Grazing Strategy
San Bruno Mountain Pilot Grazing Program

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Executive Summary

San Bruno Mountain State and County Park is an island of undeveloped land in a sea of urban development on the northern San Francisco Peninsula. It is home to a wide array of native plant and animal species, and provides vital habitat for four federally-listed butterfly species which rely on larval host plants, nectar plants, and other habitat features occurring in grassland areas of the park. Butterfly host and nectar plants on San Bruno Mountain are threatened by competition from introduced annual grasses which, if left unmanaged, can form tall, dense stands of biomass and recalcitrant thatch that crowd out the smaller statured host and nectar plants. Since its establishment as a park, San Bruno Mountain has also lost butterfly habitat due to the encroachment of shrubs into grassland habitat.

The 1982 San Bruno Mountain Area Habitat Conservation Plan, which describes conservation and management measures to benefit listed butterflies on San Bruno Mountain, recommends and authorizes the reintroduction of livestock grazing to San Bruno Mountain as "an effective means of maintaining the grassland habitat by eliminating brush and tall grass which would outcompete the butterfly host plants." Several scientific studies in California's Central Coast Region support this conclusion, yet grazing has not been rigorously tested as a tool for butterfly habitat enhancement on San Bruno Mountain. In 2018 the San Mateo County Parks Department established a Technical Advisory Committee to examine the scientific foundations, feasibility, efficacy, and logistics required to test livestock grazing for habitat improvement for callippe silverspot, Mission blue, and Bay checkerspot butterflies on San Bruno Mountain. The committee identified two locations in the eastern portion of the park with documented butterfly host and nectar plants to serve as pilot study areas.

This *Grazing Strategy* document provides a road map for conducting the pilot study. It contains the following sections, which are designed to support and guide implementation of grazing in the pilot grazing areas:

Section 1 introduces the project and explains the rationale for the pilot grazing study.
Section 2 describes the pilot grazing areas, their habitat value to butterflies, and provides relevant information about the three butterfly species that are the focus of the grazing pilot study.
Section 3 outlines the goals and objectives of the pilot study and specifies the target conditions to achieve with grazing management.
Section 4 lays out strategic and tactical approaches for achieving the pilot study goals and target conditions with livestock grazing. This section recommends management practices to achieve performance standards while also minimizing the potential negative impacts of livestock grazing.
Section 5 describes the infrastructure required to implement the pilot grazing program.
Section 6 discusses considerations for structuring a grazing lease agreement.
Section 7 provides a framework to rigorously monitor and evaluate the effectiveness of livestock grazing to achieve desired conditions.

Taken together, the elements of this plan provide a strategic roadmap for testing the effectiveness of grazing to improve habitat conditions for listed butterflies on San Bruno Mountain. The findings of this study will inform future grassland management on San Bruno Mountain and will provide a valuable demonstration of whether (and how) livestock grazing can be used to enhance habitat for the three target butterfly species.

Section 1. Introduction

San Bruno Mountain State and County Park (operated by San Mateo County Parks Department) is located on the northern San Francisco Peninsula. Viewed from ground-level, it is the sole mountain in its area, reaching over 1300 feet above sea level. Viewed from above, it is a distinct island of undeveloped land in an otherwise urban environment. These two features, coupled with its unique soils, topography and biology make San Bruno Mountain (SBM) a significant location for the conservation of native plant and animal species. Four sensitive butterfly species exist on SBM. The 1982 San Bruno Mountain Area Habitat Conservation Plan (HCP) was written to address management of the Mission blue (*Icaricia icarioides missionensis*) and callippe silverspot (*Speyeria callippe callippe*) butterflies. In addition to those two federally-endangered butterflies, San Bruno Mountain also hosts the San Bruno elfin butterfly (*Callophrys mossii bayensis;* Federally Endangered) and is the site of a relocation effort for the Bay checkerspot butterfly (*Euphydryas editha bayensis;* Federally Threatened).

Mission blue, callippe silverspot and Bay checkerspot butterflies all require grassland habitat for host plants, and to some degree for nectar plants. However, grasslands on San Bruno Mountain have experienced dramatic changes in ecology and management over the past 250 years and face challenging impediments to conservation of host plants and the listed grassland butterfly species.

Two of the most pressing conservation challenges on San Bruno Mountain are:

1) Transformation of native grasslands to non-native herbaceous species such as wild oats (*Avena* species), bromes (*Bromus* species), and a variety of forbs. These species crowd-out and out-compete the smaller-statured butterfly host plants, and otherwise create habitat conditions at odds with host plant reproduction and survival.
2) Encroachment of woody species, particularly coyote brush (*Baccharis pilularis*) into grasslands, and the type-conversion of these areas from grasslands to shrublands that do not foster the butterfly host plants. Approximately 663 acres (34%) of the grasslands mapped on San Bruno Mountain in 1932 have since been converted to shrublands (Weiss et al. 2015).

Grazing was terminated on San Bruno Mountain in the early 1960s (Amme 2002; TRA Environmental Sciences 2007) and its removal is a likely driver of subsequent shrub encroachment and accumulation of annual grass thatch in grasslands (Weiss et al. 2015). The HCP recommends and authorizes the reintroduction of livestock grazing to San Bruno Mountain as "an effective means of maintaining the grassland habitat by eliminating brush and tall grass which would outcompete the butterfly host plants" (SBM HCP Steering Committee 1982). The 2007 San Bruno Mountain HCP amendment also calls for a grazing study to "determine the overall benefit of the grazing on the endangered butterflies" (TRA 2007a). Indeed, there are several studies from Coastal and Central California that show the potential benefits of livestock grazing toward achieving the goals outlined by the HCP (McBride and Heady 1968; Weiss 1999; Hayes and Holl 2003; Russell and McBride 2003; Ford and Hayes 2007).

In 2018 the San Mateo County Parks Department (SMCPD) established a Technical Advisory Committee (TAC) to examine the scientific foundations, feasibility, efficacy, and logistics

required to test livestock grazing for habitat improvement for callippe silverspot, Mission blue, and Bay checkerspot butterflies on San Bruno Mountain. Two locations with known host plant populations and butterfly occurrences were identified for the pilot study (Figure 1). These areas each contain high proportions of "Essential Priority" butterfly habitat – described in a 30-year assessment of the HCP as areas where callippe silverspot and Mission blue butterflies persist and host and nectar plants are abundant (Weiss et al. 2015). This grazing strategy document describes the goals of the grazing pilot study, the infrastructure required to reintroduce grazing, and a tactical approach to achieve management objectives based on the principles of rangeland management. In this document, the term "grazing strategy" refers to the strategic and tactical elements of the grazing program that are designed to achieve the objectives and performance standards described herein. This document is designed to guide grazing through the duration of the pilot study, but it is not a long-term grazing management plan meant to guide grazing management on San Bruno Mountain in perpetuity. The observations and conclusions from the pilot study will be used to make decisions about long-term use of grazing as a management tool on San Bruno Mountain and will inform future grazing management planning efforts.

In 2002, a grazing plan was created for San Bruno Mountain (Amme 2002), but it was never implemented. It proposed a 3-year pilot grazing trial at five locations in the park ranging from four to 75 acres. The plan includes valuable descriptions of management history and existing conditions and suggests grazing strategies to benefit native grassland vegetation in the park. While it did cover the two currently proposed pilot grazing areas, it did not specifically focus on the management goals and objectives identified by the TAC and lacked some specifics on grazing strategy and monitoring required for the current pilot project. In this new (2023) grazing strategy document, we have built on the Amme (2002) work and incorporated conversations and guidance from the TAC to further develop management goals, objectives and performance standards, detailed grazing strategies to apply to achieve goals and objectives (grazing strategy), and monitoring recommendations.

The desired outcome of this project is the improvement of habitat conditions for callippe silverspot, Mission blue and Bay checkerspot butterflies in the pilot grazing areas. The pilot study will experimentally evaluate whether livestock grazing can help achieve these conditions. When habitat conditions are met, the reproductive capacity of these species is very high (Pers. comm. Dr. Stuart Weiss 2022). Therefore, grazing management in the pilot grazing areas will focus on increasing host plant presence and abundance, lowering vegetation height and density to facilitate butterfly access to host plants, and increasing nectar-bearing plants. Changes in host and nectar plants may take several years to observe given that grassland plant species dynamics fluctuate annually in response to the region's variable weather (Spiegal et al. 2016).

Section 2. Existing Conditions and Resources to be Affected by Grazing Treatment

Two pilot grazing areas (PGAs) have been demarcated on the east side of San Bruno Mountain (Figure 1). The San Mateo County Parks Department selected these sites because they support butterfly host plant populations and known occurrences of callippe silverspot and Mission blue butterflies. These areas are also both relatively large, predominantly-grassland, and have appropriate access and terrain for reintroducing livestock grazing. In 2020, Nomad Ecology

performed a Biological Resources Assessment (BRA; NOMAD 2020) in which they mapped vegetation alliances and host plants within the PGAs. Detailed descriptions of the PGAs, including information from the Nomad BRA, are given below.

Southeast Slope

The Southeast Slope PGA covers 115.4 acres. This site encompasses a low-elevation field along Bayshore Blvd, a steep south- and east-facing slope and a ridge that runs along the north and west edges of the site. Elevation ranges from approximately 35 feet along Bayshore Blvd to 915 feet at the ridge's highest point. Sixty-four percent of the terrain is greater than 40% slope and 12% is above 80% slope (Figure 2).

Figure 1. The two pilot grazing areas

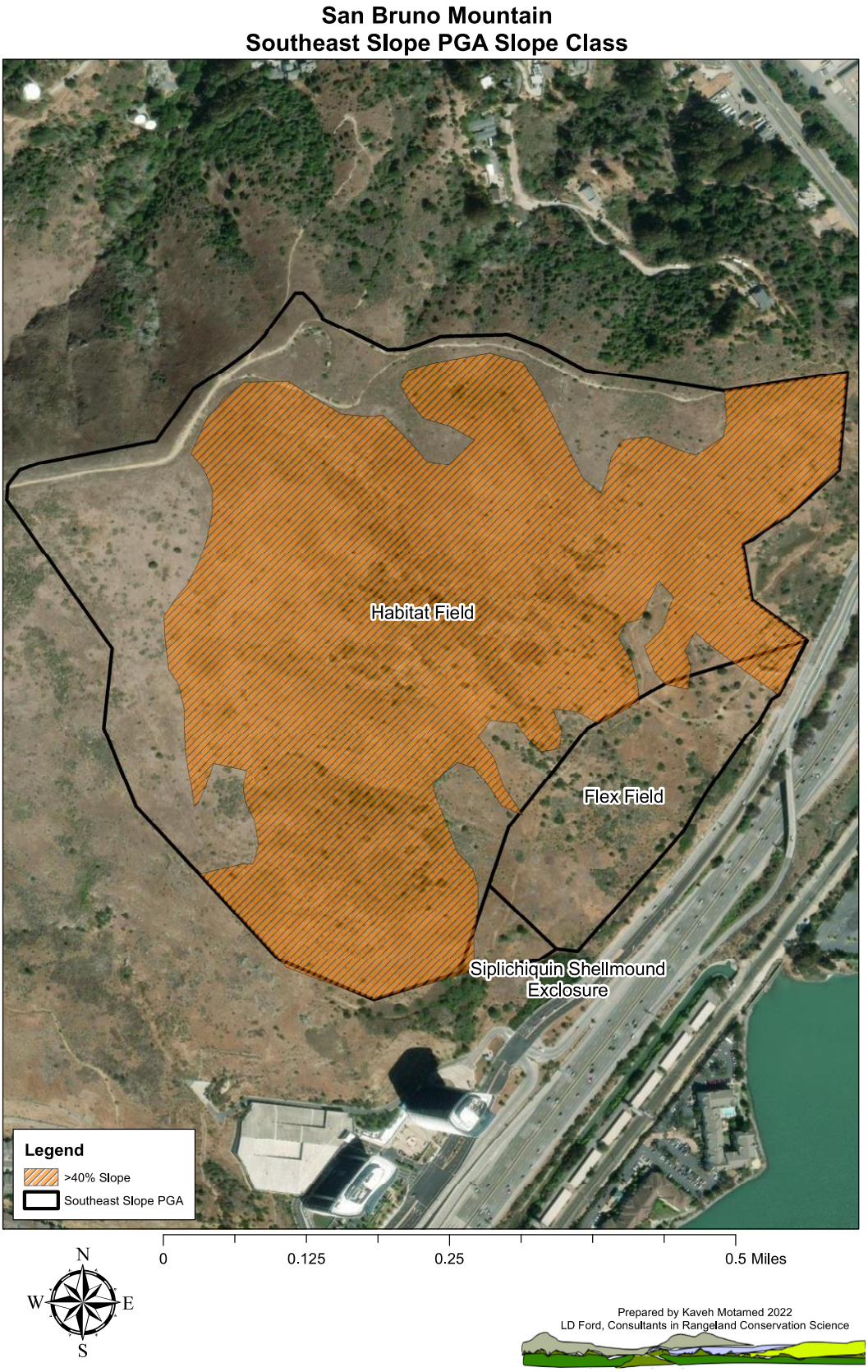

Figure 2. Slope classes in the Southeast Slope Pilot Grazing Area

Soils. The USDA Web Soil Survey (USDA 2022) identifies three soil map units in the Southeast Slope PGA (Figure 3). The vast majority of the area, including the southeast-facing slopes and the butterfly habitat along the ridge, is mapped as either the *Barnabe-Candlestick complex, 30 to 75 percent slopes* or *Candlestick-Kron-Buriburi complex, 30 to 75 percent slopes*. These map units are comprised of well-drained fine and gravelly sandy loams formed from weathered sandstone. Depth to restrictive bedrock in the major components of this map unit is 10-40 inches, although in places along the ridge it can be less, and rock outcrops form a minor component of the *Candlestick-Kron-Buriburi complex*. The lower-slope portion of the PGA along Bayshore Blvd. is mapped as *Candlestick variant loam, 15 to 30 percent slopes*. These well-drained, alluvial soils are composed of loams and clay loams and tend to be much deeper than the soils occurring on the slopes and ridge, with depths to restrictive features >80 inches. Off-road erosion susceptibility is not rated for these features, however, the susceptibility to erosion on roads and trails for all three of these map units is rated as "severe."

Vegetation. Vegetation in the Southeast Slope is a mixture of annual grasslands, coastal scrub, and perennial grasslands. Approximately 70 acres (56%) of the area was mapped as the Avena spp.-Bromus spp. semi-natural herbaceous alliance, while all other herbaceous communities were minor by comparison (Nomad 2020). Fifty-five acres (44%) of the area was mapped as shrub dominated – with coyote brush being the most common shrub type – followed by broom (*Genista monspessulana*; Nomad 2020). These acreages were based on a slightly larger footprint for the PGA, so the total acreage tallies do not equal our acreage numbers, however the approximate proportion of vegetation types is the same. A drainage dominated by willow (*Salix lasiolepis*) runs along the southeast border of the grazing area, however this riparian area will be excluded from the grazing area, so it is not considered further in this document. No emergent wetlands occur in the Southeast Slope; however, several branching ephemeral drainages were recorded in the BRA (Nomad 2020).

Host plants. At the time the BRA was written, approximately eight acres of the Southeast Slope was occupied by the host plant Johnny Jump-up (*Viola pedunculata*). Silver bush lupine (*Lupinus albifrons*) was present in only one-third of an acre. Other lupine species and California plantain (*Plantago erecta*) were present in less than 1/100th of an acre. English plantain (*Plantago lanceolata*) was abundant but was not mapped (Nomad 2020). Host plant occurrences were clustered along the main ridge in the northern portion of the Southeast Slope. Viola also occurred on prominent ridges coming south and east from the main ridge (Figure 4).

Cultural resources. At the base of the hill in the southern portion of the Southeast Slope, there is an archaeological site: the Ohlone Siplichiquin shellmound. It is unclear at the time of writing exactly what the extent of the site is or what mitigation measures will be required. Depending on the size and location of the site, it may be simple to exclude grazing from the site either through altering the location of the perimeter fence or by constructing an exclosure within the PGA (see *Section 5 Infrastructure*). Excluding livestock grazing from the site will likely not have a great effect on grazing capacity or placement of infrastructure. However, if a large exclosure is required it may affect these factors (including the location of the flexible use field fence and water trough).

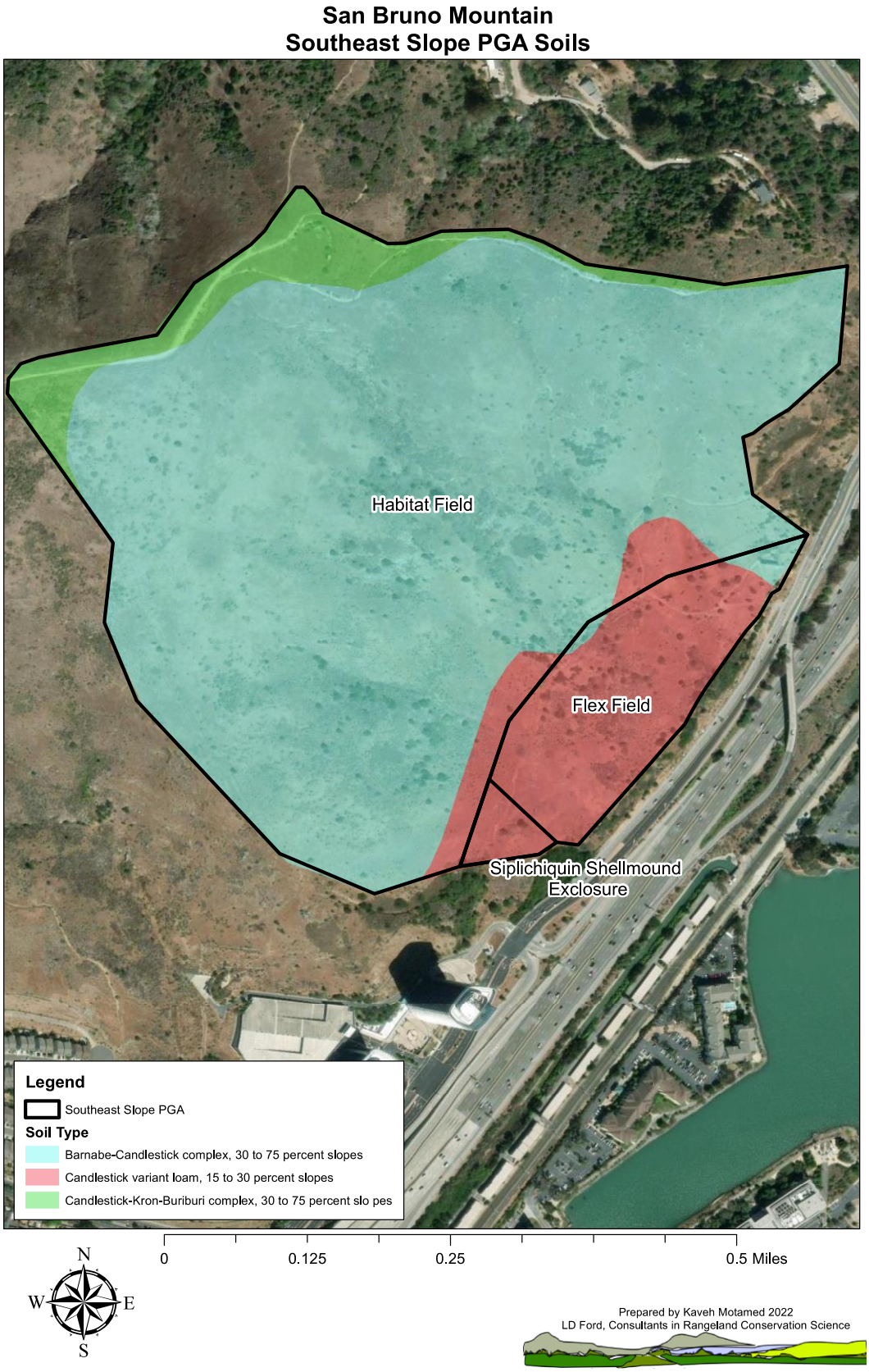

Figure 3. Soils in the Southeast Slope Pilot Grazing Area. Source: USDA 2022

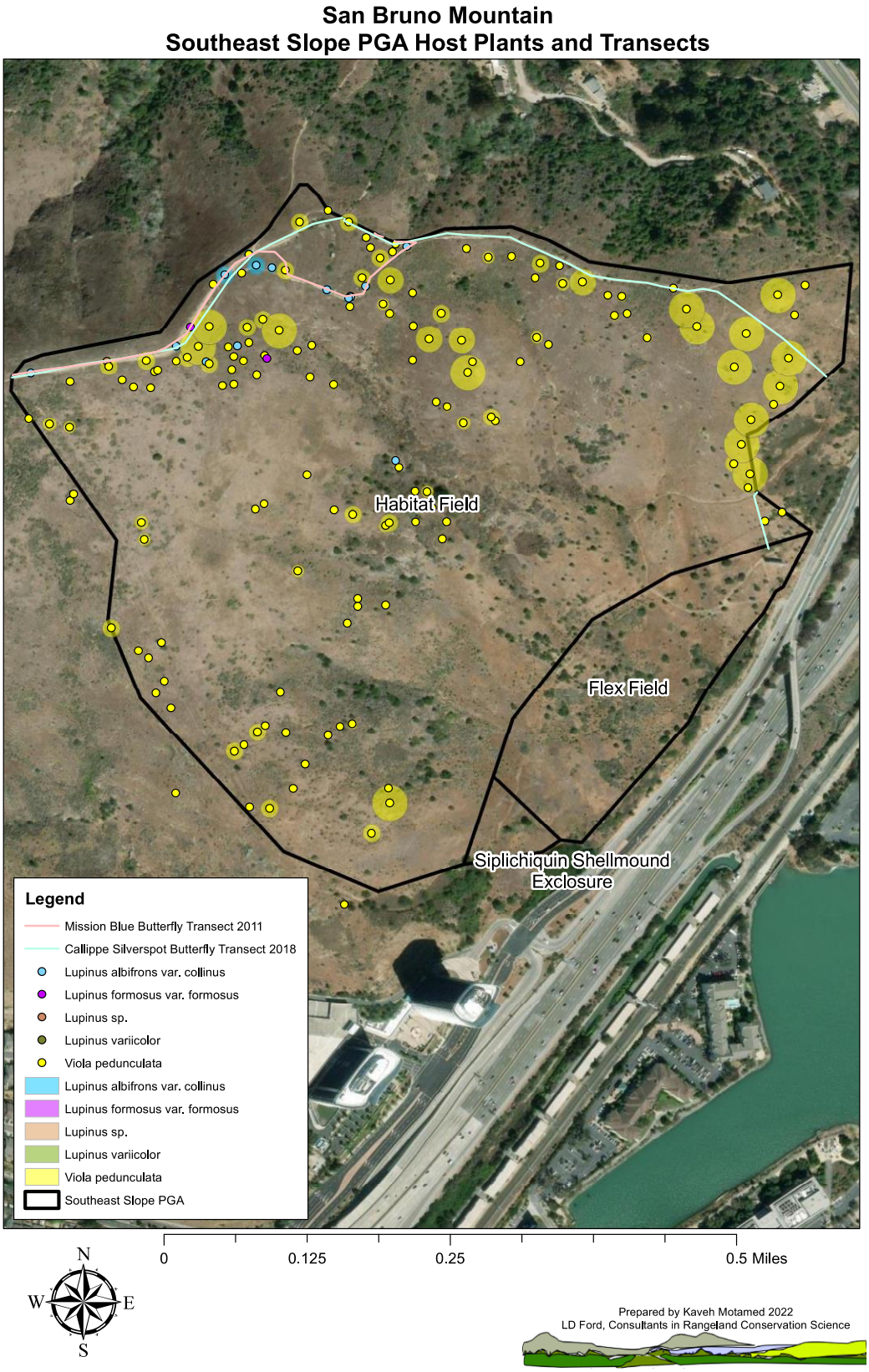

Figure 4. Host plants and butterfly survey transects in the Southeast Slope Pilot Grazing Area. Host plant data from Nomad (2020)

Access. Vehicle access to the Southeast Slope is provided through a gate on Bayshore Blvd. This road continues through the low-slope portion of the PGA. A dirt road also enters the PGA in its northwest corner and the road continues along the entire ridge. There is a social trail used for recreation that provides pedestrian access from a neighborhood to the north portion of the ridge as well. Movement within the site is limited. The road from Bayshore Blvd. does not continue to the ridge, nor is it well-maintained through the low-lying area. Hiking from the bottom of the site to the ridge requires traversing steep terrain on unmaintained paths. Access is discussed further in *Section 5 Infrastructure*.

