weather and climate at many temporal and spatial scales. Productivity, fire, local dieback, recruitment are all affected by yearly weather and the cumulative impact and frequency of extreme events often drives the longer-term climate signal.

A primary mechanism is drought stress. Vegetation physiognomy (structure) is largely limited by CWD, and progresses from forest/woodland at low CWD, through shrublands, and finally to grasslands at high CWD. Over the next 30 years the relatively minor increases in CWD will not be limiting except in the most arid microsites. Scrub encroachment will continue to threaten large parts of the grasslands for the foreseeable future. Even in an effectively drying climate, there will still be years – wet springs that provide residual soil water after grasses senesce - that allow native brush (especially coyote brush) to establish in grasslands, albeit at reduced frequency. The increases in CWD through time, especially at end of century will likely limit shrublands and woodlands to the more mesic part of SBM. If this occurs, we may reach a point where ongoing scrub management may become less critical, or at least less costly.

CWD and extreme heat are surrogates for fire risk. Warmer summer temperatures and drier vegetation increase the possibility of ignitions leading to rapid and intense fires. Vegetation management for fuels reduction adjacent to developed areas will be increasingly important.

The relative stability of AET means that vegetation productivity will remain high in the mild coastal habitat through mid-century. There is a compensation of higher AET in warmer winters and earlier dry seasons that contributes to the relative stability. Annual grass growth will remain a threat to native grasslands and butterfly host plants (especially in high N-deposition areas, see below). The combination of high productivity and increased fire risk emphasizes the need for vegetation fuels management.

The uncertainty in future fog frequency modifies these projections. If fog decreases, CWD and fire risk will increase, conversely, if fog increases, fire risk will decrease. However, the spatial pattern of fog is stable because of physiography, and the fog gradient across SBM will remain strong. Because of the downscaling methods used for GFDL and PCM (constructed analogs from historical weather patterns, Hidalgo et al 2008), fog is partially built into the projections and is reflected in lower projected temperature increases near the coast than inland. Studies of fog frequency and impact across San Bruno Mountain should be a research priority.

Increased winter temperatures will drive earlier phenology of both plants and butterflies. As long as butterflies and their host plants shift phenology somewhat in phase, the topographic complexity and long perennial growing seasons should act to minimize phenological "decoupling." If host plants become less available when larvae need them, stressors to the butterfly populations increase substantially.

Atmospheric N-deposition

Atmospheric nitrogen deposition, both wet (rain and fog) and dry (direct gaseous deposition to plants and soils) from vehicles, urban area sources, and industrial plants contribute significantly to nitrogen availability, which in turn impacts plant composition and diversity (Weiss 1999, Fenn et al. 2010). Nitrogen deposition may be playing a significant role in changing vegetation on SBM, including increased growth of grasses and nitrogen-loving invasive forbs (i.e. thistles), and increased rates of shrub encroachment. Fog can be a major transport and deposition pathway, and undoubtedly delivers substantial deposition especially of NH_3 which is highly soluble in water.

A review of N-deposition on SBM (Weiss 2006) provides detailed background on the state of knowledge, and suggests some modeling and measurements to clarify the issue. This current review updates and summarizes that report, and adds in a spatial analysis and consideration of pollutant trends into the future.

We use a compilation of local air quality data, regional model data, and some other local N-deposition studies to assess the role nitrogen deposition plays in vegetation dynamics and management, including anticipation of future weed invasions and potential sources of mitigation funding. The results at this point are qualitative and based on expert opinion informed by other studies.

The most recent estimate of N-deposition on SBM is from the 4-km CMAQ model run for year 2002 (Fenn et al. 2010). The spatial resolution provides regional-scale patterns, so that areas like the northern Peninsula can be compared with other areas at scales of 10-20 km, but it does not resolve fine-scale gradients across SBM. Absolute values from CMAQ are less reliable than the spatial patterns. And, as seen below, there has been a ~30% reduction in NO_x emissions and NO_2 concentrations since 2002, but at the same time the CMAQ appears to underestimate total deposition (Fenn et al 2010).

