# San Bruno Mountain
# Stewardship Grazing Plan


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## Introduction

San Bruno Mountain is one of the most diverse native coastal scrub and coastal prairie plant communities in the metropolitan Bay Area. The mountain is an island wilderness next to the Bay surrounded by urban development. Since the cessation of livestock grazing and the more efficient prevention of fires in the early 1960's, the native prairie grassland has become weedier, and there are fewer native wildflowers. The balance of the coastal scrub and prairie plant communities has also been tainted due to the expansion of the scrub and chaparral plant communities. The combined effect of introduced exotic species and the expansion of the native scrub community threatens to displace the prairie community that supports the host plants and nectar resources for three endangered butterfly species. The San Bruno Mountain Habitat Conservation Plan (HCP), a Habitat Conservation Trust Fund funded by assessments on property holders, provides for species monitoring and exotic plant removal. The elimination and control of eucalyptus and gorse infestations is an expensive undertaking. Thus far little or no effort has been directed at managing the spread of native scrub and controlling the annual grasses and weeds that threaten the prime native perennial grassland plant community. The cost and logistics of such an endeavor is yet to be determined. The purpose of this report is to inventory the mountain's prairie grassland and infrastructure resources, evaluate the use of livestock grazing on San Bruno Mountain as a tool to control noxious weeds and annual grasses, and design a grazing plan whose main objective is to restore and enhance the vitality of the native prairie resources.

A draft of this report without cost estimates and a final report with initial cost estimates were circulated in the summer of 2000. Review letters and comments were received from Sheila Barry, U.C. Extensions Bay Area Natural Resource Advisor; Ray Budzinski, Wildland Vegetation Program Manager for the East Bay Regional Parks District (EBRPD); Thomas Reid Associates (TRA); and San Mateo County Parks staff. During this time public concern for grazing issues on public land increased. The EBRPD's Grazing Review Task Force also reviewed wildland management policies (EBRPD 1992, EBRPD 2000), held public meetings, and published a draft Grazing Review Task Force Summary Report (November 2000). The literature and testimony of specialists and regulatory agencies were supportive of the positive effects of proper grazing practices in achieving restoration goals. The loss of native grassland plant communities and wildflower displays of the past is a regional syndrome. The importance of grazing is recognized by the California Native Plant Society, Natural Resources Conservation Service, The Nature Conservancy, the U. S. Fish and Wildlife Service, and many Public Park and open space districts. Most recently, the Mid-Peninsula Open Space District has implemented a two year trial plan consisting of comparing techniques to combat yellow starthistle, testing, using hand control, mowing, applying herbicide, grazing, burning, planting native seeds, and monitoring the number and cover of exotic and native species (Kephart 2001.) Both burning and grazing showed similar positive results in increasing the cover and diversity of native species. Prescribed grazing is the more cost effective of the two techniques.

During the last 10 months Patrick Kobernus, Thomas Reid Associates' San Bruno Mountain Ecologist, and the author of this report have investigated alternatives and cost estimates for a pilot grazing program. This final report incorporates reviewer comments and

suggestions, as well as information derived from active goat grazing operations in the Bay Area. A more specific, near-term pilot grazing program is presented. Priorities and estimates for a five-year program with monitoring to evaluate the grazing effects are presented as well.

**San Bruno Mountain Land Use History and Vegetation Change**

On San Bruno Mountain, livestock grazing began in the early ranching period (1700's) and continued into the mid 20th century. Up until the early 1940's the Guadalupe Valley west of the town of Brisbane was the headquarters of the ranch grazing the mountain region. This valley and the surrounding mountain supported a cow-calf and small dairy operation since the turn of the 20th century. The cattle grazed Guadalupe Valley, the saddle area, the Guadalupe Hills, and reached the larger grassland on the southeast ridge of the mountain via the grassland corridor adjacent to Brisbane's west boundary. During this period, grassland covered almost twice the land area that it does at the present time (Reid 1982). The San Bruno Mountain ranch included a winding ranch road lined with eucalyptus from Guadalupe Valley up to the saddle and ended at the beginning of what is now Crocker Avenue. At some time prior to the 1930's a small reservoir was developed in the Colma Creek watershed near April Brook. A gasoline pump house was used to irrigate vegetable gardens on the northern saddle area. The soil there is a deep sandy, clay loam soil, ideal for truck gardens and flower gardens that were common in the Daly City/Colma area during the 1930's and early 1940's. Lettuce, carrots, cabbage and artichoke were grown on the northern saddle fields during that time. A large concrete water trough still exists in the bog area, which was the prime water source for a large 15-acre pasture that once existed at the saddle summit (Jack Cuddy pers. com.). During the late 1940's, a small Grade B Dairy operation with 10 to 15 cows possibly still existed in the saddle area.