Northeast Ridge

The Northeast Ridge PGA covers 76.1 acres. This site is bordered by Guadalupe Canyon Parkway to the north and Mission Blue Drive to the south. The east and west sides border residential development. The site is centered around a ridge, with a broad, gently sloping top; however, the site includes some fairly steep slopes down to the site perimeter. Unlike the Southeast Slope, there is no low-elevation flat pasture at the Northeast Ridge. Elevation ranges from approximately 170 feet along Mission Blue Drive to 490 feet on the western portion of the ridge. Slopes are gentler than in the Southeast Slope PGA (Figure 5). Forty-two percent of the terrain is above 40% slope, and the rest of the area is less steep.

Soils. The USDA Web Soil Survey identifies two soil map units in the Northeast Ridge PGA (Figure 6). The vast majority of the area, including the butterfly habitat along the ridge, is mapped as the *Candlestick-Kron-Buriburi complex, 30 to 75 percent slopes*. This map unit is comprised of well-drained loams and fine sandy loam soils formed from weathered sandstones. Depth to restrictive bedrock in the major components of this map unit is 10-40 inches, although in places it is much less, and rock outcrops form a minor component of this soil map unit. A small portion of the lower elevation portions of the PGA is mapped as *Orthents, cut and fill-Urban land complex, 5 to 75 percent slopes*. These well-drained, alluvial soils tend to be much deeper than the *Candlestick-Kron-Buriburi complex*, with depths to restrictive features >80 inches. No texture information is available. Off-road erosion susceptibility is not rated for these features, however, the *Candlestick-Kron-Buriburi complex* susceptibility to erosion on roads and trails is rated as “severe”.

Vegetation. Much like the Southeast Slope, vegetation in the Northeast Ridge is a mixture of annual grasslands, coastal scrub, and perennial grasslands. Forty-five acres (49%) of the area was mapped as Avena spp.-Bromus spp. semi-natural herbaceous alliance, while all other herbaceous communities were minor by comparison (Nomad 2020). Approximately 39 acres (42%) of the area was mapped as shrub dominated – with coyote brush being the most common shrub type – followed by broom (*Genista monspessulana*; Nomad 2020). These acreages were based on a slightly larger footprint for the PGA, so the total acreage tallies do not equal our acreage numbers; however, the approximate proportion of vegetation types is the same. No emergent wetlands occur in the Northeast Ridge; however, several branching ephemeral drainages were recorded in the BRA (Nomad 2020).

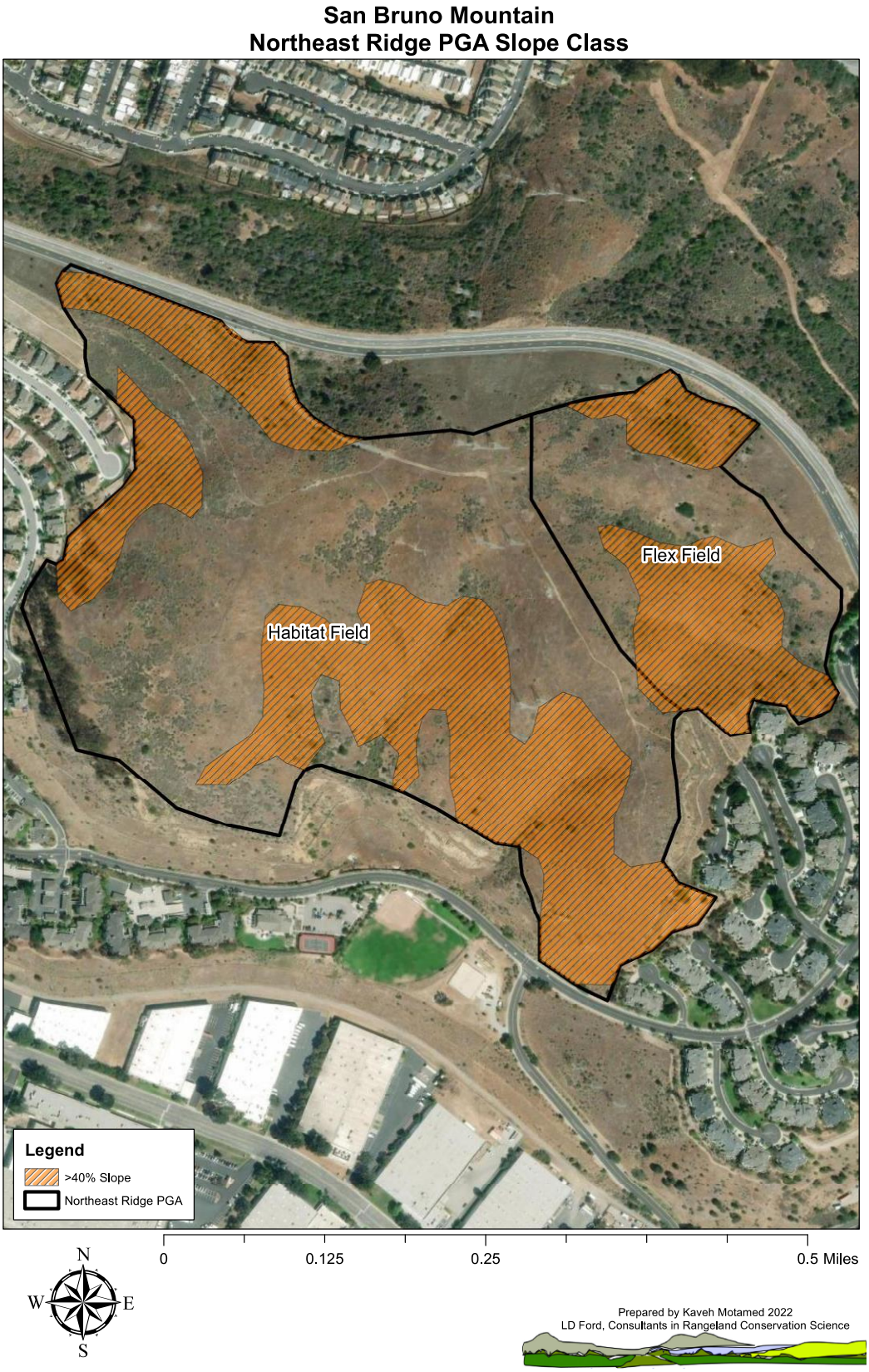

Figure 5. Slope classes in the Northeast Ridge Pilot Grazing Area

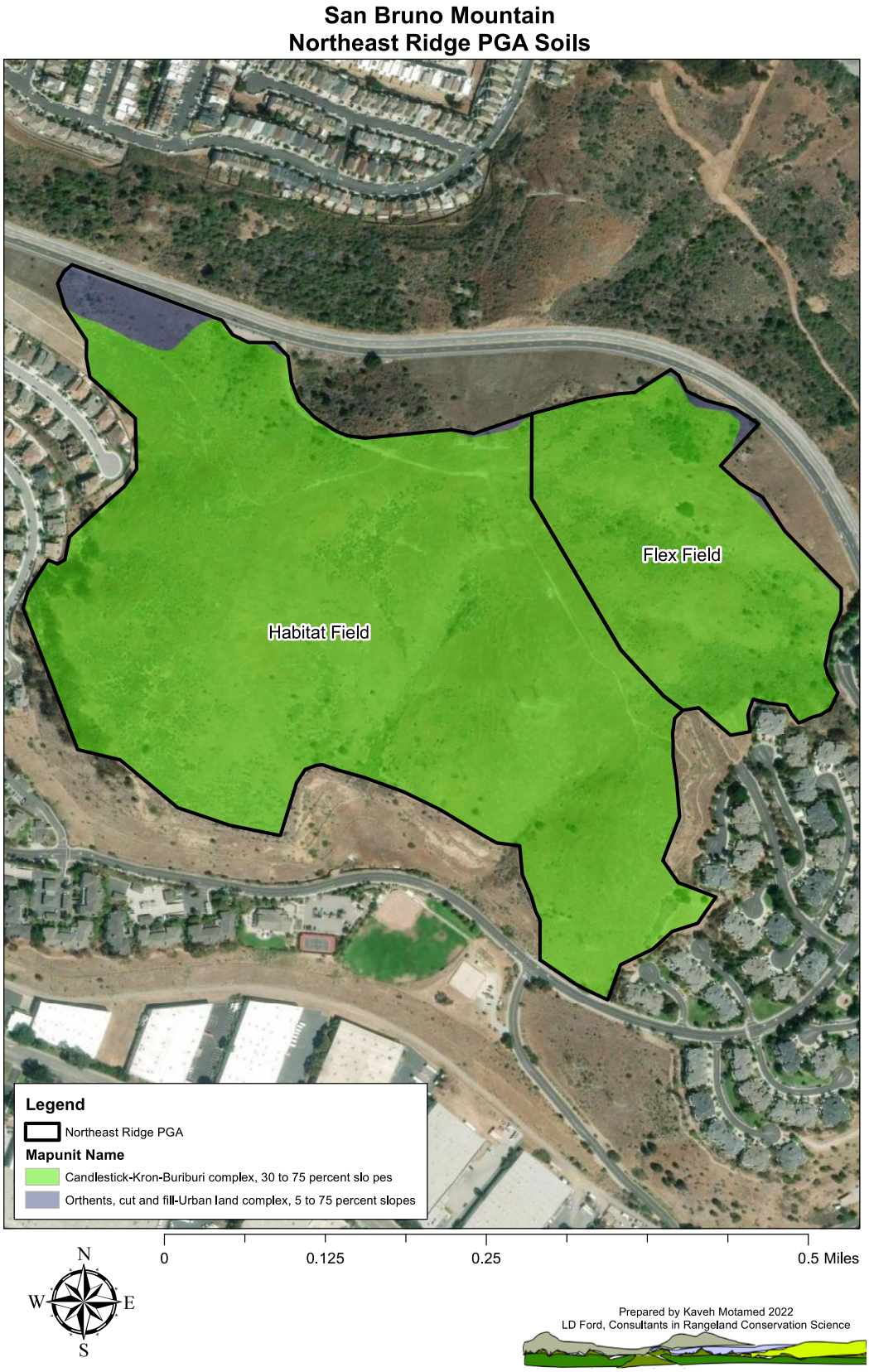

Figure 6. Soils in the Northeast Ridge Pilot Grazing Area. Source: USDA 2022

Host plants. At the time the BRA was written, 5.5 acres of the Southeast Slope was occupied by the host plant Johnny Jump-up (*Viola pedunculata*). Silver bush lupine (*Lupinus albifrons*) was present in 0.72 acres. *Lupinus formosus* var. *formosus* and *Lupinus variicolor* were present in 0.11 and 0.02 acres respectively. California plantain (*Plantago erecta*) was not detected in the area, however English plantain (*Plantago lanceolata*) was abundant (Nomad 2020). Violas occurred throughout the site, however individual populations were smaller in the center of the site and tended to be larger towards the perimeter. Lupines also occurred across much of the site, but patch sizes were larger along the north and west portions of the ridge (Figure 7).

Cultural resources. SMCPD does not have information about significant cultural resources in this PGA that need to be addressed in this grazing strategy.

Access. Vehicle access to the Northeast Ridge is provided through a gate on Guadalupe Canyon Parkway. A dirt road goes from this gate to the northern portion of the ridge. This road (a PG&E road used to access electrical towers) continues south along the ridge. There is a social trail used for recreation that provides pedestrian access from a neighborhood directly to the southeast. Access is discussed further in *Section 5 Infrastructure*.

Target Butterfly Species

Three listed butterfly species are the focus of this grazing pilot study: callippe silverspot, Mission blue and Bay checkerspot butterflies. These three species use different host and nectar plants, and they have different reproductive cycles. These factors all inform our objectives, performance standards, and the grazing strategy developed to achieve these goals. Table 1 summarizes key attributes of the target butterfly species and their habitat that are relevant to the grazing strategy.

Pest Plants

For the purposes of this grazing strategy, pest plants are non-native invasive plants that have the potential to spread within the PGAs and negatively affect natural resource values, including butterfly host plants, nectar plants and native plant species.

Nomad (2020) identified 25 invasive weeds in the two PGAs. These include all invasive plants ranked by either the California Invasive Plant Council inventory[1] or the California Department of Food and Agriculture weeds list[2]. Many of these species are considered naturalized in the California Central Coast and are nearly ubiquitous within the PGAs. Our list of pest plants (Table 2) includes species from the Nomad list that we believe have high likelihood of further invasion within the PGAs or across San Bruno Mountain.

[1] Cal-IPC inventory -- https://www.cal-ipc.org/plants/inventory/
[2] Encycloweedia: Data Sheets, California Noxious Weeds -- https://www.cdfa.ca.gov/plant/IPC/encycloweedia/weedinfo/winfo_table-sciname.html

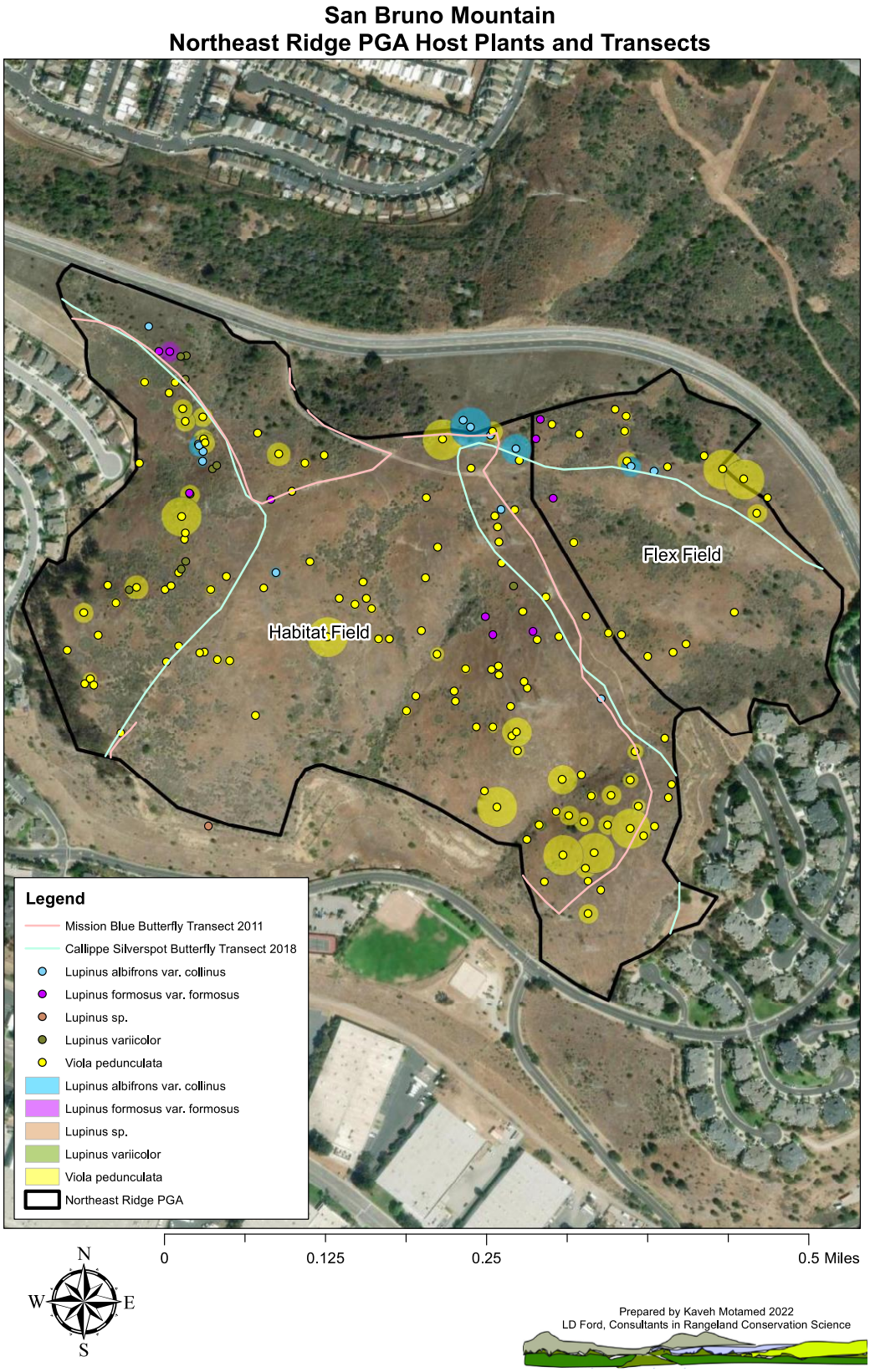

Figure 7. Host plants and butterfly survey transects in the Northeast Ridge Pilot Grazing Area. Host plant data are from Nomad (2020)

Table 1. Target butterfly species' occurrence in the PGAs and ecological and biological attributes relevant to the grazing strategy.

Species	Occurrence in PGAs[a, j]	Host Plant(s)[b, c, j]	Nectar Plants [b, c, j]	Reproductive Cycle
Callippe Silverspot (*Speyeria callippe callippe*)	***NE Ridge:*** Observed throughout most of area; particularly in higher-elevation areas. ***SE Slope:*** Observed along main ridge and on smaller ridges sloping off of main ridge.	-*Viola pedunculata*	-*Carduus pycnocephalus* -*Cirsium quercetorum* -*Dipterostemon capitatus* -*Eriogonum latifolium* -*Horkelia californica* -*Monardella villosa* -*Scabiosa atropurpurea* -*Silybum marianum* -*Raphanus sativus*	Mating occurs in mid spring to early summer in grassland habitat.[d] Females oviposit up to 412 eggs on dirt, grass, and plant debris in the vicinity (usually within 0.9 meters) of dense host plant patches, but not directly on host plants.[d] Larvae hatch from egg after 1 week and enter diapause.[d] Diapause lasts at least 8 months from early summer to the following spring.[d] After emerging from diapause, larvae eat the host plant *Viola pedunculata*. They likely develop from 6-14 weeks before entering the pupae stage. Pupae are close to the ground and pupal stage lasts approximately 2 weeks.[d] Adults rely on diverse nectar sources throughout flight season (April to July), travelling up to 1 mile to access nectar plants[d]
Mission Blue (*Icaricia icarioides missionensis*)	**NE Ridge:** Found throughout area, but most observations in north and east section. **SE Slope:** Most observations along main ridge and on	-*Lupinus albifrons* -*Lupinus variicolor* -*Lupinus formosus var. formosus*	-*Achillea millefolium* -*Carduus pycnocephalus* -*Cirsium quercetorum* -*Dipterostemon capitatus* -*Eriogonum latifolium* -*Heterotheca sessiliflora* -*Heterotheca villosa* -*Horkelia californica* -*Monardella villosa* -*Phacelia californica* -*Sidalcea malviflora*	Adult flight season from late March to Early July, and reproductive activities occur in patches of the host plants.[e,f] Adults use a diverse array of nectar plants[f], but do not travel far from host plant locations.[e] Females oviposit throughout flight season, laying eggs directly on host plants (mostly on new growth)[e] Approximately 3 weeks after larvae emerge, they begin diapause (usually in leaf litter at base of host plants).[e]

	ridge on west side of grazing area.		-*Silybum marianum* -*Sisyrinchium bellum* -*Raphanus sativus*	Larvae emerge from diapause in spring and resume feeding.[e] MBB have a mutualistic relationship with some native ants, which protect MBB larvae from parasitoids and predators. [e] Fungal parasite *Colletotrichum lupini* threatens host plant populations [f, g] Rocky outcrops provide host plant habitat [g, h]. Lupines also grow in areas with thin soils along ridge lines, cut slopes, dirt paths, and other areas with bare soil.
Bay Checkerspot (*Euphydryas editha bayensis*)	Extirpated from San Bruno Mountain in the mid 1980s.[i] Between 2017 - 2021, Bay checkerspot butterflies were reintroduced to the Main Ridge, Owl and Buckeye Canyons, and Northeast Ridge of San Bruno Mountain. Adults have been detected in the NE Ridge after larvae release.[i]	-*Plantago erecta* -*Plantago lanceolata* -*Castilleja exserta* (secondary host plant)	-*Achillea millefolium* -*Allium sp.* -*Cirsium sp.* -*Lasthenia californica* -*Lomatium sp.* -*Sanicula arctopoides* -*S. bipinnatifida* -*Sidalcea malviflora*	BCB adults emerge from pupae in early spring, after which they begin a 4-6 week flight season.[k] BCB flight season mean date on San Bruno Mountain was April 1st, with the maximum number of BCB flying on April 16th.[j] During the flight season, adults mate, lay eggs and feed on nectar. Generally, eggs are laid in March or April.[k] Larvae hatch approximately 10 days after egg is laid, growing to the 4th instar over the following two weeks, after which they enter a dormant period over the summer, which they spend under rocks or in soil cracks.[k] *Plantago lanceolata* is palatable to Bay checkerspot larvae for a longer time period than *P. erecta. P. lanceolata* often thrives in grazed areas.[l]

[a] *Assessment of the Past 30 Years of Habitat Management and Covered Species Monitoring Efforts Associated with the San Bruno Mountain Habitat Conservation Plan* (Weiss, Naumovich, and Niederer 2015)
[b] *San Bruno Mountain Habitat Management Plan 2007* (TRA Environmental Sciences 2007)
[c] *Biological Resources Assessment, San Bruno Mountain Cattle Grazing Pilot Program, County of San Mateo* (Nomad 2020)
[d] *Species Status Assessment for the Callippe Silverspot Butterfly (Speyeria callippe callippe) Version 1.0* (USFWS 2020)

[e] *San Bruno Elfin Butterfly (Callophrys mossii bayensis) and Mission Blue Butterfly (Icaricia icarioides missionensis) 5-Year Review: Summary and Evaluation* (USFWS 2010)
[f] 5-year Review Mission blue butterfly (*Icaricia icarioides missionensis*) (USFWS 2022a)
[g] *Amendment to Recovery Plan for San Bruno Elfin Butterfly (Callophrys mossii bayensis) and Mission Blue Butterfly (Icaricia icarioides missionensis)* (USFWS 2019)
[h] *San Bruno Mountain Area Habitat Conservation Plan. Volume 1* (SBM HCP Steering Committee 1982)
[i] Personal communication, Dr. Stuart Weiss 2022
[j] *Reintroduction of the Bay Checkerspot Butterfly to San Bruno Mountain* (Weiss et al. 2022)
[k] *Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area* (Elam, Wright, and Boettle 1998)
[l] 5-year Review Bay checkerspot butterfly (*Euphydryas editha bayensis*) (USFWS 2022b)

Table 2. List of known pest plants occurring in the PGAs (refined from Nomad 2020), and information on interactions with grazing.