Air quality data include the California Almanac of Air Quality and Emissions 2012, which provides NO_2 concentrations from 1980- from BAAQMD stations in downtown San Francisco and Redwood City, along with county-scale and regional emissions estimates for NO_x and NH_3 in 5-year intervals.

Studies with passive samplers (Fenn et al. 2010) allow some estimation of the range of influence from urban sources into open space. We use these data to constrain the high N-deposition zones along the lower slopes of SBM.

Nitrogen Deposition Results

San Bruno Mountain is surrounded by urbanization and receives deposition primarily from vehicular traffic. Total CMAQ N-deposition averaged across SBM for 2002 is estimated at 7 kg-N ha^{-1} yr^{-1}. The estimated value is above the critical load established for California grasslands (6 kg-N ha^{-1} yr^{-1}) and is in a range where increased grass growth in a mild coastal environment is likely (Fenn et al. 2010). The estimated natural background is <1 kg-N ha^{-1} yr^{-1} (Fenn et al 2010).

The N-deposition is not uniformly distributed across SBM. Areas close to the urban edge receive much more deposition than more distant areas; the higher elevations receive more clean Pacific air mixed with the diluted urban plume. Attenuation rates with distance/elevation from passive samplers at Edgewood Natural Preserve and Coyote Ridge are shown in Table 8-02. At Edgewood, EW-East and EW-400E represents the gradient over 1400 ft distance (400 m) from an isolated line source (Highway 280) over flat terrain, and has an 84% decline in NH_3 concentrations. This distance is similar to criteria for placement of air quality stations relative to freeways, The 1000 ft. (300 m) elevation difference between KC-Low and KC-High over 0.8 miles is similar to the scale of SBM, and represents a gradient away from Highway 101 in a well-mixed plume from upwind sources that envelops the ridgetop, with some strong inversions below the ridgetop. There is only a 38% decrease in NH_3 over this distance. NO and NO_2 are more complex because they are so reactive, but decline substantially with distance. Further details of the air pollution chemistry and meteorology are beyond the scope of this report.

Table 8-2: Passive sampler gradients of pollutant concentrations

Site	Distance between samplers	Elev. Diff	NH_3	NO	NO_2	Setting
KC	0.8 mi	1000'	-38%	-63%	-39%	Highway 101 in a well-mixed pollution plume from upwind, low elevation inversions
EW	0.23 mi	<25'	-84%	-71%	-37%	Clean marine air crossing Highway 280 line source

From these empirical analyses, and field observations of grass/thistle growth, we produced a multi-distance (100 m increments) buffer inward up to 500 m from the HCP Boundary to delineate the N-deposition gradient. We then delineated a lower deposition zone around the Industrial Park and Brisbane, reaching east from the base of Devil's Arroyo through the Quarry, Owl-Buckeye and Brisbane acres that are sheltered from upwind regional and local N-sources. Lower deposition is indicated by the quality of the grassland in these areas (fewer dense tall stands of *Avena* and thistles within several hundred meters of the edge).

Figure 8-4: Nitrogen Deposition Buffer

Temporal Trends

Temporal trends show a 50% reduction in NO_2 concentrations in San Francisco and San Mateo Counties from 1988 to 2012, with a 30% reduction from 2002 (CMAQ date) to 2013. Total NO_x emissions have declined, and are expected to continue their decline through 2015, when they are projected to be at 20-25% of 1975 values, or 50% of 2013 values. Overall NH_3 emissions, including agriculture, are projected to be flat through the period 2000-2035. The vehicular component of NH_3 emissions (generated by catalytic converters), which is the major source around San Bruno Mountain, may decline as more zero emissions vehicles and electric vehicles enter the fleet.