It became impossible to maintain a viable grazing operation on the mountain with the sale and development of the Guadalupe Valley and the construction of the Guadalupe Canyon Parkway, which took out the reservoir and the large saddle pasture. Limited seasonal grazing continued for a few more years on the mountain's southeast grassland. The gradual loss of the springs and water sources to urban encroachment on the southeast grassland sealed the fate of grazing on the mountain in the early 1960's.

Since the removal of grazing, the native grassland plant community on San Bruno Mountain has mirrored grassland succession in other parts of the Bay Area where native grasslands are being taken over by the gradually expanding exotic grasses, forbs, and weeds, as well as the dramatic encroachment of the native Coyote brush scrub (*Baccharis*) (McBride and Heady 1968, McBride 1974, Reid 1982, Foin and Hektner 1986, Reeberg 1987, Kobernus 1998). San Bruno Mountain has a large infestation of gorse (*Ulex europaea*) in the north saddle area, mainly on the previously cultivated fields of the north saddle. European broom species (*Cytisus* sp. and *Genista* sp.) are common along the northern margins of the mountain along Guadalupe Valley and Brisbane. Both the tall and spreading forms of coyote brush (*Baccharis pilularis* Var. *pilularis* and Var. *consanguinea*) are the most dominant and prolific native invaders of the perennial grassland on San Bruno Mountain. Introduced grasses and weeds such as Italian ryegrass (*Lolium multiflorum*), slender oats (*Avena barbata*), ripgut (*Bromus diandrus*), red brome (*B. madritensis rubens*), softchess (*Bromus hordeaceus*), filaree (*Erodium* spp.), burclover (*Medicago polymorpha*), thistles (*Carduus pycnocephalus*, *Centaurea solstitialis*, *Silybum marianum*), and mustards (*Brassica* and *Sisymbrium* spp.) are common in the San Bruno Mountain grassland habitat, especially on former livestock loafing and feeding areas. In the last

20 years the introduced annual rattlesnake grass (*Briza maxima*) has become a dominant grassland type in the grasslands on the north slope of the mountain, where native wildflowers were once common.

In the absence of grazing, the exotic annual grasses and the introduced perennial velvet grass (*Holcus lanatus*), build up a dense thatch in the grassland that smothers native herbs and wildflowers and greatly reduces species diversity and richness. The native flowering, broadleaf perennials are directly threatened by the annual grasses and advancing coastal sage scrub. These threatened perennials include the silver lupine (*Lupinus albifrons* Var. *collinus*) and Johnny-jump-ups (*Viola pedunculata*), which are key larval host species for the endangered Mission blue butterfly (*Icaricia icarioides missionensis*) and Callippe silverspot butterfly (*Speyeria callippe callippe*), respectively. The gradual loss of perennial grassland habitat is further compounded by the spread of fennel (*Foeniculum vulgare*), Italian thistle (*Carduus pycnocephalus*) and Bermuda buttercup (*Oxalis pes-carpae*) into the mountain's grassland from the mountain's urban and agricultural margins. The "miner's canaries" for the native grasslands of San Bruno Mountain are the Mission blue butterfly, Callippe silverspot butterfly, and San Bruno elfin butterfly (*Incisalia mossii bayensis*). The Bay checkerspot butterfly (Euphydras editha bayensis) has not been seen on San Bruno Mountain since the 1980's, and is presumed to have been extirpated.