Species	Common Name	Cal-IPC Invasive Plant Rank	CDFW Noxious Weed List	Interactions with Grazing
Brachypodium distachyon	Purple false brome	Moderate		No information on grazing for control.[a] Mowing alone is not enough to control species.[b] Tends to inhabit low-nutrient sites in East Bay Area, including those favored by *Stipa pulchra* (author's personal observation).
Brassica nigra	Black mustard	Moderate		Often dominates areas that are ungrazed, rarely problematic in grazed areas.[a]
*Carduus pycnocephalus**	Italian thistle	Moderate	Listed	Cattle generally don't consume Italian thistle due to spines.[a] May invade loafing grounds or other areas of high cattle impact.
Centaurea melitensis	Tocalote	Moderate	Listed	No information available on control with grazing, however congener (yellow starthistle), can be controlled if grazed intensively after bolting but before spines develop on heads.[a]
*Cirsium vulgare**	Bull thistle	Moderate	Listed	Sheep, goats, and horses (but not cattle) will consume young plants and can provide valuable control.[a]
Cytisus scoparius	Scotch broom	High	Listed	Foliage is somewhat toxic to livestock; however, goats can help manage resprouts after cutting or burning treatments.[a]
Eucalyptus globulus	Blue gum	Moderate		Livestock generally do not browse blue gum. Grazing not considered a viable control mechanism.[a]
Foeniculum vulgare	Fennel	High		Grazing is not an effective control measure for fennel; mechanical and chemical methods are effective for control.[a]
Genista monspessulana	French Broom	High	Listed	Foliage mildly toxic to livestock, except goats which can be used to manage resprouts after fire or cutting treatments.[a] Multiple years of heavy goat grazing can effectively control French broom.[c] Produces large amount of seed, which may be viable for 80 years.[d]
Helminthotheca echioides	Prickly ox tongue	Limited		Little is known about palatability to livestock.[a]
Hirschfeldia incana	Short-pod mustard	Moderate		Grazing is not expected to control short-pod mustard.[a]

* *Carduus pycnocephalus* and *Cirsium vulgare* are nectar sources for the listed butterfly species

[a] *Weed control in natural areas in the Western United States* (DiTomaso et al. 2013)

[b] *Brachypodium Control Experimental Treatments to Control Brachypodium An Adaptive Approach for Conserving Endemic Species San Diego County, California* (Conservation Biology Institute 2014)

[c] *Genista monspessulana in Fire Effects Information System* (Zouhar 2005)

[d] *Fire on the Mountain: a Land Manager's Manifesto for Broom Control* (Swezy et al. 1997)

Section 3. Grazing Management Goals and Objectives

This Goals and Objectives section is adapted from a document that was primarily written by SMCPD with input from LDFord and the TAC.

Primary Goal

The primary goal for the San Bruno Mountain Pilot Grazing Program is to enhance and conserve habitat for three federally-listed grassland butterfly species: the Mission blue butterfly, the callippe silverspot, and the bay checkerspot (Table 3). This primary goal aligns with the purpose of the HCP, "to provide for the indefinite perpetuation of the Mission blue and callippe silverspot butterflies," as well as for the other butterfly species that have been added to the HCP since its inception in 1982 (SBM HCP Steering Committee 1982). This goal also aligns with the goals, objectives, and success criteria put forth in the 2007 San Bruno Mountain Habitat Management Plan, the Mission Blue Recovery Plan Amendment (USFWS 2019) and the Callippe Silverspot Species Status Assessment (USFWS 2020). For Mission blue and callippe silverspot, one goal listed in the 2007 plan is to maintain or expand self-sustaining and viable populations of both Mission blue and callippe silverspot butterflies by maintaining a sufficient quality and quantity of suitable habitat for each species, which is achieved at least in part when grasslands on SBM are consistently providing suitable host and nectar plant habitat for each (TRA Environmental Sciences 2007). Before Bay checkerspot reintroduction efforts began (in 2017), the goal for the Bay checkerspot was to maintain the distribution and abundance of Bay checkerspot host and nectar plants so that reintroduction could occur, with an objective of applying vegetation management tools that sustain high quality Bay checkerspot habitat (TRA Environmental Sciences 2007).

For the purposes of the Grazing Pilot Program, the primary goal and its accompanying objectives and performance standards focus on habitat enhancement rather than on butterfly population numbers. This is because butterfly populations are highly variable, capable of fluctuating over orders of magnitude from year to year for reasons not directly tied to management practices such as grazing. For example, though we hope to create grassland conditions through cattle grazing that favor host and nectar plants and thus benefit listed butterflies, variations in annual weather conditions and the presence and abundance of parasitoids and predators could still lead to butterfly mortality (Weiss et al. 2015), and thus disappointing and perhaps misleading population survey results.

In determining whether the prescribed grazing treatment achieves the performance standards associated with objectives 1a and 1b, it will be important to view the data collected in the context of each study year's weather conditions, as weather is the primary driver of composition and abundance changes in California's annual grasslands (Spiegal et al. 2016). A 2007 study commissioned by the Solano Land Trust and carried out at King Ranch to investigate how different grazing regimes affect cover and amount of grazing-related damage sustained by *Viola pedunculata* (California golden violet or johnny jump-up), the host plant for the callippe silverspot, found that most of the variation in *V. pedunculata* cover was associated with variation in rainfall. Abundant early season rainfall favored non-native annual grass biomass and cover at the expense of *V. pedunculata* (Bernhardt and Swiecki 2010). Fire can also have a major effect

on vegetation composition. Following a fire at Sears Point, *V. pedunculata* were abundant in burned areas, while callippe silverspot nectar plants were destroyed in restoration areas (Coast Ridge Ecology 2021).

Table 3. Goals, Objectives, and Performance Standards for the Pilot Grazing Study. In this framework, goals are the high-level end results that the Grazing Pilot Program is trying to achieve with grazing. The associated objectives are specific outcomes that are important components of each goal that may be influenced by grazing management or the overall administration of the grazing program. The performance standards are criteria that will be used to judge successful accomplishment of study objectives.

Goals	Objectives	Performance Standards
Goal 1 (Primary Goal): Enhance and conserve habitat for listed grassland butterfly species: Mission blue, callippe silverspot, and Bay checkerspot.	**Objective 1a:** Increase or maintain the number and cover of butterfly host plants (to the extent feasible given variation due to different weather years).	**PS 1a:** Increase or maintain the number and cover of host plants in grazed areas relative to ungrazed controls.
	Objective 1b: Increase or maintain the number and cover of butterfly nectar plants (to the extent feasible given variation due to different weather years).	**PS 1b:** Increase or maintain the number, cover and diversity of nectar plants in grazed areas relative to ungrazed controls.
	Objective 1c: Maintain grassland herbaceous height, residual dry matter (RDM), and heterogeneity of herbaceous height within optimal habitat conditions to benefit butterfly host and nectar plants and facilitate adult butterfly access to host plants.	**PS1c:** Maintain **minimum** fall RDM at 800 lbs/acre on slopes less than 40% and 1200 lbs/acre on slopes more than 40% (Bartolome et al. 2006; Weiss et al. 2015). Fall RDM in butterfly habitat fields should be **kept below** 2500 lbs/acre (Weiss et al. 2015). **PS1d:** Maintain spring herbaceous obstruction height in butterfly habitat fields. Ideal height is 5 to 6 inches achieved by early May, although 8-inch obstruction height is acceptable (Pers. comm. Dr. Stuart Weiss 2022). Individual plant heights may be taller than 8 inches*. Past years'

		thatch is absent or minimal in spring sample. During periods of rapid spring growth, herbaceous vegetation obstruction height may get up to 12 inches for short periods of time, but this should be brought back to the target height after rapid spring growth is complete. Obstruction height is the maximum height at which a Robel Pole is 80% obscured when viewed from near-ground level at a distance of 20 feet from the pole. Maximum vegetation height is often greater than obstruction height. * Singleton and Courtney (1991) observed that female Oregon silverspot butterflies, which are similar to callippe silverspot butterflies, chose to oviposit within sites with vegetation heights of 8.6 to 10 inches (22-25 cm).
Secondary Goals		
Goal 2: Maintain the overall health of grassland ecosystems, including existing and potential sensitive biological resources (special status plants and wildlife, and sensitive plant communities), native biodiversity, and soil integrity.	**Objective 2a:** Maintain special-status plant populations and extent of sensitive plant communities. Maintain or increase native plant diversity.	**PS2a:** Maintain distribution of currently occurring special-status plants. Maintain or increase percent cover of native plant species.
	Objective 2b: Promote special-status wildlife populations.	**PS2b:** Maintain or enhance habitat conditions that can be affected by grazing programs and benefit special-status wildlife populations.
	Objective 2c: Control erosion to prevent grazing from contributing to significant sediment movement.	**PS1c; PS2c:** New major erosion features resulting from grazing activities are not detected in pilot grazing areas; existing erosion features are not exacerbated by grazing.

Goal 3: Minimize the impacts of invasive non-native pest plants.	**Objective 3:** Avoid and control the introduction and expansion of invasive non-native pest plants in grasslands associated with the grazing program.	**PS3:** No significant new stands or expansion of existing infestations of non-native pest plants are observed in the grazed areas.
Goal 4: Reduce shrub encroachment into grassland habitats and maintain minimum grass/shrub mosaic.	**Objective 4:** Promote herbivory and trampling of encroaching shrubs to maintain or reduce the relative proportions of shrubland that occur the year grazing is initiated.	**PS4:** Shrub cover (absolute percent cover) does not expand in grazed areas. (Parameters used to evaluate characteristics of the shrub/grass mosaic to be defined by the TAC).
Goal 5: Reduce the fire hazard associated with the buildup of dry herbaceous vegetation in the grasslands during the summer and autumn seasons.	**Objective 5:** Evaluate the potential of the pilot grazing program to reduce herbaceous fuel loads in grazing areas.	**PS1c; PS5:** Measure herbaceous biomass inside/outside exclosures in the grazing area in spring and fall to determine total fuel reduction due to grazing.
Goal 6: Maintain feasibility of grazing operation	**Objective 6:** Ensure that it is feasible for the grazing operator to comply with the terms of the grazing agreement. Performance standards are attainable and challenges associated with infrastructure, public use, and site access are minimized.	**PS6:** Perform an annual meeting with the grazing operator to identify resource constraints, public use conflicts, infrastructure condition, feasibility of performance standards, and other management challenges. Questions during meeting should also identify things that work well.

Secondary Goals

In addition to the primary goal of enhancing habitat for listed grassland butterfly species, the Pilot Grazing Program has ancillary goals relating to the overall health of grassland ecosystems, pest plant control, shrub encroachment, and wildfire fuels reduction (Table 3). As a pilot study, the Grazing Pilot Program also has the goal of determining the feasibility of cattle grazing at San Bruno Mountain.

The second goal for the Pilot Grazing Program is to maintain the overall health of the grassland ecosystems where grazing will occur, including existing and potentially-occurring sensitive biological resources such as special status plants and wildlife and sensitive plant communities, native biodiversity, and soil integrity. This second goal also aligns with the purpose of the HCP as defined by the HCP Steering Committee in 1982: “to conserve and enhance the value of the Mountain as a whole as a remnant ecosystem or biological refuge which contains other rare or unusual species in addition to the [rare] butterflies” (pp. III-1). The authors of the HCP go on to assert that:

> *"In providing for the conservation of the Mission Blue and Callippe Silverspot the more pervasive goal is to simultaneously provide for the perpetuation and enhancement of the grassland habitat which supports the butterflies, including its high proportion of native plants, local and regional endemics, and the animals which utilize the grassland."* (SBM HCP Steering Committee 1982, pp. III-1).

Accordingly, Objective 2a and Performance Standard 2a focus on maintaining special-status plant populations, sensitive plant communities, and native plant diversity, while Objective 2b and Performance Standard 2b focus on the special status wildlife species that utilize the grassland.

Vegetation Structure Based Performance Standards

Two of the performance standards in Table 3 refer to target vegetation structure to be achieved with livestock grazing management. Residual Dry Matter (RDM) is a measure of the above-ground herbaceous biomass remaining at the end of the grazing season (in the fall). Spring herbaceous biomass obstruction height is a measure of the height and density of vegetation during the spring and early summer, while plants are actively growing and at peak forage conditions. Below is a description of these standards and their relevance to the grazing pilot study.

Residual Dry Matter. University of California Rangeland Monitoring Series Publication 8092: *Guidelines for Residual Dry Matter (RDM) on Coastal and Foothill Rangelands in California* (Bartolome et al. 2006) provides minimum RDM levels for California annual-dominated grasslands based on rainfall, slope, tree canopy cover, and other factors. Adequate upland RDM should be maintained in the fall (before the start of the rainy season) to protect the soil surface from erosion, protect immature seedlings from frost, and avoid repeatedly high levels of bare ground, which can favor thistles and other weedy species.

The RDM guidelines were not designed for butterfly habitat management, and the timing of RDM measurement does not coincide with butterfly oviposition or adult activity. Nevertheless, excessive RDM (and the resulting accumulation of thatch) decreases habitat quality for butterfly host plants by reducing establishment of lupines and occurrence of *Viola pedunculata* (Weiss et al. 2015). It also negatively impacts some important wildlife species (e.g., burrowing owl), which prefer short-statured vegetation for foraging, nesting, movement, and defense from predators (Hammond et al. 2022). As such, a maximum RDM standard should be adopted to optimize host plant and wildlife habitat.

Based on Bartolome et al. (2006) and the professional judgment of the authors of this document, the minimum RDM standard should be 800 lbs/acre on slopes below 40%, and 1200 lbs/acre on slopes greater than 40% for grassland areas in the PGAs. This uses the "Annual Grassland/Hardwood Rangeland" RDM category, rather than the "Coastal Prairie" RDM category. These categories are based on total annual precipitation, and San Bruno Mountain does not receive enough precipitation to fall into the Coastal Prairie RDM category (UC IPM 2022; PRISM Climate Group 2022). In the fields or areas designated for habitat, maximum RDM values should not exceed 2500 lbs/acre, and ideally would not exceed 2000 lbs/acre. The flexible

use fields do not have a maximum RDM target, but ideally RDM will not exceed 3000 lbs/acre in that area for other conservation purposes (Table 4).

It is not generally possible for livestock operators to achieve precise, uniform, or long-lasting RDM levels. An adaptive process based on monitoring results (and periodic observations) should be used to help to refine these RDM targets, and to gradually adjust grazing management that better achieves the objectives. One tool that can be useful is to assess residual herbaceous biomass at sites in late spring. In the absence of livestock grazing, approximately 50% of standing biomass is lost over summer months due largely to photodegradation and wind fragmentation (Larsen et al. 2021). If grazing is confined to the winter and spring months, then approximately twice the minimum RDM standard should be left on the ground at the end of the grazing period to ensure that the minimum RDM standard is met in the fall.

Table 4. RDM standards and targets for the habitat fields and flexible-use fields in the Pilot Grazing Areas.

	Habitat Fields	Flexible-use Fields
Minimum RDM Standard	800 lbs/ac (slopes <40%) 1200 lbs/ac (slopes >40%)	800 lbs/ac (slopes <40%) 1200 lbs/ac (slopes >40%)
Maximum RDM Standard	2500 lbs/ac (all slopes, except areas inaccessible to livestock)	NO STANDARD
Maximum RDM Target	2000 lbs/ac	3000 lbs/ac

Targets versus Performance Standards

Here we use "performance standard" or simply "standard" as the minimum, maximum, or range of RDM levels to be achieved by grazing management. Failure to meet a standard indicates the need to assess what, if any, corrective action is needed to the grazing practices or operations, depending on the severity and frequency of failure, the presence of any extenuating circumstances (e.g., fire, drought), and best professional judgment.

We use "target" to describe the RDM level that the grazing operator should aim for, within the broader range of RDM minimum and maximum standards. Failure to meet the minimum target does not indicate the need for corrective action, so long as results are within the range of standards.

It can be difficult to meet RDM standards in high- and low-rainfall years, or if factors such as fire, invasive pest plants, or infrastructure vandalism interfere with the grazing operation. Also, RDM measurements should not be included in "service areas," such as around watering troughs, gates, and gathering areas. Such mitigating factors should be considered when evaluating each year's monitoring results and for planning management adjustments, as should whether missed standards are a repeated or rare occurrence.

Spring Herbaceous Biomass Obstruction Height. Monitoring of obstruction height of the herbaceous foliage provides information about height and density of spring vegetation. These measurements reflect density and height of the grassland's herbaceous vegetation, which is controlled by species composition and total vegetation production in a given year and the ability of grazing management to reduce overall herbaceous biomass and vegetation height during the late winter and spring. Some annual grass species (such as wild oats) grow tall, but may not form dense stands, while other species (such as soft chess brome [*Bromus hordeaceous*] and brome fescue [*Festuca bromoides*]) are lower statured, but often form very dense stands. Taller and denser spring vegetation can directly compete with host and nectar plants and may limit access of butterflies to host and nectar plants (Pers. comm. Dr. Stuart Weiss 2022, Singleton and Courtney 1991).

There are no published, peer-reviewed standards for spring obstruction height in relation to habitat quality for the three listed butterflies, however the technique is used for monitoring grazing and mowing impacts to other butterfly host plants (*Viola adunca*; Fuller 2022). Grazing management plans designed to benefit *Viola pedunculata* (among other conservation objectives) have specified mean year-round herbaceous height standards of 3-12 inches (LDFord 2007). Other research has shown that a species similar to callippe silverspot, the Oregon silverspot butterfly (*Argynnis zerene hippolyta*), preferentially oviposits in areas where vegetation is between 8.6 to 10 inches, avoiding areas with taller vegetation. This standard refers to stubble height, which differs from obstruction height (Singleton and Courtney 1991). In Sunol Regional Park, grazed sites with average vegetation height between 3-12 inches consistently had higher cover of *Viola pedunculata* compared with ungrazed sites with vegetation height between 13-25 inches (Peterson 2020). Typically, obstruction height is somewhat lower than measured vegetation height because it takes into account density as well as height, but that relationship depends on several factors including species composition, timing of grazing, and total production.

In March and May of 2022, we visited the PGAs with Dr. Stuart Weiss and SMCPD staff members to discuss grazing standards for butterfly habitat. Based on these field discussions and the above reports and studies, we developed the following spring obstruction height standards for the habitat fields:

- Ideal average spring obstruction height in the habitat fields is 5-6 inches, but up to 8 inches is acceptable.
- During periods of rapid spring growth, obstruction height up to 12 inches is acceptable.
- Obstruction height should be measured in early June to evaluate spring herbaceous biomass conditions after the rapid spring growth period has subsided.
- These standards do not apply to the flexible use fields or service areas.

Section 4. Grazing Strategy

The term "grazing strategy" refers to the strategic and tactical elements of the grazing program that are designed to achieve the performance standards in Table 3. Livestock grazing is the tool, and the grazing strategy describes the methods with which that tool is wielded: the kind & class

of livestock, the timing of the grazing period, the distribution of grazing, and the stocking rates. These parameters are constrained by environmental limitations of the sites, including: their size, shape, topography, forage production capacity, and availability of watering facilities. They are also affected by the performance standards: location of habitat fields, target habitat conditions for the butterfly species, and residual spring biomass and RDM standards. The following section describes the grazing strategy for the PGAs, the rationale for these tactics, and the anticipated effects on target resources.

Livestock Species

Factors that determine the livestock species best suited to the pilot grazing study include management goals and objectives, availability and interest of local livestock operators, predation potential, grazing infrastructure needs and feasibility, costs, and relevance to potential future grazing management at San Bruno Mountain. Management goals and objectives are especially important in selecting animal species because different grazing animals prefer, and select for, different types of vegetation (Table 5).