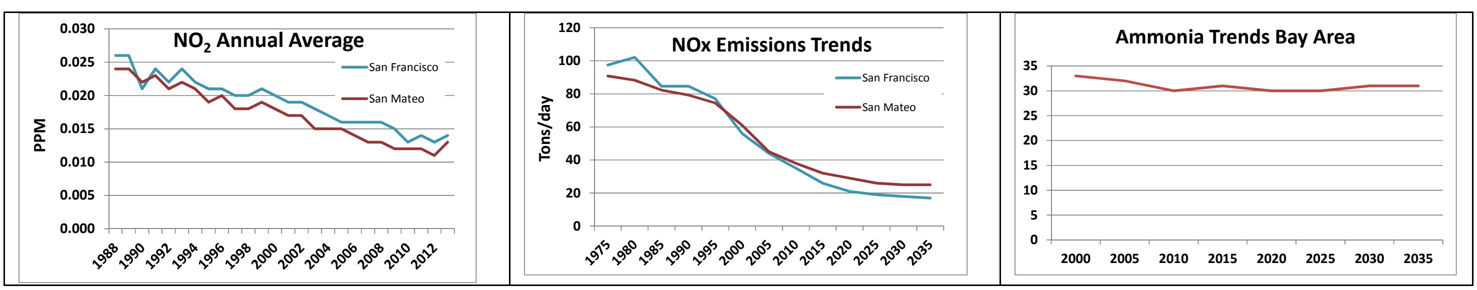


Figure 8-5:Air Quality Data

Impacts of N-deposition on Vegetation and Management

Atmospheric nitrogen deposition increases vegetation productivity, and allows annual grasses and weedy forbs like thistles to grow far more than they would otherwise (Huenneke et al 1990, Fenn et al 2003). These annual grasses and forbs can have a direct impact on butterfly host plants by both mechanisms of direct competition and obstruction of flowers from the view of butterflies (Figure 8-6).

The accumulation of thatch can effectively depress native species. Management and restoration may be particularly difficult because of excessive nitrogen. Increased grass and thistle growth can overwhelm restoration efforts aimed at short-stature native forbs such as lupines, a process obvious at lower elevations of the South Slope. The effects on scrub are less clear, but most plants can take advantage of increased nitrogen availability. N-deposition also increases grassland fuel loads, and grasslands in close proximity to developed areas may require fuels reduction and consistent firebreak establishment.

Figure 8- 6: Two mature silver bush lupine plants are almost impossible to locate among the non-native grasses. Lupine located in picture foreground. Terra Bay Fire Road, August 2014.

Because of complexities of atmospheric chemistry, emissions reductions do not necessarily translate proportionately into reduced deposition (Fenn et al. 2010), but the general downward trend is encouraging. But, over the next 30 years N-deposition will remain a substantial impact on parts of SBM. The long-term legacy of decades of N-deposition will take several decades to work through the system, even when annual deposition falls below the established critical load for grasslands (6 kg-N ha^{-1} yr^{-1}). Also, as more is known of the pervasive cumulative impacts of N-deposition, current critical loads may be lowered.

Grazing is highly effective in managing increased annual grass growth, and at this point is the only practical method for doing so. Mowing can be effective in small areas, but steep terrain necessitates string cutting except in limited areas. Fire, as discussed elsewhere, can temporarily reduce grass when burns occur in late spring/early summer. The grazing trial proposed for the Northeast Ridge is especially important to begin to address N-deposition impacts.

Chapter 9. Cost-effective Management with a Limited HCP Budget: Community Involvement on San Bruno Mountain

Summary

Effective habitat management on San Bruno Mountain will require a unique team of collaborators hailing from the County, non-profits, business and development interests, and the general public. Suggestions for increasing visitor use, volunteerism, and community education for the benefit of covered species are provided here.

This chapter offers suggestions and ideas for improving habitat management on San Bruno Mountain. First and foremost, we believe that an educational campaign to invite locals out to the Mountain can help catalyze more interest in this unique habitat. Currently, there is only one formal location (the main parking lot on Guadalupe Canyon Parkway) that invites users and offers information. All other access points to the Mountain are less formal, and perhaps more intimidating to newcomers. Establishing more inviting access points to the Mountain is a critical factor in increasing visitation and therefore interest.