**Climate**

San Bruno Mountain receives 24 to 30 inches of rainfall per year mostly in the winter and spring months (November through April), typical of California's coastal Mediterranean climate. The late spring, summer, and early autumn months receive little rainfall. However, in the spring and summer months the saddle area and the mountain's high peaks are shrouded in fog and strong winds much of the time, while the southeastern slopes are more temperate and sunny. The cool temperatures and fog drip are a source of up to 10" of accumulated precipitation (Gilliam 1962). Average temperatures on the mountain vary no more than 10 degrees through the year. Cool and mild temperatures prevail throughout the year, generally being between the low 50's in the winter and mid 60's in the summer.

**Substrate and Soils**

San Bruno Mountain is composed of fractured sandstone of the Franciscan Formation (Hsu 1968). It is a high mountain (1300') with a steep western face situated on the east side of the San Andreas Fault. The north facing slopes, saddle area, and the northeast ridge are composed of moderately deep, sandy loam soils. The mountain's southwest facing escarpment has more shallow and gravelly soils mixed with rocky outcrops. The saddle area has very deep loamy soil derived from coastal terrace formations. Much of the saddle area was cultivated with vegetable crops during the 1930's and 1940's. The base of the western and southwestern parts of the mountain has sandy soils derived from ancient sand dune and alluvium deposits. Most of the sand deposits have been mined and these areas are now occupied by home developments and cemeteries. A large agricultural production nursery (Pacific Nurseries) exists on the rich sandy loamy soils on the south side of the mountain, the last remaining nursery of a once thriving nursery industry.