Cattle. Cattle are the most appropriate species for grazing in the pilot study because they are grazers that selectively consume grasses – the most widespread plant functional group in the PGAs and also the main competitor with the butterfly host plants. Cattle grazing is typically conducted year-round or for most of the grassland growing season, and thus would provide the continuous treatment better than contract grazing with goats or sheep. Also, there are more livestock operators who graze cattle than the other kinds of livestock in the greater San Francisco Bay Area, and cattle ranchers are accustomed to paying fees or providing services in exchange for grazing opportunities. Having said this, given the small size of the PGAs, finding a rancher who is willing to drive to San Bruno Mountain may be difficult, and either a no-fee or a fee-for-service agreement may be needed to find an agreeable grazing operator/partner. If the pilot grazing program is deemed successful and the area available for grazing is increased on San Bruno Mountain in the future, then there may be more interest in paid grazing agreements. Cattle grazing will be the most ecologically-appropriate and cost-effective method for the pilot study and probably also for a future scenario with increased grazing area.

Horses. Horses are typically raised more like pets than livestock, and many are fed supplemental hay and grains more frequently. This practice would increase the likelihood of introducing additional invasive weed species, and sometimes results in unintended over-use or under-use of rangeland resources in patterns associated with stable and pasture infrastructure. Some horses behave in ways that result in more soil erosion than cattle would, and thus are not preferable.

Sheep. Sheep tend to prefer forbs somewhat more than grasses, and are more susceptible to predation from coyotes, mountain lions and domestic dogs. Since the butterfly host plants are all either forbs or broad-leaved subshrubs (*Lupinus albifrons*), sheep may selectively graze some of the host plants. There are fewer grazing operators who raise sheep in the greater San Francisco Bay Area than cattle. In the Bay Area, sheep and goat grazing is typically performed by "contract grazers," and contract grazing costs can exceed $1000 per acre per year per treatment during times of demand for targeted grazing from other land management agencies (LDFord and Ecosystems West 2018). Controlling grassland growth is necessary during the entire growing season, which might mean repeated treatments. In the butterfly habitat areas, this could exceed

$100,000 per treatment (with multiple treatments needed annually) and would cost more if scaled up to a larger portion of the park in the future.

Goats. Goats are not recommended for use in the pilot study. They are primarily browsers and may not consume enough grasses to achieve the performance standards. Like sheep, they also target forbs and are susceptible to predation from large carnivores. Contract goat grazing services are available, but this can be very expensive (as noted in the "sheep" paragraph above), and will also require multiple treatments and 24-hour supervision by herders.

Table 5. Generalized dietary preferences by domestic livestock species.

Species	Dietary Preferences
Cattle	Grazer: mostly grasses, some seasonal use of forbs and browse
Horses	Grazer: mostly grasses, some forbs and browse
Sheep	Intermediate feeder: high use of forbs, but also use high volumes of grass and browse
Goats	Browser to intermediate feeder: high forb use, but can utilize large amounts of browse and grass; highly versatile

(Adapted from Vallentine 2001)

Timing and Grazing Period

Timing of grazing is key when considering potential impacts of livestock grazing to butterfly host plants, nectar plants and reproduction. Timing of grazing can impact competition of host and nectar plants with annual grasses, overall height and density of vegetation during butterfly mating and oviposition periods; and the total herbaceous biomass, vegetation structure, and bare ground at the beginning of the subsequent growing season. The magnitude and timing of grazing will impact these factors and the resulting conditions will be evaluated through the performance standards in Table 3. The success of the grazing program to benefit butterfly populations and performance standards will be directly tied to the timing when grazing occurs.

All of the butterfly host plants are forbs (and the subshrub, silver bush lupine). Like many other plants in California grasslands, they grow most actively in the late winter and spring. This is also when taller annual grasses like wild oats and bromes are actively growing. Thus, grazing at this time (especially with cattle who prefer grasses), may reduce competition between annual grasses and host plants for soil moisture, nutrients, light and space. This has been shown to be effective in serpentine soils for the host plant *Plantago erecta* (Weiss 1999). This is also largely true for the herbaceous nectar plants, which are also forbs (Hayes and Holl 2003; Stahlheber and D'Antonio 2013; Bartolome et al. 2007).

The three butterfly species typically mate and oviposit during the spring and early summer (Table 1). During this period, access to host and nectar plants is essential for improving reproductive success. Therefore, grazing in the spring and early summer months will reduce rapidly-growing spring vegetation and improve access to host plants (Table 10).

Although grazing in the winter and spring months is optimal from the standpoint of the study goals, that does not mean grazing must be confined to those seasons. Flexibility is one of the most important strategies for successful conservation grazing programs. With respect to timing, this means allowing the grazing program to operate outside of winter and spring months. This may be essential to reduce excess herbaceous biomass in high-production years, maintain habitat benefits in years when late spring rainfall or colder temperatures delay the development of grassland plant phenology, or to improve conditions for one of the secondary goals like fuel management or wildlife habitat. Flexibility in the grazing period may also be essential for the grazing operator, who may require flexible on- and off-dates in order to deal with low production years, wildfire threats, or other logistical issues pertaining to the livestock operation.

Stocking Rate

The Southeast Slope and Northeast Ridge should each be managed as individual units. Although each PGA will have a habitat field and a flexible-use field, stocking rate decisions should be made for each unit as a whole because most of the time the gate between habitat and flexible-use fields will be left open and forage on both sides of the fence will be available to livestock. The stocking rates below are based on production values measured in each PGA (Ratcliff and Ford 2020), and also reflect interannual variability estimated using the Rangeland Analysis Platform.[3] The estimates do not include thatch from previous growing seasons. Therefore, in the first year, the stocking rates may be conservative, but we anticipate thatch to reduce by years 2 and 3 of the study to levels more characteristic of grazed rangelands. A detailed explanation of the grazing capacity calculations that informed the stocking rates can be found in Appendix A.

Stocking rates are expressed as a combination of the following factors:

1. The kind of animal used for grazing
2. The number of animals used, converted into Animal Units (AUs). Animal Units are defined as “one mature cow of approximately 1,000 pounds and a calf up to weaning, usually 6 months of age, or their equivalent” (NRCS 2003). All other kinds and classes of livestock can be converted to animal units by using Animal Unit Equivalents ().
3. The length of time grazing occurs
4. The acreage grazed by the livestock

Table 6. Animal unit equivalents (AUEs). Adapted from National Range and Pasture Handbook (NRCS 2003)

Animal Species	Animal Unit Equivalent
Cow, dry	0.92
Cow, with calf	1.00
Bull, mature	1.35
Cattle, one-year-old	0.60
Cattle, two-year-old	0.80
Horse, mature	1.5
Sheep, mature	0.2
Goat, mature	0.15

[3] Rangeland Analysis Platform 2022, University of Montana --https://rangelands.app

Southeast Slope. Based on the grazing capacity estimate (Appendix A), the Southeast Slope PGA can support approximately 157 animal unit months (AUMs) in an average production year. This initial estimate of grazing capacity can be adjusted after the first year if it is found to be too high or too low.

This stocking rate can be achieved with young or adult animals, using animal unit equivalents from to determine the number of animals (rounding to the nearest number as needed). For example, 43 1-year old cattle for 6 months (.6 AU x 43 animals x 6 months = 154.8 AUM) or 13 cows with or without unweaned calves year-round (1.00 AU x 13 animals x 12 months = 156 AUM) would both be roughly equivalent to 157 AUMs. In a low or high production year, the initial grazing capacity estimates are 115 and 219 AUMs respectively. Table 7 shows the number of AUs that can graze the PGA for various grazing periods based on the estimated annual grazing capacity of approximately 157 AUMs.

Table 7. Livestock type, number of animals, and length of grazing period for the Southeast Slope Pilot Grazing Area.

Livestock Type	Animal Unit Equivalent[1]	Duration of Grazing	Number of AUs (whole numbers)	Acres	AUMs
Cow	1	12 months	**13**	95.5	156
Cow	1	6 months	**26**	95.5	156
Stocker cattle	0.6	12 months	**21**	95.5	151.2
Stocker cattle	0.6	6 months	**43**	95.5	154.8
Sheep	0.2	6 months	**130**	95.5	156
Goat	0.15	6 months	**174**	95.5	156.6
Horse	1.25	12 months	**10**	95.5	150

[1] Adapted from National Range and Pasture Handbook (NRCS 2003)

Northeast Ridge. Based on the grazing capacity estimate (Appendix A), the Northeast Ridge PGA can support approximately 111 animal unit months (AUMs) in an average production year. This initial estimate of grazing capacity can be adjusted after the first year if it is found to be too high or too low.

This stocking rate can be achieved with young or adult animals, using animal equivalents from to determine the number of animals (rounding to the nearest number as needed). For example, 30 1-year old cattle for 6 months (.6 AU x 30 animals x 6 months = 108 AUM) or 9 cows with or without unweaned calves year-round (1.00 AU x 9 animals x 12 months = 108 AUM) would both be roughly equivalent to 111 AUMs. In a low or high production year, the initial grazing capacity estimates are 71 and 151 AUMs, respectively.

Table 8 shows the number of AUs that can graze the site for various grazing periods based on the estimated annual grazing capacity of approximately 111 AUMs.

Table 8. Livestock type, number of animals, and length of grazing period for the Northeast Ridge Pilot Grazing Area.

Livestock Type	Animal Unit Equivalent[1]	Duration of Grazing	Number of AUs (whole numbers)	Acres	AUMs
Cow	1	12 months	**9**	53	108
Cow	1	6 months	**18**	53	108
Stocker cattle	0.6	12 months	**15**	53	108
Stocker cattle	0.6	6 months	**30**	53	108
Sheep	0.2	6 months	**92**	53	110.4
Goat	0.15	6 months	**123**	53	110.7
Horse	1.25	12 months	**7**	53	105

[1] Adapted from National Range and Pasture Handbook (NRCS 2003)

Supplemental Feeding

In general, supplemental feeding does not directly benefit the goals and objectives of this grazing pilot study, with the exception of Goal 6 "Maintain Feasibility of Grazing Operation". Supplemental feeding could lead to some areas of the PGAs receiving too much use and it runs the risk of introducing novel invasive weeds to the PGAs. However, it may be an essential strategy for maintaining the feasibility of the grazing operation, and therefore should not be prohibited. The small size and isolation of the PGAs means that forage demands of a herd could overcome forage availability in certain weather-years, or at some times of the year. Supplemental feed could be an important strategy to help the grazing operator maintain the health of their herd while they figure out where to move or sell their livestock in such years. Supplemental feeding should follow these guidelines:

1) Only use certified weed-free hay or feed. Information on weed-free forage can be found online at this link: https://www.cal-ipc.org/solutions/prevention/weedfreeforage/
2) Only provide supplemental feed in the flexible use fields of each PGA, unless there is a tactical reason to provide feed in the habitat fields (such as to attract livestock to an under-used area of the field).
3) Before providing supplemental feed, make sure it is not being put on or adjacent to sensitive cultural or biological resources.
4) Monitor supplemental feeding sites periodically for new invasive plant species.

Animal Distribution

The distribution of livestock are affected by several factors including species, breed, terrain, weather, availability of forage and water, and forage quality (Bailey 2004). In some situations, livestock will avoid certain areas of the landscape, while using other areas heavily. In the context of the goals in Table 3, this would be a problem if it resulted in areas of the PGAs falling below or above RDM targets and standards, vegetation height becoming too high in the habitat field, creation of bare areas that lead to erosion, loafing or trampling in areas with high host-plant or rare-plant occurrence, inability to reduce fuels in priority areas such as along roads and perimeter fences.

At the two PGAs, potential livestock distribution problems could arise if livestock do not have sufficient access to watering troughs, prefer to avoid steep slopes or higher elevations (especially

in the Southeast Slope PGA), congregate or "loaf" on ridges with significant butterfly habitat, or avoid areas of the PGAs due to conflicts with recreation, predators, or poor forage quality.

During some years, low precipitation might reduce the growth potential of the grasses as well as the butterfly host and nectar plants. An adaptive management approach should be taken to re-distribute livestock as necessary. If an area of host plants is not being grazed sufficiently to improve habitat conditions, then the Livestock Operator (or SMCPD) should consider altering livestock distribution through the placement of additional mineral licks, turning water troughs on or off (ensuring there will always be a trough available with sufficient volume and flow for the livestock), or using the flexible use field to increase or decrease the overall effect of grazing in portions of the habitat field. If grazing appears responsible for harm to portions of the habitat field, then temporary exclosures using electric fencing could be established to remove livestock access to that area. Effective use of electric fencing requires training livestock to the fence and would require that the Grazing Operator can install and maintain electric fencing.

Habitat and Flexible use Fields

In order to achieve the performance standards outlined in Table 3, the timing, number and duration of grazing must be manipulated to produce the desired grazing effect in any given year. Forage and habitat conditions can change dramatically from year to year or within a year in response to variable weather conditions or disturbances such as wildfire or flooding. In order to manage livestock to maximize habitat conditions in the portions of the PGAs with high-quality butterfly and host-plant habitat, grazing operators need the ability to increase or decrease livestock grazing in the habitat fields with host and nectar plants. In years with low forage production, this means they need to be able to move their livestock out of the habitat field when performance standards are achieved. In years with high forage production, grazing operators may need to concentrate livestock in habitat areas to achieve target conditions. The two PGAs are isolated from other grazed lands, so grazing operators cannot simply open a gate to an adjacent field when performance standards are achieved. Neither is it a realistic expectation that they can quickly remove livestock from the PGAs once optimal conditions are reached. Since moving livestock off-site is not always feasible for grazing operators, it is important to provide flexibility within each PGA. The best way to do this is to use one cross-fence to break each area into two fields. One field should be the area where habitat conditions are to be optimized (the "habitat field"), the second field should be an area where it is acceptable for livestock to utilize more or less forage (potentially resulting in a deviation from performance standards) if necessary. This second field is the "flexible use field" (flex-field).

Southeast Slope Flexible Use Field. In the Southeast Slope PGA, the flexible use field should divide the high-quality butterfly habitat occurring along the ridge from the rest of the PGA. The very steep slopes and undulating topography of this site mean that installing a fence midslope would be difficult and the resulting fence would be difficult to access for herding livestock or making repairs. A cross fence installed at the bottom of the slope (Figure 8) would create a low-slope field in the productive area adjacent to Bayshore Blvd. This field also provides an ideal location for gathering livestock downhill from the higher elevation areas for branding, loading onto trucks, delivering supplemental feed if necessary, or other needs. The proposed 13-acre (10.6 grazeable acres) flexible use field has no known host plant populations, no known rare plant populations, and no emergent wetlands (assuming the riparian area along Bayshore Blvd. is

excluded from the PGA; Nomad 2020). There is a large patch of the native grass *Elymus triticoides* in the flexible use field. This grass is known to tolerate livestock grazing and trampling (Young-Mathews and Winslow 2010), however it may be prudent to monitor grazing effects to this plant in years where the flexible use field gets heavy use.

The proposed 102.4-acre (84.9 grazeable acres) habitat field would contain all the known populations of host plants on the ridge and its adjacent slopes. Some parts of the habitat field would be inaccessible to livestock ("ungrazeable") due to steep slopes or dense shrubby vegetation (Figure 8). It is assumed that livestock will provide adequate forage utilization in host plant habitat if a watering trough is installed on the ridge (see *Section 5 Infrastructure*).

Northeast Ridge Flexible Use Field. The Northeast Ridge PGA has host plant occurrences mapped across the entire area. As such, there is no flexible use field location that would completely separate potential host plant habitat from non-habitat areas. There is a flex-field location that would provide the needed flexibility while still serving to concentrate the majority of the host plant habitat in a separate habitat field (Figure 9). This location would minimize the total length of fencing needed to create a flex-field and create a field that is close to the habitat field water tie-in and easily accessible by truck should supplemental feeding be necessary.

The proposed 16.7-acre (8.1 grazeable acres) flexible use field has no known rare plant populations and no emergent wetlands (Nomad 2020).

The proposed 59.5-acre (45.2 grazeable acres) habitat field would contain the majority of the mapped host plants on the ridge portion of the Northeast Ridge and its adjacent slopes. Some parts of the habitat field would likely be inaccessible to livestock ("ungrazeable") due to dense shrubby vegetation. If adequate numbers of livestock are used, it is assumed that livestock will provide adequate forage utilization in host plant habitat.

Summary of Grazing Strategy (Grazing Calendar)

Table 9 provides a suggested concept-calendar of grazing in each field by months of the year. This calendar represents a potentially-typical year for a year-long grazing program. The actual calendar should be adapted each year by the grazing operator and SMCPD to respond to changes in conditions, the available livestock, and feasibility for the grazing operator. This concept does not mean grazing would occur in habitat fields only during the green months, and in the flex-fields only during the yellow months. Instead, it suggests starting grazing in November (start of the grassland growing season) in the combined (gates open) habitat and flex-fields. And then shift to grazing in both fields or just one kind of field around March, depending on how much good forage is available, and how much grazing will be needed in the remaining months of the growing season to achieve the performance standards.

The priority is to optimize habitat conditions for the butterflies in the habitat fields. When the habitat fields have met the performance standards, and no more grazing would benefit the butterfly habitat, move the livestock to the flexible use field only, and plan to remove the livestock from the PGA when feasible. If additional grazing is needed to meet the performance standards, continue grazing in the habitat fields.

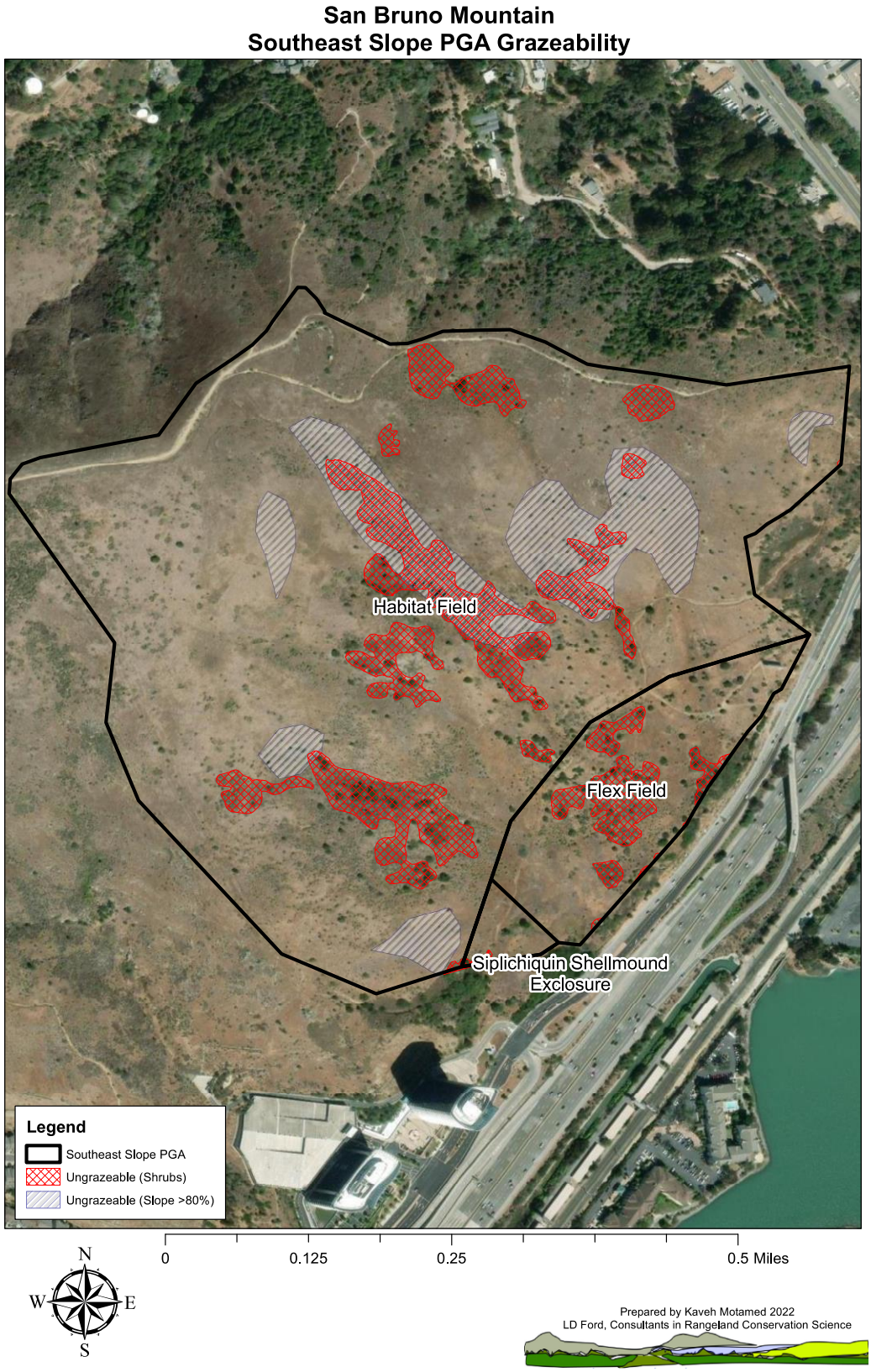

Figure 8. Map showing flexible use and habitat fields in Southeast Slope Pilot Grazing Area. Shading indicates areas that are ungrazeable due to slope or shrub cover.