The following suggestions are offered to help build awareness about the natural resources and recreation opportunities on SBM. Increased community awareness will make stewardship efforts more successful and hopefully, well-funded:

1. Continued funding for volunteer-based programs and outreach activities is essential for raising awareness and subsequently funding for San Bruno Mountain. We recommend considering a well-planned county-non-profit joint effort over the course of a year or so wherein San Bruno Mountain is celebrated for its unique diversity as well as the unique partnerships that have helped maintain the ecological value of the mountain. We can imagine a “My Backyard: San Bruno Mountain” campaign that lets people easily learn to love the mountain. The non-profits and citizen groups should be championed in this effort, and they should be used as the main vehicles for outreach.
2. Promotion of “The Natural History of San Bruno Mountain” by Allshouse and Nelson when it is published could be a focus of an early campaign. A special publically accessible speaker series about natural history of the mountain may be an effective educational effort.
3. Consider piloting a “Mountain-friendly” gardening program where residents around the Mountain are provided with a list of guidelines that will help maintain habitat: e.g. don’t plant an invasive, help recognize and manage local invasives, reduce pesticide use, grow and learn to recognize key native plants that occur on SBM, etc. This program could be piggybacked off the “Bay Area Friendly Gardens” that prioritize native plants and restrict chemical use.
4. Corporate funding will be likely once well-defined projects with community leadership are established. Corporations likely will not fund the County, per se, but they may help out with cooperative efforts where the County is helping organize SBM projects. Past corporate campaigns that have been successful usually include some degree of recognition through naming or awards. For instance, consider a “Corporate Mountain Hero of the Year” award. Also consider allowing for corporations to help fund tangible goods like signs, maps, and other promotional deliverables that will recognize them in writing.
5. Regular non-profit support through matching funds could go a long ways toward building strong partnerships. It is common that Counties offer a competitive grant program or award for

the best non-profit project proposal. This will stimulate interest in the Mountain and help fund organizations and projects with vision.

6. Early weed detection is critical for reducing long term invasive species costs. Formalizing an early detection network could offer a great cost savings to the County. There are a number of platforms that could be used for data reporting of rare and invasive plants including smart-phone based programs like iNaturalist and Calflora Observer. These platforms are customizable and allow for easy data sharing among registered users and groups.
7. Although annual reports are required, we recommend considering alternating report intensity: even years will have a more comprehensive annual report and odd years will be streamlined. This cost savings could benefit other on-the-ground management, rare plants surveys, or other stewardship actions.
8. Volunteer efforts are critical for maintaining habitat on San Bruno Mountain. Volunteer driven efforts on the Mountain have helped fill an essential role in weeding, native habitat restoration, and even rare plant surveys (e.g. TRA 2007, Cannon 2008). We recommend continuing to maintain creative and engaging projects where volunteers can increase stewardship success. One such collaboration involving fuels management and habitat stewardship in the East Bay Hills has shown great promise (Naumovich 2012).
9. Photomonitoring by citizen scientists can help engaged people in the SBM and its resources. One easy way to engage people is to erect a photomonitoring station (Figure 9-1) with information and information.

Figure 9- 2: Photomonitoring station created by URS and Nerds for Nature after the Morgan Fire on Mt. Diablo

Chapter 10. Sample 5 Year Site Prescription: Owl-Buckeye Ridge

Summary

We provide a conceptual workplan for a highly valuable habitat area known as Owl-Buckeye Ridge. This location is ideal for restoration as it contains both CS and MB survey transects, host plants for both butterfly species, and is easily accessible for work crews implementing a variety of stewardship tools. This plan is intended to serve as a living document that will likely be amended as different tools and techniques achieve varying degrees of success.

Owl-Buckeye and Transmission Line Ridge

Owl-Buckeye ridge and Transmission Line ridge are adjacent north facing slopes just to the east of the quarry. MB and CS butterfly population numbers have stayed relatively constant on the transects in these two areas over the course of the HCP (see Chapter 3). Despite butterfly population numbers staying stable, grassland vegetation has been converted to scrub and woodland on both ridges and in the surrounding area. Many acres of open grasslands, and much of the historic distribution of CS and MB have been lost since 1982 – the relatively moist northerly slopes and deep soils in swales favor scrub in the absence of disturbance and management. The two irregular patches of grassland need to be secured, and this section outlines a work plan over 5 years to clear the interiors, secure the perimeters, and enhance host plant resources.

GIS analysis of 2004 grassland layer, Viola distribution and historic butterfly occurrences have informed our designation of the majority of this area as Essential grasslands (Figure 10-1).

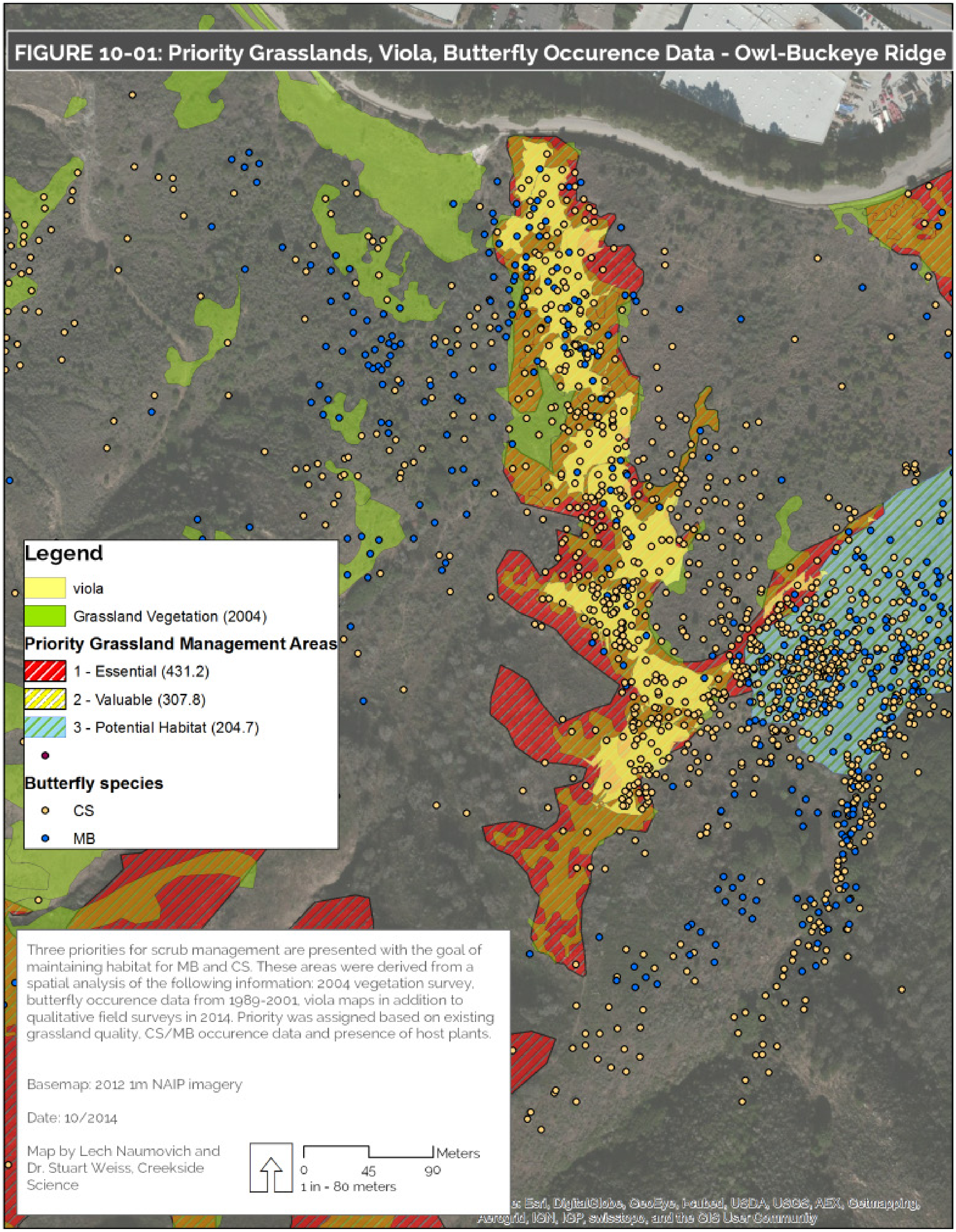


Figure 10- 1: GIS Data that informed the prioritization of grasslands on Owl-Buckeye ridge.

We offer the following provisional 5-year conceptual plan to aid in the management and restoration of the Essential (and in this case Lower Quality) grasslands.

Year 1

a) Take pre-treatment photopoints (see Figure 10-2 for locations)
b) Identify priority invasives for treatment
c) Cut and paint *Baccharis*, *Heteromeles*, *Frangula* and other select species in core area with professional contractor (see Figure 10-3)