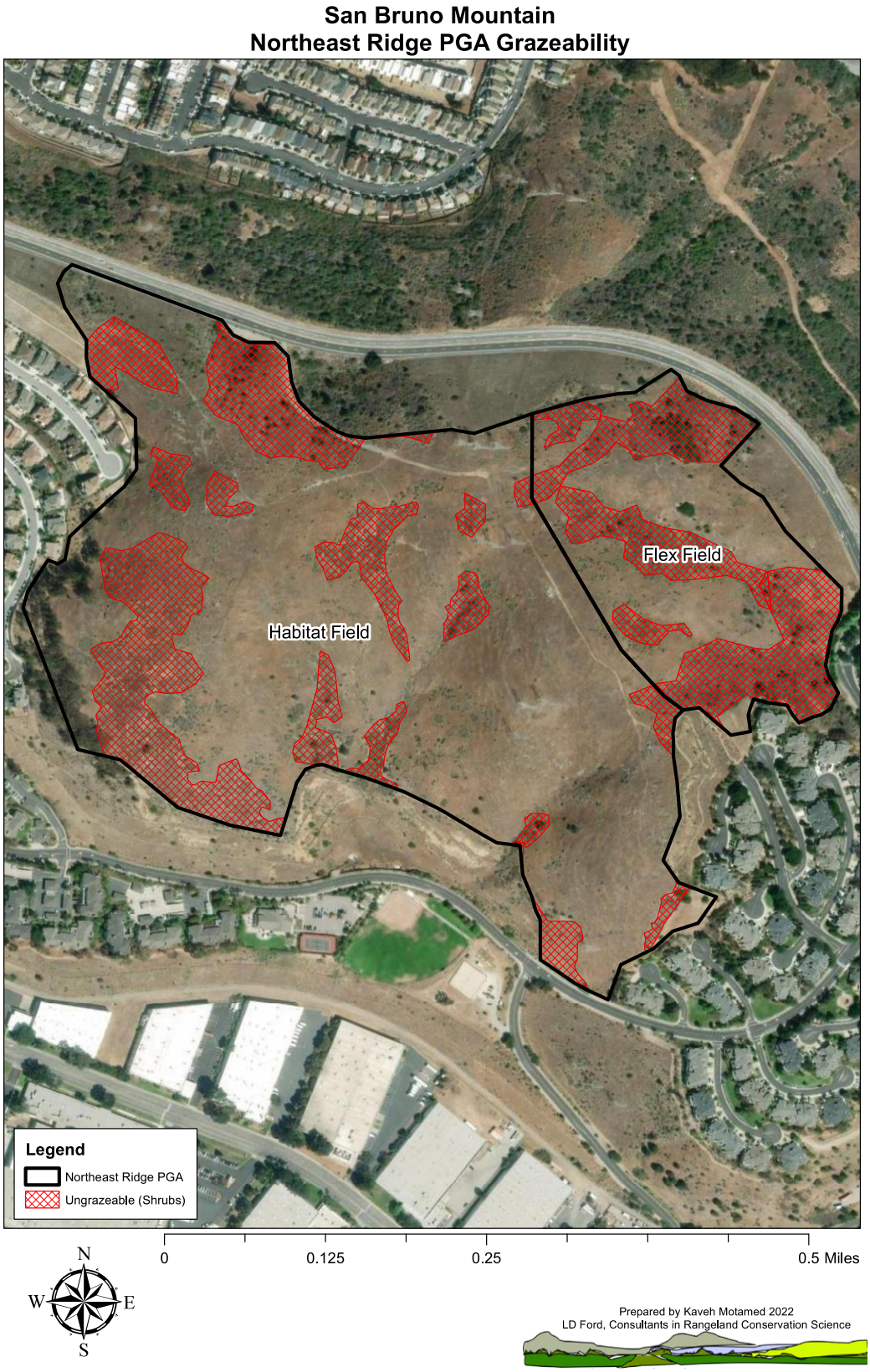

Figure 9. Map showing flexible use and habitat fields in Northeast Ridge Pilot Grazing Area. Shading indicates areas that are ungrazeable due to shrub cover.

Table 9. Calendar of grazing activities for the two PGAs. Green indicates the "Primary Grazing Period", Yellow indicates the "Flexible Grazing Period"

Month	Southeast Slope Habitat Field	Southeast Slope Flexible-use Field	Northeast Ridge Habitat Field	Northeast Ridge Flexible-use Field	Notes
November					Start of grazing season is usually November through January. Difficult to determine next year's forage production at this time. All fields should be grazed to benefit host/nectar plants and reduce herbaceous biomass/height.
December					All fields should be grazed to benefit host/nectar plants and reduce herbaceous biomass/height. In extreme fall or winter drought, put livestock into flexible-use fields.
January					
February					
March					Keep grazing habitat fields to benefit host/nectar plants. If production is low, continue grazing flexible-use fields too, if high, concentrate livestock in habitat field.
April					
May					
June					If stocker cattle are used, they will likely come off in late spring/early summer. If a year-round cow-calf operation, continue grazing both fields as necessary to meet performance standards.
July					If a cow-calf operation, continue grazing both fields as necessary to meet performance standards. Grazing in late summer/fall is most effective for reducing shrub encroachment.
August					
September					
October					If a cow-calf operation, continue grazing both fields as necessary to meet performance standards.

Expected Effects on Focal Resources -- Limitations of Grazing and Weather

The effects of livestock grazing will be a result of the number, distribution, timing, and type of grazing animal used (Bush 2006). These are the variables that are under the control of the rangeland manager. Just as important are the variables outside of our control: weather, plant population dynamics, and unplanned ecosystem disturbances such as wildfire or severe drought, which often drive annual dynamics in California rangeland ecosystems (Spiegal et al. 2016). The eventual effect of reintroducing grazing to the PGAs will be an interaction of these variables; and to a large degree, the resulting conditions will depend on weather conditions over the period of the pilot study. Furthermore, it may take several years to get the desired "grazing effect" in the PGAs. The Grazing Operator may wish to stock conservatively in the first few years, and it may take time to work through the thatch that has accumulated in recent history. The ideal length of the grazing trial is not known at this point. We estimate that a minimum of four to five years of study will be required. Given the overriding influence of climate on vegetation, it would be good

to observe grazing effects across a variety of weather years. The County should continue to hold TAC meetings to review results from the grazing study to determine whether more study years are necessary to show the effects of cumulative years of grazing and provide the best grazing management guidance to optimize habitat conditions for the butterflies.

The primary expected result of reintroducing livestock grazing is a reduction of herbaceous biomass, height, and density in grassland areas of the PGAs. If cattle are used for grazing (as recommended here), then the livestock will consume primarily herbaceous forage, and likely will select grasses over forbs. Dominant vegetation in the majority of grassland areas of the PGAs is wild oats and bromes (*Avena* and *Bromus* spp.; Nomad 2020). Assuming adequate stocking rates are achieved, livestock grazing should result in reduction in cover, height, and biomass of these species. Although year-round grazing would be compatible with study objectives and their related performance standards, winter and spring grazing is particularly desirable as it will reduce annual grass cover and height during the period of the year when host plants are competing with grasses and when butterflies are breeding and locating host plants for oviposition (Table 10).

In the first year of grazing, there will likely be a fair amount of thatch built up from past years. In 2020, LDFord measured production and thatch in the two PGAs and found that the Northeast Ridge had an average of 1800 lbs/acre of thatch from previous years, representing about 35% of the total 5200 lbs/acre of herbaceous biomass in grasslands. In the Southeast Slope, the numbers were similar: there was an average of 1600 lbs/acre of thatch, amounting to approximately 34% of the total 4700 lbs/acre of herbaceous biomass in grassland areas. Cattle will consume some amount of this thatch but will likely not select for it since it is leached of protein and other essential nutrients. Assuming adequate stocking rates are achieved, we expect the proportion of thatch to reduce in grazeable areas over time as overall herbaceous biomass is reduced and thatch is trampled by livestock. Depending on stocking rates and weather, this process may take two or more years.

Between reducing herbaceous biomass and thatch from previous years, we expect livestock grazing to achieve PS1c (RDM) and PS1d (spring obstruction height) standards in the habitat fields, assuming adequate stocking rates are utilized and there is not above-average vegetative production during the study period.

The other performance standards associated with Goal 1 assess the response of host and nectar plants to grazing treatments. These goals are critical to evaluating the effect of grazing for benefitting these plants and ultimately butterfly habitat. Based on previous studies, we expect grazing to benefit host and nectar plants (Table 10), but unlike herbaceous biomass reduction, benefitting these plants is an indirect process and the results will depend on a variety of factors including favorable weather.

With cattle grazing, we do not expect major direct impacts to mature shrub cover over the period of the grazing trial (PS4). While cattle grazing does retard or stop encroachment of shrubs into coastal grasslands in California (Ford and Hayes 2007), it does not generally reduce cover of established coyote brush (*Baccharis pilularis*) plants. Grazing is expected to reduce recruitment and growth of young coyote brush plants, especially if grazing occurs in the late summer and

early fall when woody browse is relatively more nutritious compared to the dry herbaceous forage (Table 10). Woody plant encroachment is a process that can play out over decades, so it is unlikely that we will observe a grazing effect over a few years. This is another reason to continue the grazing pilot as long as possible to observe longer-term dynamics. Qualitative observations of browsing and comparisons between grazed and ungrazed areas should provide insight into whether cattle grazing will successfully reduce shrub encroachment on San Bruno Mountain. Scotch and French broom are mildly toxic to livestock (DiTomaso et al. 2013), and we do not expect livestock grazing in the PGAs will have a major effect on occurrence or cover of these species.

Cattle grazing could impact special status plants growing in the two PGAs. In the Southeast Slope there is a population of San Francisco wallflower (*Erysimum franciscanum*) that occurs on the ridge in the northwest corner of the PGA (73 individuals observed in 2020: Nomad 2020). This species has the CNPS rare plant rank of 4.2, meaning it is on a watch list because it is uncommon in the state of California. There is no published information on grazing impacts to this species, however in two congeners in California, grazing is either not mentioned by the USFWS or grazing is seen as a benefit to the species (Barry and Huntsinger 2021). It is a perennial herb that blooms from March to June (CNPS 2022), which is during the window of time when grazing will likely be used in the area. Although this implies there may be a threat posed by grazing, CNPS (2022) notes that San Francisco wallflower is threatened by non-native vegetation – in which case, grazing may benefit this species. We recommend SMCPD monitor this population during the grazing pilot study to determine the impacts of grazing. Monitoring could focus on grazing of plants during the bloom period and changes in total extent and number in the area identified by Nomad.

In the Northeast Ridge a small patch of three Scouler's catchfly plants (*Silene scouleri* subsp. *scouleri*) were identified in a rocky outcrop in 2020 (Nomad 2020). This species has the CNPS rare plant rank of 2B.2, meaning it is rare, threatened or endangered in California, although common elsewhere. CNPS considers "herbivory" to be a threat to this species (CNPS 2022), although the herbivore species is not defined. Given that the species occurs in a rock outcrop in the grazing area, that it blooms from June to August (after the primary grazing period), it is unlikely that cattle will negatively impact this species. Nevertheless, it should be monitored to determine grazing impacts, especially if summer grazing is permitted in the Northeast Ridge PGA. If SMCPD is concerned about grazing impacts to this species, the occurrence area is small enough that an exclosure can be erected before grazing begins.

A few pest plant species will likely be controlled by grazing in the PGAs; however, each species will respond differently to grazing, and effects should be considered on a species-by-species basis (Table 2). Winter and spring grazing may effectively control species such as *Centaurea melitensis, Brassica nigra,* and potentially *Cirsium vulgare*. However, grazing is unlikely to eliminate these plants from the PGAs and many of the other pest plants will likely be unaffected by grazing. *Carduus pycnocephalus* may thrive in cattle loafing areas or other high-use areas or areas where soil is disturbed. If supplemental feeding occurs in the PGAs, supplemental feeding sites should be annually monitored to ensure no new pest plants are introduced from the feed.

Grazing may affect other resources of concern to SMCPD. These include wildlife populations, soil erosion, and fire hazard (Table 10). SMCPD should monitor for these impacts and evaluate monitoring results using the performance standards in Table 3.

Contingency Plans for Grazing Problems, Unusual Weather and Other Issues

Several unexpected issues could negatively impact the grazing program and its desired outcomes. As discussed in *Section 3 Grazing Management Goals and Objectives*, differences in annual weather patterns can have a major effect on forage production, species composition and site access. Operating a grazing program on public lands with recreational access can pose difficulties as well. Table 11 gives a list of issues that could arise and contingency strategies to minimize or mitigate impacts to the grazing program and goals of the pilot grazing study. This list is not exhaustive, and the specific solutions may not apply in all situations – they are listed to illustrate possible responses to issues as they arise.

Table 10. Timing of livestock grazing and potential impacts to project goals and objectives.

Legend: **+** ***= Likely Positive Impact;*** **(+)** ***= Potentially Positive Impact;*** **-** ***= Likely Negative Impact;*** **(-)** ***= Potentially Negative Impact***

Target Resource or Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Management Considerations
Butterfly Host Plants	(+)	(+)	+	+	+	+	+	+	(+)	(+)	(+)	(+)	Primary benefit of grazing on host plants is during the growing season when annual grasses are competing with host plants. However, depending on the amount and timing of forage production, there may be a benefit to reducing RDM and thatch at other times of the year.
Butterfly Nectar Plants	(+)	(+)	+	+	+	+	+	+	(+)	(+)	(+)	(+)	Winter grazing has been shown to benefit annual forbs (both native and exotic) in coastal Californian grasslands (Hayes and Holl 2003; Stahlheber and D'Antonio 2013). Grazing in other seasons will likely also benefit forbs as grasses tend to achieve high cover in areas with higher residual dry matter (Bartolome et al. 2007). Some nectar plant species (such as *Raphanus sativus and Silybum marianum*) thrive in disturbed areas, including cattle loafing areas. While this isn't desirable from a weed management perspective, these plants are valuable seasonal nectar sources.
Butterfly Access to Host and Nectar Plants	(+)	(+)	(+)	(+)	+	+	+	+	+	(+)	(+)	(+)	Grazing during the late winter and spring will have the greatest impact on vegetation height, which in turn will improve butterfly access to host plants. In years with excessive production, or in years following periods where grazing does not occur, grazing outside the rapid spring growth period may also improve butterfly access to host plants.
Direct Mortality of Immature Stages of Butterflies	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	Throughout the year there is the chance that livestock could crush and kill immature life stages (eggs, larvae, pupae) of the butterflies (Weiss 1999). Callippe silverspot in particular may be vulnerable year-round due to a long period when they can be in diapause. Mission blue diapause at the base of their lupine host plants and Bay checkerspot spend diapause fairly shallow in the soil, making them potentially susceptible to trampling. Although these direct impacts are important to consider, studies and management reports suggest that the population-level benefits of managing habitat with grazing greatly outweigh the negative impacts to butterflies that may occur from trampling (SBM HCP Steering Committee 1982; Weiss 1999; TRA Environmental Sciences 2007; Weiss et al. 2015).
Special Status Plants						(-)	(-)	(-)	(-)	(-)	(-)		There are no expected impacts to Scouler's catchfly or San Francisco Wallflower. The San Francisco Wallflower bloom period is March to June and Scouler's catchfly's bloom period is June to August. The species should be monitored for impacts if grazing occurs in the bloom periods.

Table 10 continued

Target Resource or Process	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Management Considerations
Native Plant Diversity	(+)	(+)	+	+	+	+	+	+	(+)	(+)	(+)	(+)	Native annual forbs are often found in higher abundance in winter-grazed coastal areas (Hayes and Holl 2003). Inland areas also tend to have higher abundance of forbs when grazed during the wet season, while responses of native perennial grasses tend to be more idiosyncratic (Stahlheber and D'Antonio 2013; Bartolome et al. 2014).
Burrowing Owl Habitat			(-)	(-)	(-)	(-)	(-)	(-)					Burrows are vulnerable to trampling during wet winters and spring (nesting season), however this may be a minimal risk in the PGAs where BUOW are not known to breed (they are only known to infrequently use San Bruno Mountain as winter habitat). There is also a lack of ground squirrels and suitably-large natural burrows on the mountain, reducing the risk of burrow trampling.
	+	+	+	+	+	+	+	+	+	+	+	+	Prefers areas with low-statured vegetation, often prefers moderately or heavily grazed grasslands (Hammond et al. 2022). Grazing can maintain low herbaceous cover, increasing visibility and improving habitat for ground squirrels, which provide burrows for refuge and nesting.
Monarch Butterfly Habitat	(+)	(+)	+	+	+	+	+	+	(+)	(+)	(+)	(+)	The PGAs do not contain significant stands of milkweed (NOMAD 2020); however, they do contain a diverse array of nectar plants. Grazing in winter and spring is expected to benefit nectar plants used by monarch butterflies by reducing non-native annual grass biomass and height.
Control Pest Plants			(+)	(+)	(+)	(+)	(+)	(+)					Interactions with grazing are species-specific (Table 2). Grazing is effective at controlling some thistles and mustards, especially earlier in the growing season when these species are more palatable. For other species grazing has no direct effect.
Reduce Shrub Encroachment	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	+	+	+	Grazing reduces encroachment of some shrubs into grasslands in coastal California (Russell and McBride 2003; Ford and Hayes 2007), defoliation and uprooting of shrubs by livestock is more common in late summer and early fall when forage alternatives are of comparably lower quality (Ford and Hayes 2007).
Reduce Fire Hazard	(+)				(+)	+	+	+	+	+	+	+	Reduction of fuels is most effective during the rapid spring growth period (if left ungrazed, this herbaceous biomass will cure and become dry fuel) and in the dry summer and fall period. Grazing in the winter is of less value since much of the fuel is above the moisture of extinction during most of the winter and will decompose (in most years) before it becomes dry fuel.

Table 11. Potential complications with grazing program and measures to mitigate damage to grazing program or target resources.

Threat Type	Specific Threat	Resource Implications	Potential Preventative Measures or Responses (numbers refer to which resource implications they impact)
Weather	Drought	1. Low forage production 2. Early drying of herbaceous fuels 3. Reduced growth of host/nectar plants	**1a.** Reduce stock density if possible, may require removing livestock from PGAs earlier than expected. **1b.** Keep gate open between habitat/flex field, concentrate livestock in flex field when performance standards are met. Supplemental feeding in flex field may be allowed but should be limited if possible. **2a.** If fuel loads are high despite drought, graze fire-prone areas early in the season to remove fuel before it dries. Use flex-fields, supplementation, and/or temporary electric fence to achieve adequate grazing effect.
	Warm/wet winter and spring	1. High herbaceous biomass production 2. High fine fuel loads 3. Favors grass growth over forb growth	**1a.** Increase stock density if possible. **1b.** Concentrate livestock in habitat field during winter, spring, and early summer until performance standards are met. **1c. & 2a.** Keep livestock in pastures longer to reduce fuel and residual herbaceous biomass. Use flex-fields, supplementation, and/or temporary electric fence to achieve adequate grazing effect in habitat fields and fire-prone areas.
Fire	Wildfire burns grazing area	1. Direct threat to livestock from fire 2. Loss of forage due to wildfire 3. Damage to grazing infrastructure 4. Damage to host plants, nectar plants, and butterflies	**1a.** Rapid communication with livestock operator to arrange movement and ensure safety of livestock. **1b.** Train SMCPD staff (rangers) to understand pasture arrangement and techniques to move animals and ensure their safety. Ensure SMCPD staff have all necessary keys to open pasture gates. **2a.** Reduce stock density after fire if necessary (and possible). **2b.** Provide supplemental feed in the flex field if livestock cannot be removed and additional forage is required.

			3a. Immediately evaluate condition of livestock infrastructure and make rapid repairs. **4a.** Record burn effects to host and nectar plants in monitoring plots. Add variables to monitoring program to capture the extent and impacts of fire to target species.
Recreation / Other human impacts	Off-leash dogs	1. Off-leash dogs harass, attack livestock	**1a.** Post signage at gates describing grazing program and clearly stating park regulations re: dogs. Post signage well before grazing is reintroduced so that people get used to the idea. **1b.** Graze with cattle, not sheep or goats. **1c.** Increase enforcement of park rules in pilot areas. **1d.** Determine Park policy for reimbursement to grazing operator if attack occurs.
	Cut livestock fence	1. Cut perimeter fence: livestock can escape grazing area, may go to roads 2. Cut flex-field fence: makes it more difficult to control distribution within PGA	**1a.** Rapid communication with livestock operator to arrange movement and ensure safety of livestock. **1b.** Train SMCPD staff (rangers) to understand pasture arrangement and techniques to move animals and ensure their safety. Ensure SMCPD staff have all necessary keys to open pasture gates. **1.c** Immediately notify California Highway Patrol, local police departments and any other relevant jurisdictions if livestock enter roadways. **1d. & 2a.** Install fences well before livestock are introduced and monitor for vandalism. Promptly repair fences and observe where problem areas arise. **1e. & 2b.** After grazing is initiated, monitor condition of fences on a regular basis. Monitoring interval will be advised by frequency of issues in step 1&2a above but will likely need to be at least weekly. Perimeter fences should be checked frequently by either SMCPD or the grazing operator to confirm that they are up to “Lawful Fence” standards. **1f. & 2c.** Immediately fix breaches in fencing and determine the reason the fence was cut. Try to prevent future fence vandalism.

	Gates left open	1. Perimeter gate: livestock may escape PGA 2. Flex-field gate: livestock distribution compromised	**1a.** Rapid communication with livestock operator to arrange movement and ensure safety of livestock. **1b.** Train SMCPD staff (rangers) to understand pasture arrangement and techniques to move animals and ensure their safety. Ensure SMCPD staff have all necessary keys to open pasture gates. **1.c** Immediately notify California Highway Patrol, local police departments and any other relevant jurisdictions if livestock enter roadways. **1d. & 2a.** Install self-closing gates on all unlocked pedestrian gates. **1e. & 2b.** Post signage at gates describing grazing program and reminding people to close gates.
Livestock Management	Livestock Distribution	1. Livestock not utilizing habitat areas, not achieving desired impacts in priority areas 2. Livestock "over-utilizing" habitat areas	**1a.** Exclude livestock from flex field to concentrate animals in habitat field. **1b.** Place nutrient supplements in areas where more use is desired. **1c.** While the gate between habitat and flex fields is open, turn off water valve to trough in flex field (make sure there is still a functional water source accessible in the habitat field). **2a.** Keep gate between habitat and flex field open to lessen grazing pressure in habitat area. If necessary, exclude livestock from habitat field and confine to flex field. **2b.** While the gate between habitat and flex fields is open, turn off water valve to trough in habitat field (make sure there is still a functional water source accessible in the flex field).
	Conflicts between livestock and public	1. Livestock aggressive towards recreationalist 2. Members of the public complain about livestock or grazing program	**1a.** Specify acceptable kinds/classes of livestock with grazing operator **before** livestock are brought to site. Avoid bulls or any livestock that are known to be aggressive. **1b.** Make sure grazing operator understands the proximity to hiking and biking recreationists. Ask them to bring animals who are used to people.