d) Establish initial perimeter goals, and begin treatment after interior plants are removed
e) Establish final perimeter goals, remove large shrubs with professional cut and paint
f) Identify and treat priority invasives at appropriate times of year
g) Use volunteers and professional crews to eliminate stands of small shrubs that can be pulled by hand or with weed wrenches (wet season)
h) Assess current hostplant resources and needs for hostplant enhancement, especially *Lupinus formosus*. Set and sample Viola transects
i) Collect Lupine seed locally (spring/summer)
j) Select sites for seeding/outplanting experiments, including high density planting islands (Figure 10-4)
k) Treat seeding/outplanting plots (early rainy season), use volunteers under supervision
l) Plant and seed (early-mid rainy season)
m) Retake year 1 photopoints

Year 2

a) Take Year 2 photopoints (spring)
b) Monitor kill rate on large interior shrubs
c) Retreat large interior shrubs where necessary
d) Flame dense shrub seedlings on perimeter (early spring)
e) Collect Lupine seed locally (spring/summer)
f) Continue to control priority invasives
g) Clean-up small establishing shrubs with volunteer effort (follow-up)
h) Monitor establishment success in planting/seeding experiments

Year 3

a) Take Year 3 photopoints
b) Monitor kill rate on interior shrubs
c) Retreat interior shrubs as necessary
d) Remove small perimeter shrubs
e) Maintain priority invasives
f) Monitor establishment success in planting/seeding experiments including demography data (volunteer/CNPS workshop)
g) Initiate Viola plug transplant study
h) Collect *Lupinus formosus* and other host plant and nectar plant seed

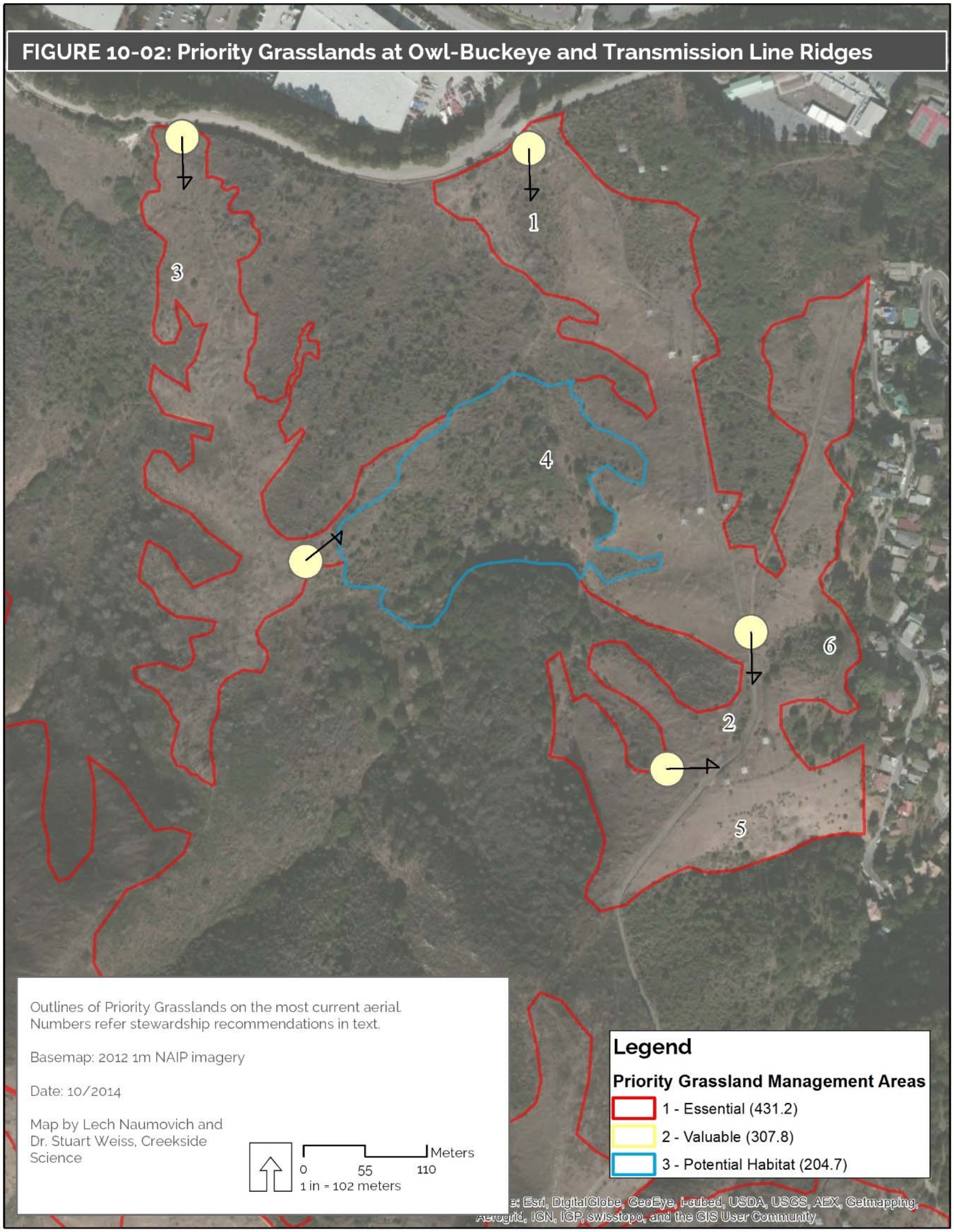


Figure 10- 2: Outline of Priority grasslands and management notes. Yellow circles with arrows designate photopoints and direction of photo. 1) Scrubby western facing slope ideal for reseeding trial with lupines. 2) Scrub near the TL ridge/Fire road that is ideal for a scrape treatment. 3) Western slope where sharp shrub perimeter should be delineated and defended. 4) Experimental area for grassland restoration and *Lupinus formosus* re-establishment. 5) Viola transplant area on local ridge 6) Fuels management collaboration area allows for scrub removal near the residential boundary.

Year 4

a) Take Year 4 photopoints
b) Initiate fuels treatment polygons
c) Widen portions of fire road with scraping if warranted
d) Seed newly scraped areas with host and nectar plants
e) Initiate dense scrub removal treatment in blue zone delineated in Buckeye canyon.
f) Monitor Viola plug establishment

Year 5

a) Take Year 5 photopoints
b) Conduct GIS analysis comparing Year 1 to Year 5 aerials using recent aerials
c) Maintain shrubs in interior and along perimeters
d) Monitor *Lupinus formosus* direct seeding and Buckeye canyon grassland restoration
e) Re-treat Buckeye canyon grasslands as needed
f) Prepare soils by scraping or flaming and attempt direct seeding experiment with *Lupinus formosus.*
g) Monitor Viola establishment from transplants

Year 6-7 – Rest

Year 8

a) Take Year 8 monitoring photos
b) Evaluate projects
c) Amend workplan

Figure 10- 3: Initial boundary for scrub removal on Owl-Buckeye ridge. Interior areas are recommended for full scrub eradication.