			1c. If conflicts arise, interview members of the public who report conflicts, understand circumstances before determining fault. If livestock are at fault, discuss removal of problematic animals with grazing operator. In some cases, the flex field may be used to temporarily confine problematic animals since no public trails go through either flex field. **1d. & 2a.** Post signage at gates describing grazing program and describing appropriate behavior around livestock. **2b.** Train SMCPD staff to understand purpose of grazing program, so that they can explain why grazing is occurring. **2c.** Assign a trained SMCPD staff member to return calls, reach out to public via community meetings, and catalog complaints. When significant complaints are raised, work with livestock operator to address them. **2.d.** Maintain a website with links to the science, planning and policy documents that justify the grazing program.

Section 5. Infrastructure Condition and Requirements

At the time of writing, the Southeast Slope and Northeast Ridge PGAs lack the fencing, watering infrastructure, roads, truck turnarounds, and corrals to commence grazing and carry out the recommended grazing strategy. Infrastructure requirements vary depending on the grazing animals used, the number of animals, the timing of grazing, and the monitoring plan and experimental design adopted by SMCPD. The sections below detail condition and extent of existing infrastructure and the additional infrastructure required to carry out the grazing strategy. Recommendations are made for where to place infrastructure to maximize strategic benefit for habitat management and livestock management. For the most part, the recommendations do not include technical specifications, but those specifications can be determined by SMCPD staff or by consulting the Natural Resources Conservation Service (NRCS). James Howard, District Conservationist San Mateo County District office can be contacted at:

email: james.howard@ca.usda.gov
phone: (650) 726-4660

Fencing and Gates

California Food and Agriculture Code 17121 describes the attributes of a "Lawful Fence" required to prevent the ingress or egress of livestock. According to this code:

> "*No wire fence is a good and substantial fence… unless it has three tightly stretched barbed wires securely fastened to posts of reasonable strength, firmly set in the ground not more than one rod [16.5 feet] apart, one of which wires shall be at least four feet above the surface of the ground. Any other type of wire or other fence of height, strength and capacity equal or greater than the wire fence herein described is a good and substantial fence*"

Full language of the code can be accessed here: https://nationalaglawcenter.org/wp-content/uploads/assets/fencelaw/california.pdf

All fences in the pilot areas should be built or repaired to meet the State Lawful Fence standards. But the Lawful Fence standards, which require only three barbed wires, could be improved upon. Three barbed wires are generally considered less than best to reduce the chances that calves will be able to escape. To reduce liability in the proximity of the PGAs to high-traffic roads, we recommend that all perimeter fences use six barbed wires with the top wire set at 52 inches to reduce the chance that livestock escape. Use of 6.5-foot t-posts (rather than 6 feet) should increase fence strength. If possible, reduce t-post spacing to 8 feet, rather than the lawful fence standards of 16.5 feet apart. Corners and pivot points should include concrete footings and 45-degree braces to increase strength.

Designs for "wildlife friendly" fences often have smooth top and bottom wires, bottom wires held at least 16 inches from the ground, and top wires no more than 42 inches in height (Paige 2012). These fence designs can be used for internal cross-fencing in the PGAs but should not be used for perimeter fencing that has greater chances of calf escape and accidents on high-traffic

roadways. Wildlife friendly designs are generally more permeable to livestock and will increase the risks (and liability) of livestock escaping the grazing areas. We recommend that SMCPD determine which local wildlife species might be harmed by attempting to pass through the proposed fencing and exactly where, and then prioritize any fence design modifications in narrow wildlife passage zones.

Southeast Slope. The Southeast Slope lacks adequate fences to contain livestock, and the fencing that exists is not in the correct location for the purposes of the grazing pilot study. There is a chain-link fence that runs along approximately 1500 feet of the southeast perimeter of the grazing area. This chain link fence is taller than the minimum 48 inches, however its strength and capacity may not meet State Lawful Fence standards. This fence abuts Bayshore Blvd. and should livestock escape here, they would have unincumbered access to Highway 101. Therefore, it should be assumed that this fence does not meet State Lawful Fence standards until inspected and repaired. The San Mateo County Parks Department also said that the riparian area running on the inside of the existing fence should not have cattle grazing during the pilot study. Therefore, we recommend a new barbed wire fence (using the perimeter fence design) to be constructed on the inside of the riparian area in the southeast portion of the pilot grazing area (Figure 10). Elsewhere, new perimeter fencing should be installed along the Southeast Slope pilot grazing area perimeter as closely as possible.

In some areas, a fencing contractor may suggest installing the fence inside the planned fence perimeter to facilitate installation. This may be especially useful in the northern portion of the study area where the perimeter is hilly and goes through some shrubby vegetation. However, fencing in this area should be kept on the north side of the ridge road so that as much of the ridge is contained in the grazed area as possible. This will also minimize the number of gates that the public needs to open and shut when accessing the ridge for recreation. Sixteen-feet-wide gates should be installed anywhere where vehicle access may be needed. This includes: the gate onto Bayshore Blvd, the gate at the top of the ridge, and the gates from the flexible use field to the habitat field. One self-closing pedestrian gate should be installed where the social trail enters the pilot grazing area in the north portion of the Southeast Slope PGA (Figure 10).

One internal cross fence will be installed to create the flexible use field (described in *Section 4 Grazing Strategy*). Although not a perimeter fence, the fence should be built to Lawful Fence Standards. However, unlike perimeter fencing, this internal fence can be built using a “wildlife friendly” design. This fence should have three 12 to 14-feet gates to allow access between the flexible use and habitat fields (Figure 10).

Figure 10. Existing and required infrastructure in the Southeast Slope. The location of the Siplichiquin shellmound is approximate and should be verified by SMCPD before infrastructure is installed.

Northeast Ridge. The Northeast Ridge PGA currently lacks adequate fences to contain livestock. There are scattered fragments of barbed-wire fence along the west and southeast borders of the PGA, however these fence fragments have not been evaluated for condition and it is safest to assume they will need to be repaired or replaced to meet State Lawful Fence standards. Elsewhere, new perimeter fencing should be installed as closely as possible to the Northeast Ridge PGA perimeter. In some areas, the fence should be built inside the original planned PGA perimeter. In the south portion of the PGA, the fence should be kept uphill from the V-ditches and eroding steep banks. Similarly, in the north portion of the PGA, near the powerlines and east of the powerlines, the perimeter fence should be kept uphill of the V-ditches and steep eroding banks above Guadalupe Canyon Parkway. Sixteen-foot-wide gates should be installed anywhere where vehicle access may be needed. This includes: the gate onto Guadalupe Canyon Pkwy. and the gate into the flexible use field from the habitat field. One self-closing pedestrian gate should be installed where the trail enters the PGA at the end of Checkerspot Drive (Figure 11). Another self-closing pedestrian gate could be installed where a social trail enters the PGA in the northwest corner of the PGA.

One internal cross fence should be installed to create the flexible use field (described in *Section 4 Grazing Strategy*). Although not a perimeter fence, the fence should be built to "Lawful Fence Standards". However, unlike perimeter fencing, this internal fence can be built using a "wildlife friendly" design. This fence should have one 16-foot gate where the road in from Guadalupe Canyon Pkwy. enters the flexible use field (Figure 11).

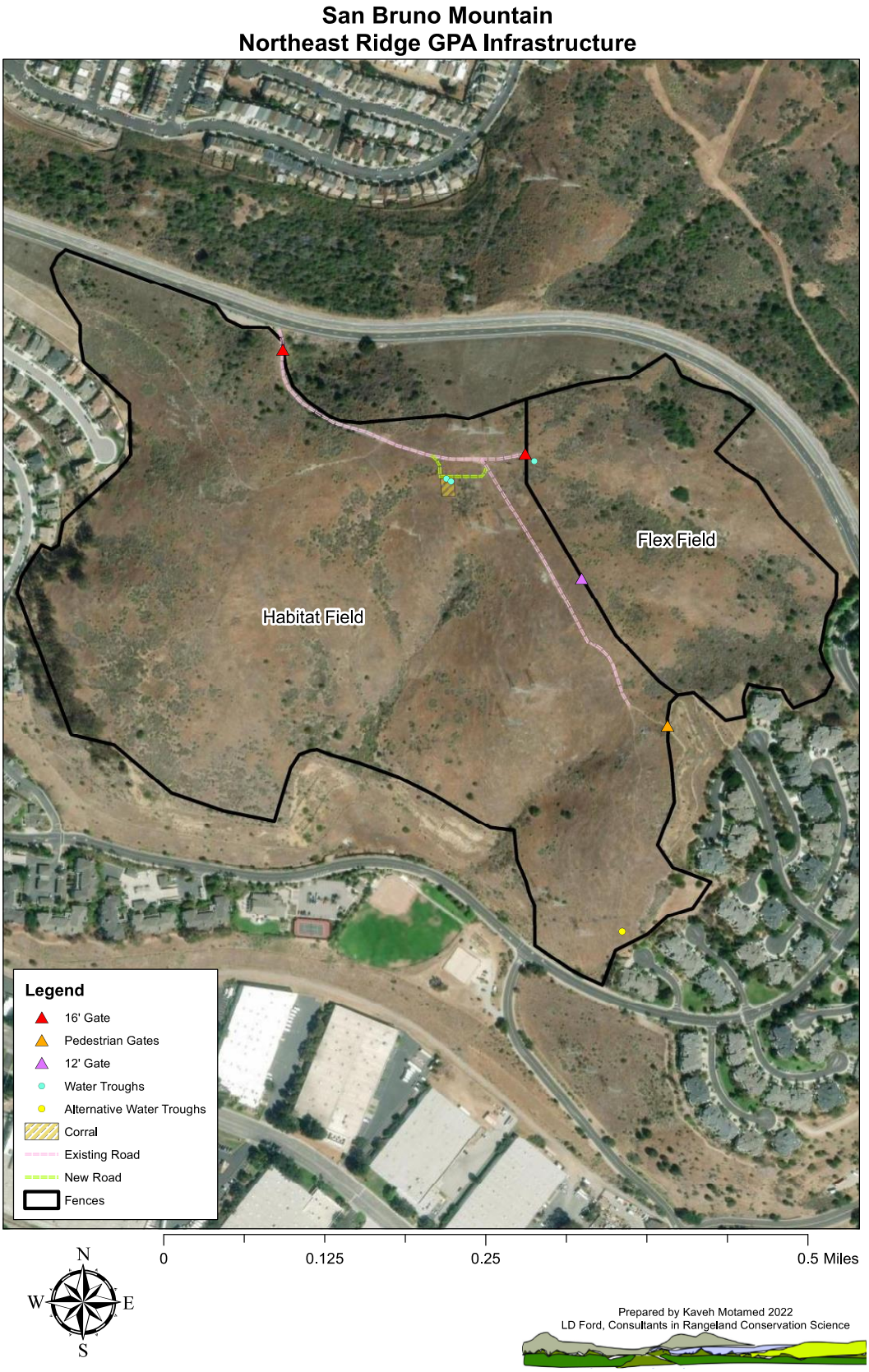

Figure 11. Existing and required infrastructure in the Northeast Ridge.

Roads

Roads are important for providing access for the installation and maintenance of infrastructure, as well as access for the grazing operator to unload and load livestock, check on livestock, and provide resources for livestock: supplemental feed, nutrients, vaccinations, and veterinary exams. Given the small size of each of the PGAs, an extensive road system is not required to provide access to remote areas of each PGA. Once onsite, access across the PGA can be achieved on foot, horse, or ATV (if allowed by SMCPD). Below is a description of the current condition and extent of roads, and a description of critical areas to access with roads. Road design and engineering specifications should be provided by SMCPD engineers or by a reputable agency like the NRCS.

Southeast Slope. There are two unpaved roads that access the Southeast Slope PGA. The first is through a gate off of Bayshore Blvd. in the low-elevation portion of the PGA in the flexible use field. The second is via the Ridge Trail, which can be accessed via a road that runs along the ridge east of Buckeye Canyon and connects to Quarry Road on the north side of San Bruno Mountain. There are no roads that connect the lower portion of this PGA to the ridge, and the terrain makes it difficult to do so. Luckily, there is no reason that a road needs to connect from Bayshore Blvd. to the ridge. A truck turnaround will need to be constructed in the lower portion of the PGA. The turnaround location will depend on the corral location; we recommend utilizing existing roads as much as possible. A turnaround may not be necessary on the ridge since the ridge is not an ideal place to load or unload livestock. Truck access to this area would be for accessing livestock, conducting infrastructure maintenance, or supervising grazing operations.

The gate onto Bayshore Blvd. is approximately 16 feet wide which is suitable to provide access to the grazing area. There is a narrow turnout from Bayshore Blvd. through a 20-foot-wide opening in the curb that runs along Bayshore Blvd. This curb will make access for the grazing operator somewhat difficult to the gate if left this way, and it only allows about 50 feet between the gate and the road. Ideally, there would be at least 60 feet (to allow for a truck plus a 20-foot trailer) between the gate and the road edge. In this case, the fix is fairly simple: by grinding the curb down north of the entry road and creating a turnout in this area, there will be ample space to turn out and get off the road. If possible, creating a similar turnout on the south side of the entry road will make exiting the PGA safer and easier.

Northeast Ridge. There is one unpaved road that accesses the Northeast Ridge PGA (Figure 11). This road can be accessed via a gate on Guadalupe Canyon Pkwy on the north side of the PGA. The road is currently 10 feet wide, with shrubs encroaching on either side. The width and condition of this road should be evaluated by potential grazing operators to determine their needs for accessing the site. It will likely need to be widened to 12 feet (which may be achieved by cutting back the encroaching shrubs). A small section of new road will need to be constructed to provide a truck turnaround at the top of the ridge and access to the corral (Figure 11).

Some modifications to the entryway and road from Guadalupe Canyon Pkwy. will be needed to make ingress and egress safer and easier for the livestock operator (Figure 11). The gate onto Guadalupe Canyon Pkwy. should be replaced with a 16-foot-wide gate that is installed at least 60 feet from the road to allow space for a full-sized truck with a 20-foot cattle trailer. The cyclone fence that runs along Guadalupe Canyon Pkwy. should be pulled back at least 15 feet (away

from Guadalupe Canyon Pkwy.) to make a turnout for an eastbound truck on Guadalupe Canyon Pkwy. West of the gate, along Guadalupe Canyon Pkwy., a steel guardrail runs along the road. In this area, the guardrail should be pulled back at least 10 feet from the entry road to create a smoother ingress/egress to the east. These modifications may require filling or re-grading the road substrate to make a drivable surface.

Watering system

Water availability is critical to supporting ranching activities, and the placement of water troughs greatly influences the distribution of livestock. Each grazing field and the corrals will need water access. In habitat fields, water trough placement should be used to encourage grazing use of habitat areas, particularly along ridges.

All troughs will be installed with shut-off valves. Additionally, troughs will be installed with wildlife escape ramps and gravel or similarly protective pads. Appendix B provides guidance on installing wildlife escape ramps. Below are recommendations for where to site water troughs in the two PGAs, but the final siting of these features will occur after review and discussion by the parties implementing this grazing strategy and may be influenced by the cost and feasibility of conveying water and installing infrastructure.

Water troughs will be fed using municipal water, accessed at the perimeter of the PGAs. The exact location and type of hook-ups will depend on review of engineering specifications by SMCPD staff and by coordination with cooperating water districts.

Southeast Slope. In the Southeast Slope, a total of four water troughs will be necessary to provide water to the flexible-use and habitat fields. The habitat field will have two troughs. The first trough should be on the ridge to encourage livestock to go to the top of the ridge and consume forage there. Figure 10 recommends a location for this trough that minimizes impacts to native-rich grasslands and to potential monitoring plots. This is also a location that is easily accessed by vehicle via “Ridge Trail”. This trough location is centrally-located on the ridge in the PGA, meaning it will likely support grazing along much of the butterfly and host plant habitat areas. Options for providing water to this trough include using a municipal hook up from the neighborhood roads north of the PGA (e.g., Harold, Annis, or Humboldt Roads), or using a hook up on the south side of the PGA (e.g., Tower Place). It may make sense to source water for the trough on the ridge from the neighborhoods to the south and source water for the lower-elevation troughs using water from Tower Place. Wherever water is sourced from, it will be a challenge to move the water to the top of the hill. If water comes from Tower Place, it will need to be pumped more than 600 feet uphill. From the neighborhoods north of the PGA it will likely need to be pumped about 400 feet uphill. One approach is to create a “false well” using a well pump in a water tank. The type and design of this system will be left up to SMCPD. The second water trough in the habitat field should be along the fence to the flexible use field (Figure 10). This trough location will provide water to livestock in the lower-elevation portions and of the PGA. By turning off water to the upper trough and leaving water to this lower trough on, livestock will be encouraged to use the lower slopes of the PGA. Similarly, by turning this trough off and leaving the one on at the top of the ridge, livestock will be encouraged to use the ridge more (and increase grazing pressure in the prime butterfly habitat areas).

The flexible-use field will have two troughs (Figure 10). The first will be a trough on the flexible-use fence that is adjacent to a trough in the habitat field. The second is a trough in the corral. There is a historic circular cement water trough in this field. We do not recommend reusing this trough. The age and quality of the trough are unknown, so it may not be as reliable as a new trough.

Northeast Ridge. In the Northeast Ridge a total of three watering troughs will be necessary to provide water to the flexible-use and habitat fields. These troughs can be fed by a single water hook-up since they will be close to each other. The habitat field trough will be on the outside of the corral and will be paired with a trough on the inside of the corral (Figure 11). This trough is on the ridge, in a flat area that is accessible by road. The trough's location will encourage use of the higher-elevation areas along the ridge in prime butterfly habitat.

The flexible use field watering trough will be along the west fence-line of the flexible-use field. This area is easily accessible by road and minimizes additional trenching required from the habitat field trough location.

Corrals, Loading Areas, and Operator Access

Each PGA will need a corral (Figure 10 and Figure 11). Corrals are critical for loading cattle onto trailers, and depending on the type of livestock operation, they may also be used for branding, vaccinations, health inspections, or other purposes. Temporary corrals may be an option if the grazing operator has the required equipment and is willing to use it; however, providing well-designed permanent corrals will lessen the burden on the grazing operator and may make the site more attractive to prospective graziers. We recommend constructing a corral with at least two pens and an alley in each PGA. This allows the rancher to hold, sort, and load cattle onto their trailer. Holding pens should be at least 30x30 feet. A 12-feet-wide alley that narrows to nine feet for the load out works for many trailers. A watering trough must be available at the corrals too. Ideally the design specifications of the corral will be approved by the selected grazing operator prior to construction, however the timeline may require that SMCPD builds corrals before a grazing operator is chosen. In this case, we recommend contacting James Howard, District Conservationist San Mateo County with the NRCS to discuss specific design specifications. The recommendations for corral placement in Figure 10 and Figure 11 do not conflict with any known resources (e.g., wetlands, sensitive species, cultural resources, or existing infrastructure), however these locations should be approved by SMCPD before siting the corrals.

Section 6. Grazing Lease/Agreement

Because the PGAs will support only a small number of livestock, grazing in this area is unlikely to be attractive to a typical commercial livestock producer. In addition, there are no neighboring ranches nor even many people grazing livestock on the eastern portion of the San Francisco Peninsula who could easily access the site. A lessee will therefore likely need to travel a long distance through Bay Area traffic to conduct operations at the site for what amounts to a very small economic benefit.

The PGAs' small sizes, targeted grazing requirements, isolated locations, and the risks that arise from the initiation of grazing in a park that has not been grazed for decades, all potentially increase the grazier's per-acre operational time and expense requirements. Therefore, we recommend the grazing lease be viewed as a conservation service provided by the grazier rather than a typical grazing lease or license. If the grazier will pay for the lease (or license or contract), the agreement can follow the model of a Market Rate Based on Qualifications or Discount for Stewardship (Barry et al. 2020). This model allows the lessor to select a grazing operator based on their qualifications for performing stewardship activities (more like a partnership with SMCPD), rather than on price. It is very likely that a no-fee lease or even payment for grazing services will be required to attract qualified applicants in this case. Providing flexibility in the terms of the grazing lease, including flexible dates of the grazing period, may also increase the pool of potential lessees. Collectively these measures would likely increase the number and quality of applicants and incentivize cooperation to meet conservation and other stewardship objectives.

Section 7. Monitoring and Adaptive Management

Adaptive Management

Adaptive management is the process whereby management is initiated, evaluated, and refined (Holling 1978). The formal adaptive management process, as shown in Figure 12, consists of a six-step cycle that is a useful framework for meeting the management goals outlined in Table 3.

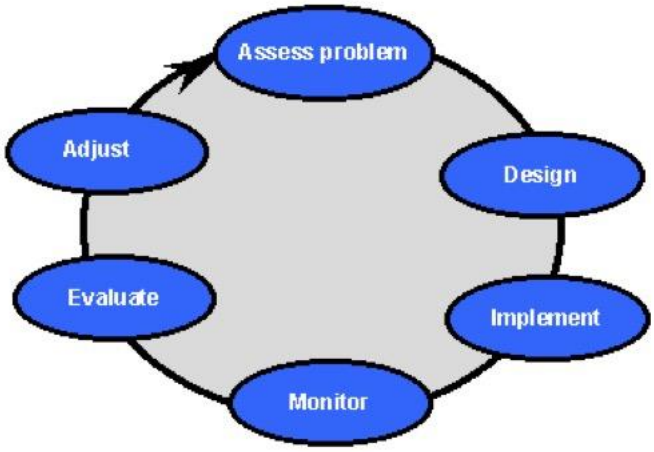

Figure 12. The Adaptive Management Cycle

Figure 12 illustrates the six steps of adaptive management. These steps should be applied to this grazing strategy as follows:

1. *Assess Problem.* In the case of this grazing strategy, the core problem is sensitive butterfly populations need habitat enhancement on San Bruno Mountain.

2. *Design.* This step was accomplished in preparing this grazing strategy. The problems are defined in *Section 3 Goals and Objectives* and the strategy is detailed in *Section 4 Grazing Strategy*.

3. *Implement.* The installation of infrastructure and implementation of the grazing program will accomplish this phase.

4. *Monitor.* Monitoring will follow the program outlined in this document and in any subsequent documents prepared by SMCPD. Monitoring will be conducted at least twice annually (spring and fall) to determine compliance with the performance standards in Table 3.