Figure 10- 4: High density MB host and nectar planting. Plants have established despite a record drought year. Spacing of plants (foreground) is 4-6" on center.

Chapter 11. Conclusions

San Bruno Mountain is a unique preserve for rare fauna and flora of the San Francisco Bay Area. The protection of this landscape through the first ever habitat conservation plan in 1982 was revolutionary. Now the initial 30-year permit period has passed, it is clear that not all the habitat management objectives have been met. Most notably, the data gaps for many of the covered species other than butterflies need to be addressed. These data gaps expose a deeper issue: management has been focused on a small number of the covered species, while the greater, integrated ecosystem has been left unattended. We hope this document informs and directs streamlined stewardship towards Priority Grassland Management Areas. Management for other covered species (non-butterflies) can be integrated into the stewardship of the grasslands. Non-grassland species also should be surveyed and monitored for changes. We offer the following main conclusions:

Habitat management goals for the next five years must shift toward limiting scrub encroachment and protecting extant grasslands.

The following must be achieved in five years:

- All Essential Grasslands have perimeters secured and interiors largely cleared of *Baccharis* and other scrub species.
- Progress on securing perimeters and interiors of Valuable Grasslands.
- Eradication of pioneer patches of oxalis and other high priority weeds within Essential and Valuable Grasslands.
- Containment perimeters of major invasive species maintained in Essential and Valuable Grasslands. Eradication and control efforts reduced if budget requires.
- Continued maintenance of invasive removal areas to prevent reinvasion in Essential and Valuable Grasslands. Continued maintenance of invasive removal areas on other parts of the mountain as budget allows.
- Systematic documentation of stewardship work needs to be documented at minimum with photopoints.

Implementation of adaptive management is critical over the next 5 years.

Managers will experimentally add more tools to the stewardship toolbox, and continually analyze experimental and monitoring results to select the most effective and pragmatic treatments. Key projects to expand management knowledge include:

- Operational-scale grazing experiment on Northeast Ridge,
- Viola propagation via wet-season core transplants,
- Plot-scaled lupine seeding trials with experimental treatments,
- Outplanting/seeding of *Lupinus formosus* in key MB habitats,
- Small-scale experiments on reclaiming gorse infested areas, and
- Coordination of fuels and habitat stewardship.

Inventory and monitoring recommendations for next 5 years

- Continue existing MB and CS abundance transects every other year in core areas, with slight modifications.
- Add Hillside/Juncus into CS transect system.
- MB presence surveys in peripheral areas.
- Lupine inventory in selected outlying areas.
- Establish reference lupine plots in core habitats for demographic monitoring.
- Trial MB egg monitoring in selected areas.
- Establish Viola transects in core CS habitats.
- Remap other covered and locally rare species, and estimate population sizes on a logarithmic scale where appropriate.

Institutional goals for next 5 years

- Reallocate budgets to emphasize scrub control.
- Implement an adaptive management cycle modified from existing schedule of meetings.
- Coordinate professional and volunteer efforts to maximize efficiency of scrub control and host plant enhancement.
- Ramp up lupine production, especially *Lupinus formosus* transplants and seed production.
- Prepare a fire contingency fund.

Keeping 30 year horizon in sight

- Invite the community to the Mountain so they begin to use it as an outdoor resource. A first step is formalizing more trailheads with kiosks and other information.
- Solidify and build relations with the local community and corporations. Elevate the role of non-profits on the Mountain.
- Grassland acres need to be remapped on SBM, including a category for transitional vegetation polygons.
- Consider reintroduction plans for the Bay Checkerspot Butterfly.
- Create a sustainable rotational grazing program that will benefit grasslands on the Mountain.

Figure 11- 1: Mission Blue eggs on L. albifrons, May 2014. The beginning of a new cycle.

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