5. *Evaluate.* Information gathered through monitoring will be used to determine if the prescribed methods are effectively meeting the primary goals and objectives in Table 3. This evaluation can also include an assessment of whether the performance standards are appropriate for the study goals.

6. *Adjust.* Information gained in steps 4 and 5 will be used to evaluate and update, as necessary, this grazing strategy and performance standards to improve the management methods and results.

The first few years will be especially key for adaptive management, because the grazing program and lessee will be new, and adjustments will likely need to be made to management practices to meet performance standards. Particular effort should be made during this time to implement adaptive management and record any lessons learned and appropriate adjustments to the provisions of this grazing strategy, especially regarding butterfly habitat quality. However, adaptive management should continue to be implemented throughout the entire pilot study to adapt grazing practices to variable weather conditions and evolving information about management – habitat relationships.

Monitoring

There are two types of monitoring necessary to support this grazing pilot program. The first is *effectiveness monitoring*. The purpose of effectiveness monitoring is to determine whether the goals and objectives of the grazing program are effectively being achieved by the specific management actions. An example of this type of monitoring would be spring surveys to identify the response of host plants to grazing management.

The second type of monitoring is *compliance monitoring*. The goals of compliance monitoring are to verify that the livestock operator complies with the terms of the livestock lease and any other relevant standards or regulations. An example of compliance monitoring is reviewing annual stocking logs submitted by the livestock operator.

Effectiveness Monitoring

Effectiveness monitoring generates information about whether the goals and objectives of the grazing program are being achieved by the management actions taken. Table 3 includes a list of goals for this grazing program pertaining to butterfly habitat quality, native and sensitive species

habitat maintenance, rangeland health, fire fuels reduction, shrub encroachment, and feasibility of the grazing operation; and lists associated objectives and performance standards. The purpose of effectiveness monitoring is to evaluate the condition of these performance standards and determine whether their associated goals and objectives are being met. In some cases, a monitoring metric may be both an effectiveness and compliance metric. This occurs when a performance standard (e.g., residual dry matter [RDM]) is related to the study goals and is also included as a term in the grazing agreement. For these cases, we will describe the monitoring metrics here in the effectiveness monitoring section.

Vegetation Structure Monitoring

Vegetation structure monitoring will occur in two time periods. Spring monitoring will occur in the late spring and early summer and will evaluate whether the grazing program is having the desired effects on plant species composition, biomass, and obstruction height. Fall monitoring will consist of RDM sampling and mapping to ensure that the grazing program is resulting in the desired reduction of residual herbaceous biomass, while still leaving adequate cover to protect the soil. It will also include vegetation height mapping. These monitoring methods will evaluate the effectiveness of grazing in maintaining butterfly habitat as recommended in Goal 1, maintenance of rangeland health as recommended in Goal 2 and reduction of fire fuels as recommended in Goal 5.

RDM Monitoring. RDM monitoring should be conducted annually in the fall before the rainy season begins as described in Bartolome et al. (2006). Minimum and maximum RDM standards for the two PGAs are reported in Table 3 (PS1c) and in *Section 3 Grazing Strategy*.

RDM sampling is a point-based approach to measuring RDM. This method provides a measured sample of RDM at a point on the landscape. It can be highly precise, yielding continuous, quantitative RDM measurements. However, the ultimate accuracy of this method is determined by the location of the plots and the skill of the observer. Thus, locating representative sample locations is important. Two methods of doing this are: 1) a "key area" approach where locations are selected because they represent broad or important features of the landscape, or 2) randomly-located samples. Although randomly-located samples can provide unbiased estimates of RDM for a given management unit, the inherent variability of RDM at the ranch scale (Ratcliff et al. 2022) means that a large number of samples are required to get reasonably accurate estimates when taking random samples. Therefore, a key-area approach should be used to efficiently monitor RDM at key locations in the PGAs.

At the RDM monitoring sites, samples can themselves be representatively- or randomly-selected. Representative clipping means that the observer chooses a sampling location that represents average conditions within the key area (typically 10-15 meters from the sampling point) and takes the RDM sample from that location. This approach cuts down on the need to collect numerous random samples at each sampling location to generate an accurate estimate. Between 10-15 sampling locations in each PGA will provide ample RDM monitoring in these small areas, with much higher resolution than is typically used for RDM monitoring. This sampling resolution is desirable for determining patterns of grazing use and resulting habitat conditions, especially given the hilly terrain and potential for heterogenous livestock distribution. These sample locations will include (but not be limited to) the host plant study plots described below.

The methods for conducting RDM sampling are consistent with Bartolome et al. (2006). They consist of the following steps:

1) Establish a fixed monitoring location for repeated measurements between years.
2) Go to the monitoring site in September or October (ideally just before the first significant rains).
3) Clip all herbaceous biomass within a quadrat of known size (often a 0.96 ft^2 hoop).
    a. Exclude summer annual plants, woody plants, and leaves from woody plants from the sample.
4) Put the RDM sample in a paper bag and label the bag with the plot number.
5) Dry the sample. Air dry is OK, but a drying oven provides a more accurate value. If air-drying, make sure the sample doesn't mold.
6) Weigh the sample. If using a 0.96 ft^2 hoop, then 1 gram of sample weight = 100 lbs/acre of RDM.
7) Record data in a format where comparisons can be made between locations and years (e.g., an Excel spreadsheet).

RDM Mapping. While conducting RDM sampling, another RDM monitoring approach called RDM Mapping should simultaneously be performed. In this approach, categories of RDM are visually estimated in a spatially-continuous manner on the landscape and recorded on a map. To create each year's RDM map, the monitor(s) will visually estimate RDM and divide the PGAs into map polygons that generally fall within one performance-based RDM category (i.e., "Meets RDM minimum standard"). Visual estimation will be "calibrated" by RDM clipping at the reference sites and additional clips as needed. A minimum map unit (MMU) will need to be established before mapping begins, typically 2.5 or 5 acres are used. We recommend a 2.5-acre MMU since the butterfly habitat areas occur as relatively small patches within the PGAs. RDM conditions within polygons do not need to be uniform, especially if the anomalous patches are too small to address with management. Further description of this method and a photo guide to aid in RDM estimation can be found in Guenther and Hayes (2008).

We recommend three RDM mapping categories based on the performance standards in (Table 3):

- Below RDM minimum standard (<800 lbs/acre)
- Meets RDM minimum standard and below RDM maximum target (800 – 2500 lbs/acre)
- Exceeds RDM maximum target (>2500 lbs/acre)

Obstruction Height

Obstruction height is a combined measure of vegetation height and visual density of vegetation that will be conducted in the PGAs annually in early June after peak standing crop. In this method, a robel pole is placed vertically at the sample location. The observer moves 20 feet from the poll and brings their eye down to the height at which vegetation visually obstructs 80% of the corresponding height of the poll. From this position they look at the poll and determine the highest 1-inch interval that is 80% obstructed by vegetation. This measurement is repeated at the four cardinal directions for each plot and each individual value is recorded. Obstruction height

will be measured at the vegetation composition plots (both inside and outside exclosures) and at the other RDM measurement locations.

Plant Species Composition

Several of the goals of this project relate to changes in plant species composition. The primary goal includes objectives to increase host and nectar plant number and cover in the PGAs. Goal 2 includes an objective to increase native plant cover and Goal 3 would minimize the impacts of invasive plants. All of these goals relate to changes in species composition as a result of grazing impacts. RDM and vegetation obstruction measure changes in the physical structure of vegetation, which tell us whether grazing was able to create the desired habitat conditions for plants; in contrast, plant species composition monitoring will tell us whether those conditions resulted in the desired changes to host and nectar plants, or to native and invasive plants.

In order to evaluate the effects of grazing in the habitat fields, four to five grazing exclosures will be installed in each PGA. Although Viola and lupine habitats are not mutually exclusive, we recommend including three to four exclosures sited specifically in *Viola pedunculata* habitat, and one or two exclosures sited specifically in *Lupinus sp.* habitat (Figure 13 & Figure 14). The viola exclosures will be positioned to capture a variety of landscape positions and population statuses. Lupines are less widespread in the PGAs and the exclosures will therefore be positioned in areas with fairly robust lupine populations that are large enough for sampling. The exclosures will be 12x12-meters, which is large enough to include a 9x9-meter relevé (see below), while leaving a 1.5-meter-wide buffer between the fence and the edge of the relevé.

Species composition monitoring will focus on the exclosures and consist of paired sampling plots – one inside and one outside the exclosure for a total of eight to ten plots (four to five pairs). A before-after-control-impact (BACI) study design will sample the paired locations before grazing commences, and then for each year of the pilot grazing program. By comparing species composition before and after grazing begins in grazed and ungrazed locations, this approach will be able to determine whether species composition in grazed plots and ungrazed plots fluctuates similarly between years, or whether species abundance and cover changes differently between treatments over time (known as in statistics as an “interaction” of independent variables). If grazed and ungrazed plots show different trajectories over time, it provides evidence that grazing caused the change. This type of approach is important when studying management treatments in California grasslands where species composition can dramatically fluctuate in response to weather conditions.

The sampling design for the *Viola pedunculata* plots will be based on a modified relevé with frequency transects crossing it. The relevé is a 9x9-meter square that captures species richness on the plot and provides a visual estimate of all species cover. This is very similar in size to the relevé used in the CNPS vegetation assessment protocol (CNPS 2019) and will allow for comparisons of species richness and vegetation classification between the CNPS system and the samples in the PGAs. Following the CNPS (2019) method, visual estimation of species cover will fall into one of the following categories: <1%, 1-5%, >5-15%, >15-25%, >25-50%, >50-75%, >75%.

The frequency transects will provide an objective measure of cover and abundance of target species which can be analyzed using binomial statistics and used for testing the statistical significance of change over time. Using quadrats to determine frequency increases the chance that a binomial sample will yield frequency percent values in the optimal 20-80% range (Despain, Ogden, and Smith 1991). Five transects will cross the relevé, each consisting of 10 samples, for a total of 50 frequency samples. In this protocol, a 0.25-m^2 quadrat is placed every 0.9 meters along the transect. Any target species rooted in this quadrat is recorded. Target species include butterfly host and nectar plants (Table 1), and priority invasive species (Table 2). More species can be added to the target plant list, but it will increase the time it takes to perform the sampling. A "point" sample will record any species touching a pin dropped at the beginning of the 0.9-meter interval (Figure 15).

The sampling design for the *Lupinus sp.* plots will be similar to the *Viola pedunculata* plots but will not include frequency or point sampling. A relevé will be performed using an ocular estimation of cover, in the same way it is done for the *Viola* plots. The lupine species are relatively easy to count, and instead of using frequency, a count of total lupine plants (separate counts for different lupine species) will be made. Change over time between treatment and control plots will then be evaluated using a chi-squared contingency table.

Soils and Other Site Factors

While we do not predict major impacts to soils in the PGAs from the pilot grazing program, measuring the physical and chemical attributes of soils at the study plot can greatly improve our interpretation of grazing treatment effects. We recommend collecting one composite soil sample (consisting of four soil cores) at each paired study location to evaluate soil nutrients, texture, and depth to restrictive features. Soil samples in California annual grasslands are often collected from 0-15 cm deep (after removing organic material from the soil surface).

In addition to collecting soils, other physical site factors should be recorded, including slope, aspect, and elevation. This information will provide context on where grazing treatments seem to have the largest effect, what soil and other site factors are most related to presence and abundance of host and nectar plants in the PGAs, and whether any interactions between site conditions and grazing exist.

Additional Effectiveness Monitoring Methods

Weeds. Priority weed species (Table 2) should be monitored for throughout the grazing areas during the course of other monitoring activities (in spring and fall). Special attention should be given to supplemental feed areas, roads, areas around water troughs and corrals, trailheads and staging areas, and areas within and around existing infestations. Early detection and rapid response are critical for effective weed management. If new infestations of priority weeds are noted, they should be documented via photograph and GPS, and the results should quickly be given to SMCPD.

Wildlife Camera Traps. Several wildlife species use the PGAs. An optional monitoring technique that could be used to determine whether wildlife use of the PGAs is altered by the introduction of grazing would be to install camera traps in strategic locations to document

wildlife species, timing of use, and patterns of spatial distribution. Before doing this, consider whether SMCPD has the staff availability (or public interest) to review photographs or videos collected by the cameras.

Photo Points and Qualitative Monitoring. In addition to the plot-based monitoring proposed above, we recommend using qualitative techniques, including photo points and written descriptions, to document conditions across large portions of the PGAs and in surrounding areas where grazing was not reintroduced. These methods provide an efficient way of showing effects over larger areas and may document changes that were not captured in the study plots. Photo plots should be performed at the same locations each year, taken facing the same direction. Taking photographs during the course of spring and fall monitoring will create a valuable record of field conditions at important times of year. Phone apps like *Solocator* allow you to label photos in the field and document the direction a photo was taken.

Mission Blue Butterfly Egg Counts. Egg counts are a very good method for determining Mission blue butterfly abundance. A single standardized egg survey performed just after peak flight, will provide a good comparison between the paired lupine plots.

Additional Monitoring Plots. If time and resources allow, additional monitoring plots may be added to the PGAs to assess grazing impacts. In particular, one additional paired lupine plot (with exclosure) may be added to each PGA to better assess grazing effects on lupines in the PGAs. The location of additional lupine plots is not noted in Figures 13 and 14. If additional lupine plots are desired, they should be sited in areas with an abundance of lupines during the spring when lupines are easily identifiable.

Another opportunity for adding monitoring plots is to add an additional set of paired monitoring plots inside and outside of the Siplichiquin Shellmound Grazing Exclosure in the low-elevation portion of the Southeast Slope PGA (Figure 13). This is not considered primary habitat for butterfly hostplants; however, the grazing exclosure provides an opportunity to compare grazed and ungrazed grasslands to better understand changes in grassland composition and structure due to the reintroduction of grazing. Before installing monitoring plots in this area, it is important to consult with the County to ensure that monitoring activities will not have a negative impact on cultural resources. If an additional plot cannot be added here, this area could be a good location to put a photo monitoring point.

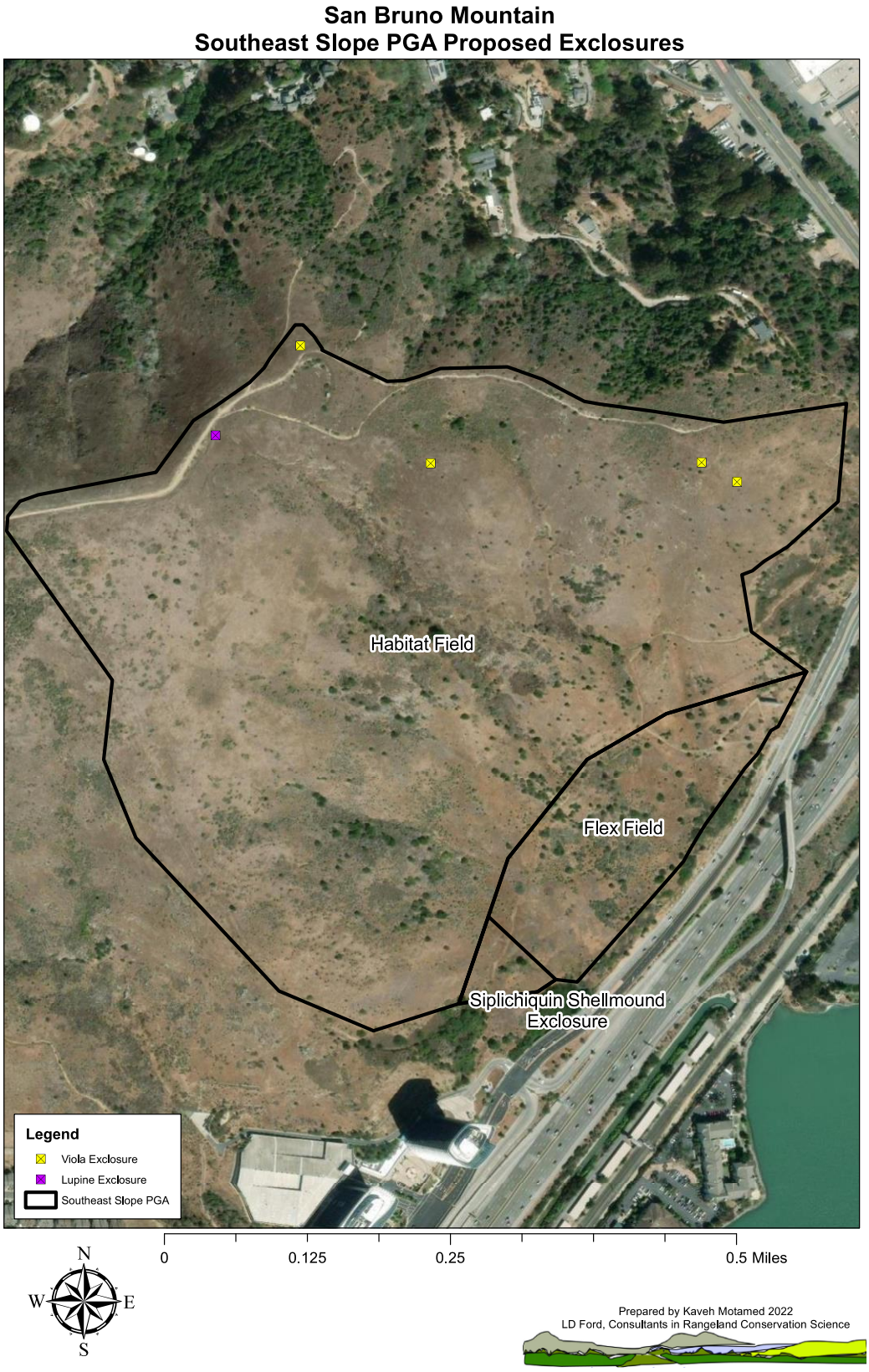

Figure 13. Grazing exclosures for monitoring in the Southeast Slope Pilot Grazing Area.

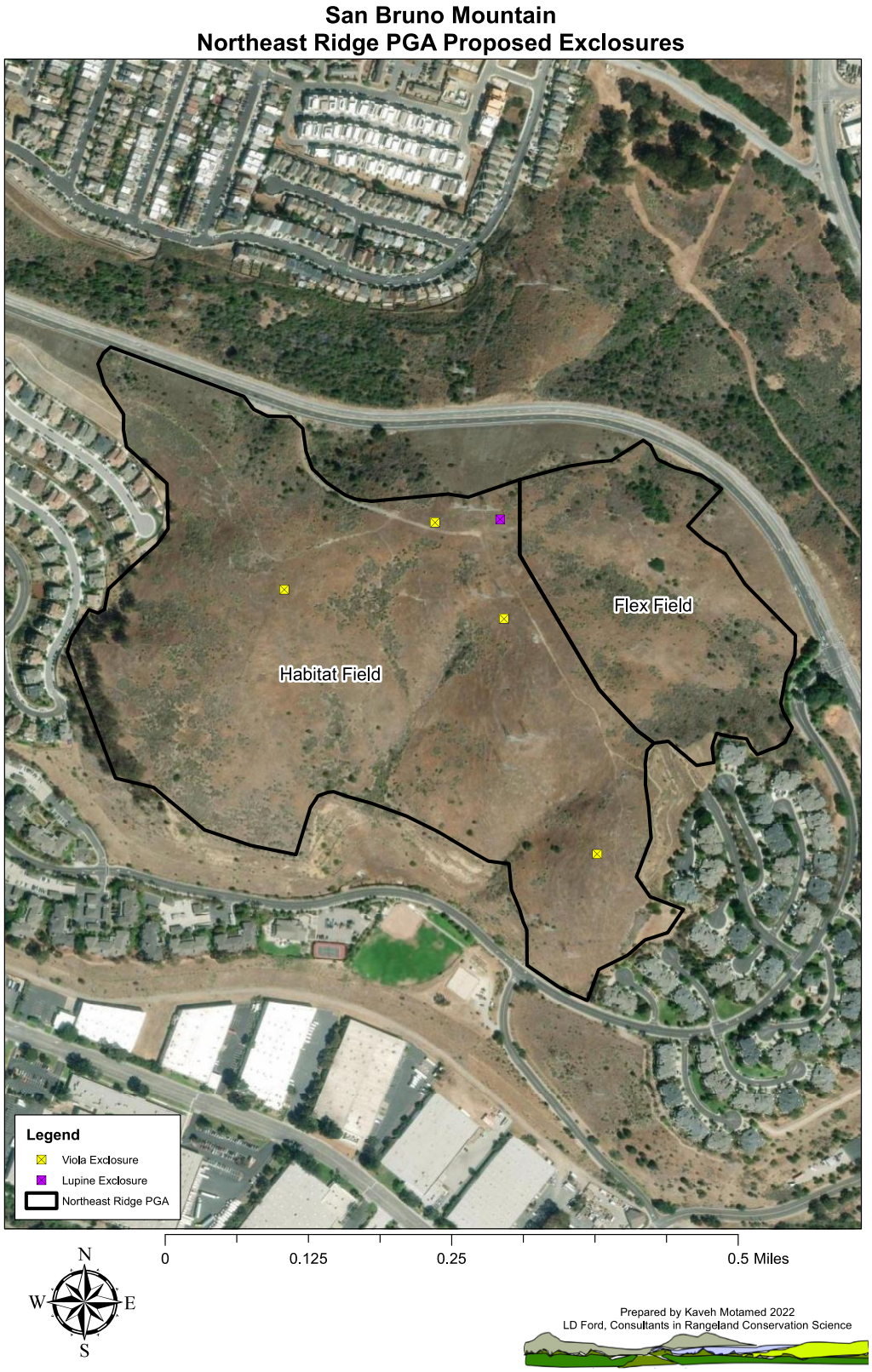

Figure 14. Grazing exclosures for monitoring in the Northeast Ridge Pilot Grazing Area.

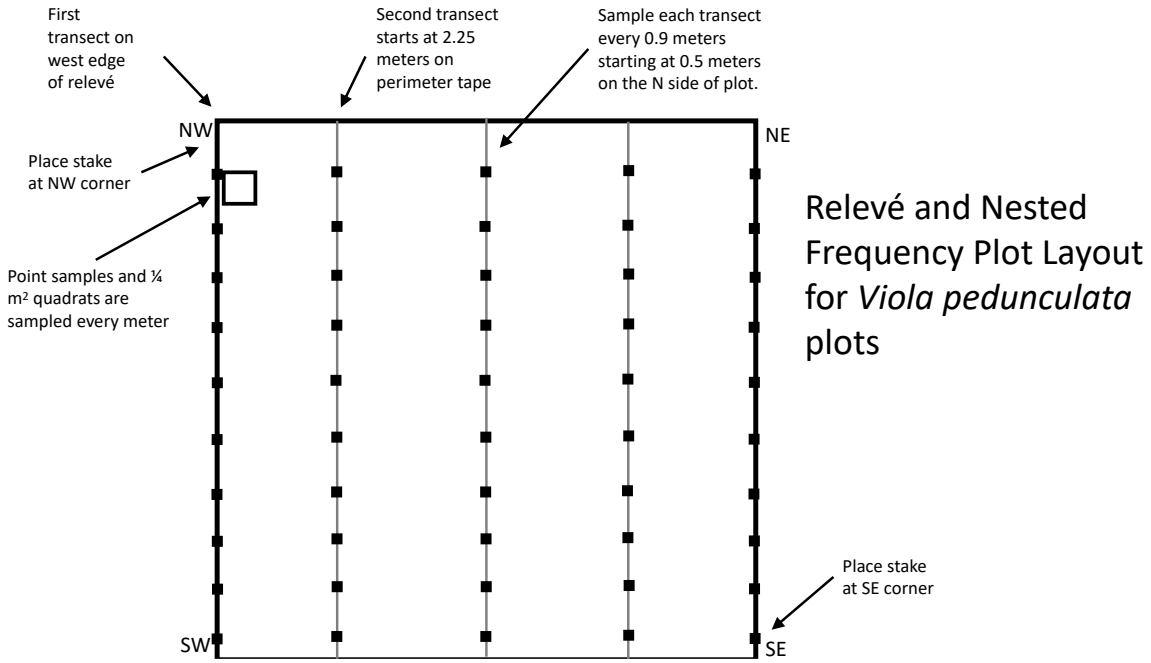

Figure 15. Relevé and Frequency Plot Layout for *Viola pedunculata* Plots

Compliance Monitoring

Compliance monitoring will be conducted by the SMCPD or their designated agent. It will be conducted to ensure that the grazing operation is being conducted consistent with the requirements and recommendations in this grazing strategy and the terms of the grazing lease agreement. RDM and spring forage height may be included as terms in the grazing lease, in which case these measurements count as both effectiveness and compliance metrics. Compliance monitoring should also include information from grazing logs: stocking rates, grazing period, cattle movement records. It should also include condition of the lease: trash, trespass, and infrastructure condition. Records of actual stocking rates, grazing periods, and moving stock between fields should be kept by the grazing operator so that resource responses to grazing levels can be accurately tracked and adjusted if needed. The latter monitoring items could be part of a checklist for the grazing operator to monitor and report.

Frequent communication between SMCPD and the grazing operator is important to ensure that SMCPD is aware of ongoing grazing activities and future plans and is alerted to any issues that require immediate attention. Communication during the grazing season will also help the grazing operator adapt their management to meet performance standards. In addition to free communication during the grazing season, an annual meeting between the grazing operator and SMCPD will take place in November or December when the grazing operator is making decisions about the upcoming grazing period. At this meeting, relevant monitoring information and adjustments to grazing practices may be discussed if warranted. The grazing operator will also report relevant information from the past year, including information about stocking rates, timing, and distribution of livestock, updates on infrastructure condition or repairs, and considerations for the upcoming grazing period. This is an opportunity to discuss what is working well for the lessee and SMCPD, and what can be improved in the coming year.

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Appendices

Appendix A

Grazing Capacity and Stocking Rate Calculations for the Southeast Slope and Northeast Ridge Pilot Grazing Areas

To estimate grazing capacity, we first need to estimate total forage production and total available forage. We can estimate forage production as the product of the **productivity** of each pilot grazing area (expressed in **pounds per acre [lbs/acre]** of forage produced) times the **total acres** of productive or grazeable land in each pilot grazing area.

Estimating Forage Production

There are several ways to arrive at productivity estimates, which may be used independently or combined. One method is to use the USDA/NRCS forage production estimates for the mapped soil types in the area of interest. However, the USDA/NRCS does not have forage production estimates for the soil map units occurring in the two pilot grazing areas (PGAs). Another option is to use recent advances in remote sensing methods, which make forage production estimates based on satellite imagery. This approach is still being developed, although several approaches are either available or in development. Established metrics (such as NDVI) are known to be correlated with annual above ground net primary productivity, however the accuracy of this approach for estimating forage production in California is not yet well established. A third option is to measure production at the site and use expert opinion to infer how production may vary spatially and across different years. A fourth option is to use current or historic stocking rates (and resulting habitat conditions) to determine how much grazing a site should have. However, we do not have access to this information for the PGAs.

Given the available options, the production estimates below are based on a combination of forage production values measured in the PGAs in 2020 by LDFord (Ratcliff and Ford 2020) and the remote sensing production application called the Rangeland Analysis Platform (RAP). RAP produces annual forage production estimates at 30-meter resolution from a combination of NDVI, vegetation type, and weather data. At the time of writing, it produces estimates from 2001 – 2021 for the PGAs. RAP is not meant to be used alone, but rather should be used in combination with on-the-ground data and expert opinion (Allred et al. 2021). This is well-suited to our needs because we can compare the RAP production estimates to the clipped estimates from 2020 to ground truth its accuracy in the PGAs, then we can use RAP's time series data to get an idea of the variation in production across years with different weather (and production) patterns.

Estimating Available Forage

After estimating production, we need to determine what fraction of the produced forage is available for cattle to consume. The best way to do this is to work back from the residual dry matter standards. The Grazing Strategy recommends using a minimum RDM standard of 800 lbs/acre on slopes <40% and 1200 lbs/acre on slopes >40%. If grazing is seasonal and is intended to generally occur in the winter and spring months, then we must also take summer decomposition of forage into account. Between peak standing crop (generally in May or June) and the onset of fall rains, an average of 8.6% of forage disappears monthly (43% disappears over 5 months) due to weathering in the Central Coast of California (Larsen et al. 2021). Thus, if

trying to leave enough forage in May to be able to achieve the RDM standard of 800 lbs/acre in October, you would need to leave 1400 lbs/acre at the time of peak standing crop on average. If 2400 lbs/acre of forage are produced then the available forage per acre would be 1000 lbs/acre. We can then convert this lbs/acre estimate to a total **Available Forage** estimate by multiplying it by the total acres on which the forage is produced. If 50 acres fall into this forage production category, then the total available forage is 50,000 lbs.

Grazing Capacity

Grazing capacity is expressed in **Animal Unit Months (AUMs).** An AUM is the amount of forage consumed in a month by a 1000-lb cow with or without an unweaned calf (NRCS 2003) and is usually considered to be 1000 lbs of forage in California (Bush 2006). Thus, we can convert pounds of available forage to AUMs by dividing by 1000 lbs (e.g., 50,000 lbs of available forage = 50 AUMs).

Stocking Rates

Stocking rates are expressed as a combination of the following factors:

1. The kind of animal used for grazing
2. The number of animals used, converted into Animal Units (AUs). Animal Units are defined as "one mature cow of approximately 1,000 pounds and a calf up to weaning, usually 6 months of age, or their equivalent" (NRCS 2003). All other kinds and classes of livestock can be converted to animal units by using Animal Unit Equivalents (Table A1.1).
3. The length of time grazing occurs
4. The acreage grazed by the livestock

Table A1.1 Animal unit equivalents (AUEs).

Animal Species	Animal Unit Equivalent
Cow, dry	.92
Cow, with calf	1.00
Bull, mature	1.35
Cattle, one-year-old	.60
Cattle, two-year-old	.80
Horse, mature	1.25
Sheep, mature	0.2
Goat, mature	0.15

(Adapted from National Range and Pasture Handbook, NRCS 2003)

Southeast Slope

Total area
The Southeast Slope grazing area is approximately 115 acres (Table 1). Of this, approximately 20 acres is not expected to produce grazeable (or accessible) forage. This is either because the area is too steep or because it has dense shrub vegetation. This results in approximately 95.5 acres of productive grassland that forms the basis for the following grazing capacity calculation.

Table A1.2. Grazeable and ungrazeable acres in the habitat and flexible-use fields at the Southeast Slope Pilot Grazing Area.

Grazing Area	Habitat/Flex Field	Cover Type	Acres
SE Slope	Habitat	Shrub	11.66
SE Slope	Habitat	Steep Slope	13.70
SE Slope	Habitat	Total Ungrazeable	17.56
SE Slope	Habitat	Total Grazeable	84.88
SE Slope	Habitat	Total	102.44
SE Slope	Flex	Shrub	2.34
SE Slope	Flex	Steep Slope	0
SE Slope	Flex	Total Ungrazeable	2.34
SE Slope	Flex	Total Grazeable	10.63
SE Slope	Flex	Total	12.97
SE Slope	**ALL**	**Total Grazeable**	**95.50**
SE Slope	**ALL**	**Total**	**115.41**

Average Production
Average forage production measured in the SE Slope in 2020 was 3100 lbs/acre (Ratcliff and Ford 2020).

The 2020 LDFord forage production number is very close to the estimated production in the SE Slope from the Rangeland Analysis Platform in 2020 (2899 lbs/acre). This close correspondence in estimates suggests that the RAP estimates are reasonably accurate for SE Slope.

20-year time series in RAP data
The 20-year time series of data from RAP suggests that forage production since 2001 has been as high as 3813 lbs/acre, and as low as 2800 lbs/acre. If we use 2020 to calibrate these numbers, we get the following conversion factor which we can apply to the RAP data to show estimate forage production between 2001 – 2021:

$$RAP\ Conversion\ Factor_{SE\ Slope} = \frac{Measured\ Production\ (2020)}{RAP\ Production\ (2020)} = \frac{3100}{2899} = 1.07$$

Table A1.3. Rangeland Analysis Platform (RAP) forage production estimates for the SE Slope and a converted estimate using the 2020 measured production values (Ratcliff and Ford 2020).

Year	Annual production (lbs/acre) (From RAP)	Adjusted production (Using Conversion Factor)
2001	3184	3405
2002	3305	3534
2003	3355	3588
2004	3526	3770
2005	3752	4012
2006	3813	4077
2007	3553	3799
2008	3379	3613
2009	3234	3458
2010	2899	3100
2011	3132	3349
2012	2905	3106
2013	3033	3243
2014	3020	3229
2015	3012	3221
2016	3178	3398
2017	2840	3037
2018	3202	3424
2019	3160	3379
2020	3165	3384
2021	2800	2994
Average	**3212**	**3434**
Minimum	**2800**	**2994**
Maximum	**3813**	**4077**

Based on the calibrated RAP estimates, the average forage production between 2001 – 2021 was 3434 lbs/acre. The lowest production estimate was 2994 lbs/acre, and the highest production estimate was 4077 lbs/acre.

Total Production:
If we use average production per acre to estimate total production, then the total production is:

$$Total\ Forage\ Production_{SE\ Slope} = \ average\ forage\ production_{lbs\ per\ acre} * acres$$
$$= 3434_{lbs\ per\ acre} * 95.5_{acres} = \ 327{,}947\ lbs$$

Unavailable forage
In the SE Slope, 43.5 grazeable acres are less than 40% slope and 52 grazeable acres are greater than 40% slope. The minimum RDM standards for slopes <40% and >40% are 800 lbs/acre and 1200 lbs/acre respectively. If we multiply the acreage in each slope class by its RDM standard we get:

$$RDM\ Total_{SE\ Slope} = 43.5_{acres} * 800_{lbs\ per\ acre} + 52_{acres} * 1200_{lbs\ per\ acre} = 97{,}200\ lbs$$

If the grazing period is in the winter and spring, then the amount of herbaceous biomass that should be left unconsumed needs to take into account summer decomposition. Assuming a 43% summer decomposition rate, the total unconsumed forage should be:

$$Total\ Unavailable\ Forage_{SE\ Slope} = RDM\ Total_{SE\ Slope} * \frac{1}{1-0.43} = 97{,}200 * \frac{1}{0.57} = 170{,}526\ lbs$$

Available Forage

Total Available forage in a winter-spring grazing system would be the total forage production minus the total unavailable forage.

$$Total\ Available\ Forage_{SE\ Slope} = Total\ Forage\ Production_{SE\ Slope} - Total\ Unavailable\ Forage_{SE\ Slope}$$
$$= 327{,}947_{pounds} - 170{,}526_{pounds} = 157{,}421\ lbs$$

Grazing Capacity Estimate (in AUMs)

To convert total available forage to a grazing capacity estimate in AUMs, we simply divide by 1000 lbs.

$$Grazing\ Capacity_{AUMs} = \frac{Total\ Available\ Forage_{lbs}}{1000_{lbs}} = \frac{157{,}421_{pounds}}{1000_{lbs}} = 157\ AUM$$

Thus, the grazing capacity in an AVERAGE production year is estimated to be 157 AUMs in the SE Slope PGA. In a low production year, the grazing capacity is estimated to be 115 AUMs and in a high production year it is estimated to be 219 AUMs (calculations not shown).

Example Stocking Rates

Stocking rates include the type of livestock, the number of livestock, the duration of grazing and the acres being grazed. The table below gives examples of different stocking rates that vary the type (kind/class), number and duration of grazing period. The term "Animal Unit Equivalent" refers to the total amount of forage consumed by that type of livestock expressed in animal units.

Table A.1.4. Example stocking rates for the SE Slope

Livestock Type	Animal Unit Equivalent[1]	Duration	Number	Acres	AUM
Cow	1	12 months	**13**	95.5	156
Cow	1	6 months	**26**	95.5	156
Stocker cattle	0.6	12 months	**21**	95.5	151.2
Stocker cattle	0.6	6 months	**43**	95.5	154.8
Sheep	0.2	6 months	**130**	95.5	156
Goat	0.15	6 months	**174**	95.5	156.6
Horse	1.25	12 months	**10**	95.5	150

[1] Adapted from National Range and Pasture Handbook (NRCS 2003)

Northeast Ridge

Total area
The Northeast Ridge grazing area is approximately 76 acres (Table 1). Of this, approximately 23 acres are not expected to produce grazeable forage. This is because the area has dense shrub vegetation. This results in approximately 53 acres of productive grassland that forms the basis for the following grazing capacity calculation.

Table A1.5. Grazeable and ungrazeable acres in the habitat and flexible-use fields at the Southeast Slope Pilot Grazing Area.

Grazing Area	Habitat/Flex	Cover Type	Acres
NE Ridge	Habitat	Shrub	14.25
NE Ridge	Habitat	Steep Slope	0
NE Ridge	Habitat	Total Ungrazeable	14.25
NE Ridge	Habitat	Total Grazeable	45.20
NE Ridge	Habitat	Total	59.45
NE Ridge	Flex	Shrub	8.52
NE Ridge	Flex	Steep Slope	0
NE Ridge	Flex	Total Ungrazeable	8.52
NE Ridge	Flex	Total Grazeable	8.14
NE Ridge	Flex	Total	16.66
NE Ridge	**ALL**	**Total Grazeable**	**53.34**
NE Ridge	**ALL**	**Total**	**76.11**

Average Production
Average forage production measured in the NE Ridge in 2020 was 3400 lbs/acre (Ratcliff and Ford 2020).

The 2020 LDFord forage production number is fairly close to the estimated production in the NE Ridge from the Rangeland Analysis Platform in 2020 (2801 lbs/acre). This close correspondence in estimates suggests that the RAP estimates are reasonably accurate for NE Ridge, but a modifier is needed to adjust the RAP estimates.

20-year time series in RAP data
The 20-year time series of data from RAP suggests that forage production since 2001 has been as high as 3753 lbs/acre, and as low as 2513 lbs/acre. If we use 2020 to calibrate these numbers, we get the following conversion factor which we can apply to the RAP data to show estimate forage production between 2001 – 2021:

$$RAP\ Conversion\ Factor_{NE\ Ridge} = \frac{Measured\ Production\ (2020)}{RAP\ Production\ (2020)} = \frac{3400}{2801} = 1.21$$

Table A1.6. Rangeland Analysis Platform (RAP) forage production estimates for the NE Ridge and a converted estimate using the 2020 measured production values (Ratcliff and Ford 2020).

Year	Annual production (lbs/acre) (From RAP)	Adjusted production (Using Conversion Factor)
2001	3138	3809
2002	3262	3960
2003	3398	4125
2004	3563	4325
2005	3753	4556
2006	3548	4307
2007	3345	4060
2008	3175	3854
2009	3071	3728
2010	2605	3162
2011	3132	3802
2012	2738	3324
2013	2979	3616
2014	3216	3904
2015	2947	3577
2016	3219	3907
2017	3029	3677
2018	3222	3911
2019	3348	4064
2020	2801	3400
2021	2513	3050
Average	**3143**	**3815**
Minimum	**2513**	**3050**
Maximum	**3753**	**4556**

Based on the calibrated RAP estimates, the average forage production between 2001 – 2021 was 3815 lbs/acre. The lowest production estimate was 3050 lbs/acre, and the highest production estimate was 4556 lbs/acre.

Total Production:
If we use average production per acre to estimate total production, then the total production is:

$$Total\ Forage\ Production_{NE\ Ridge} = average\ forage\ production_{lbs\ per\ acre} * acres$$
$$= 3815_{lbs\ per\ acre} * 53_{acres} = 202{,}195\ lbs$$

Unavailable forage
In the NE Ridge, 29.5 grazeable acres are less than 40% slope and 23.5 grazeable acres are greater than 40% slope. The minimum RDM standards for slopes <40% and >40% are 800 lbs/acre and 1200 lbs/acre respectively. If we multiply the acreage in each slope class by its RDM standard we get:

$$RDM\ Total_{NE\ Ridge} = 29.5\ _{acres} * 800_{lbs\ per\ acre} + 23.5_{acres} * 1200_{lbs\ per\ acre} = 51{,}800\ lbs$$

If the grazing period is in the winter and spring, then the amount of herbaceous biomass that should be left unconsumed needs to take into account summer decomposition. Assuming a 43% summer decomposition rate, the total unconsumed forage should be:

$$Total\ Unavailable\ Forage_{NE\ Ridge} = RDM\ Total_{SE\ Slope} * \frac{1}{1-0.43} = 51{,}800 * \frac{1}{0.57} = 90{,}877\ lbs$$

Available Forage

Total Available forage in a winter-spring grazing system would be the total forage production minus the total unavailable forage.

$$Total\ Available\ Forage_{NE\ Ridge} = Total\ Forage\ Production_{NE\ Ridge} - Total\ Unavailable\ Forage_{NE\ Ridge} = 202{,}195_{pounds} - 90{,}877_{pounds} = 111{,}318\ lbs$$

Thus, the grazing capacity in an AVERAGE production year is estimated to be 111 AUMs in the NE Ridge PGA. In a low production year, the grazing capacity is estimated to be 71 AUMs and in a high production year it is estimated to be 151 AUMs (calculations not shown).

Grazing Capacity Estimate (in AUMs)
To convert total available forage to a grazing capacity estimate in AUMs, we simply divide by 1000 lbs.

$$Grazing\ Capacity_{AUMs} = \frac{Total\ Available\ Forage_{lbs}}{1000_{lbs}} = \frac{111{,}318_{pounds}}{1000_{lbs}} = 111\ AUM$$

Example Stocking Rates
Stocking rates include the type of livestock, the number of livestock, the duration of grazing and the acres being grazed. The table below gives examples of different stocking rates that vary the type (kind/class), number and duration of grazing period. The term “Animal Unit Equivalent” refers to the total amount of forage consumed by that type of livestock expressed in animal units.

Table A.1.7. Example stocking rates for the NE Ridge

Livestock Type	Animal Unit Equivalent[1]	Duration	Number	Acres	AUM
Cow	1	12 months	**9**	53	108
Cow	1	6 months	**18**	53	108
Stocker cattle	0.6	12 months	**15**	53	108
Stocker cattle	0.6	6 months	**30**	53	108
Sheep	0.2	6 months	**92**	53	110.4
Goat	0.15	6 months	**123**	53	110.7
Horse	1.25	12 months	**7**	53	105

[1] Adapted from National Range and Pasture Handbook (NRCS 2003)

Appendix A. References

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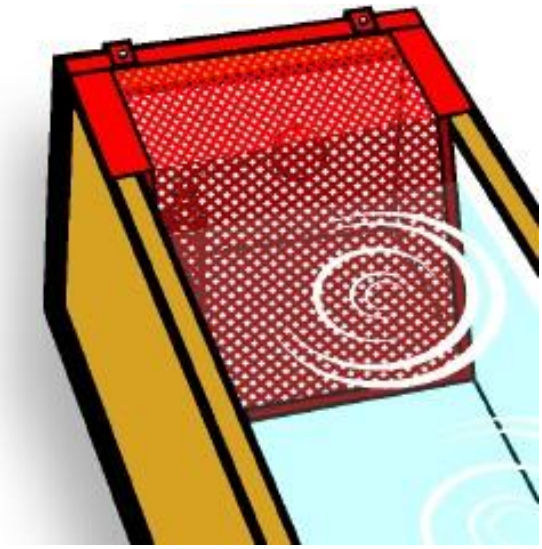
Appendix B

Effective Wildlife Escape Ramps for Watering Troughs

Text and figures excerpted from Taylor and Tuttle's (2012) handbook "Water for Wildlife: A handbook for ranchers and range managers". See handbook for further guidance, including instructions for the easy-to-build design shown on the right below.

Several basic principles should guide the design and installation of all wildlife escape structures. An effective escape device should:

- extend down into the water and meet the inside wall of the trough so animals swimming along the perimeter will find the structure, rather than becoming trapped behind or beneath it or missing it entirely
- reach to the bottom of the trough so it will be effective even if water levels drop sharply
- be firmly secured to the trough rim so it will not be knocked loose by livestock or other animals
- be built of grippable, long-lasting materials, such as painted or coated metal grating, roughened fiberglass, concrete, rock and mortar or high-strength plastic composites
- have a slope no steeper than 45 degrees so animals can climb out without slipping back into the water
- be located to cause minimal interference with livestock



Appendix B. References

Taylor, D.A.R. and M.D. Tuttle. 2012. *Water for Wildlife: A handbook for ranchers and range managers*. Revised Edition. Bat Conservation International. 20 pp.