## Plant Community Inventory

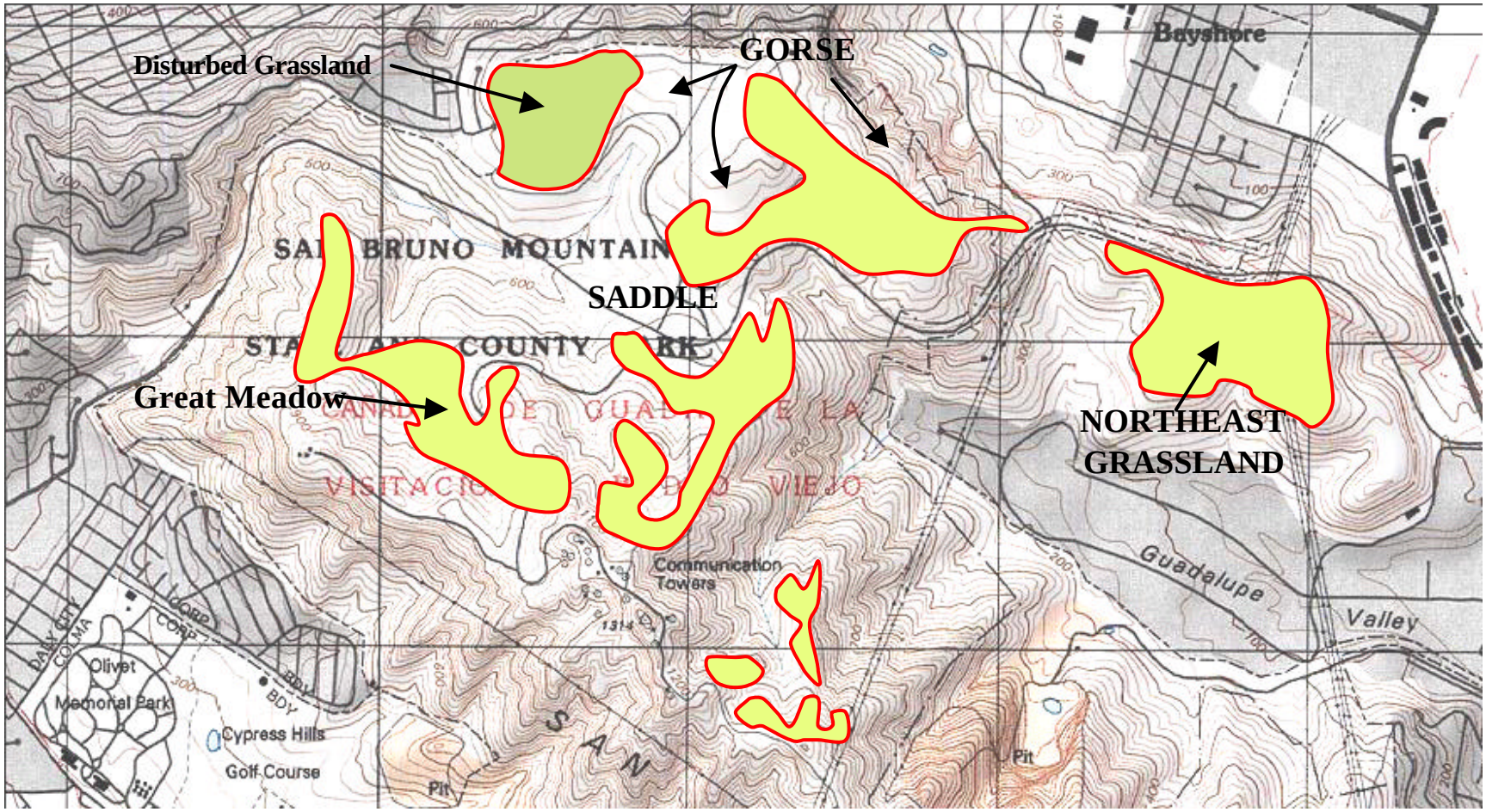
### The Grasslands

San Bruno Mountain has a rich and diverse coastal prairie community (*Festuca-Danthonia*), typical of the California coastal headlands and terraces from Humboldt County to northern San Luis Obispo County (Küchler 1964, Heady *et al.* 1977). It is one of the richest and most diverse in the Bay Area. The unique position of the mountain in the center of the coastal gap of the Bay Area where wind and summer fog are a constant occurrence throughout the summer, allows the coastal prairie grassland to exist on the mountain peaks and saddles. The coastal prairie vegetation intergrades with dune scrub, chaparral, woodland, and interior valley needlegrass plant communities, creating one of the richest coastal plant assemblages in the State.

There are two primary grassland areas on San Bruno Mountain: 1.) the North Grasslands, a coastal prairie grassland complex including the saddle, northeast ridge (aka Guadalupe Hills) and the northerly facing exposures of the mountain, and 2.) the Southeast Grassland: a mixed coastal grassland including coastal grassland and valley needlegrass grassland elements. These two grassland areas are virtually cut off from each other by the quarry and steep slopes covered with dense stands of coastal scrub. In the summer the North Grassland summit and northern exposures are often shrouded in wet fog with more than brisk winds. At the same time, the mountains Southeast Grassland exposures are more likely to be in the sun, with milder temperatures and less wind.

***The North Grasslands***: The North Grasslands coastal prairie plant community exists on two soil types and exposures: the gentle sloped, Saddle and Northeast Ridge corridor and the mountain's higher northerly facing grassland balds and glens below the summit area (**Map 1**). The soils on the Saddle and Northeast Ridge (Guadalupe Hills) are generally deeper than the mountain's higher, more exposed slopes. Gorse and velvet grass dominate the previously cultivated areas of the Saddle (Disturbed Grassland). An intact prairie grassland east of the cultivated area extends down the Saddle ridge where it joins the Northeast Ridge just beyond the intersection of Guadalupe Canyon Parkway and Carter Street. This area had never been cultivated, though some recent disturbance has occurred related to gorse removal. The Northeast Ridge, lower in elevation and in a milder and warmer environment, includes elements of needlegrass grassland. The deeper soils of the swales and south slopes of the Northeast Ridge are dominated by rank growth of annual grasses (*Lolium multiflorum, Bromus hordeaceus, B. diandrus, Briza maxima,* and *Avena barbata*) and large stands of Italian thistle (*Carduus pycnocephalus*) and mustard (*Brassica* spp). California golden violet and silver lupine are found on thinner soils and rocky, exposed sites where the annual growth is less rank and native prairie grasses and herbaceous plants are abundant. Both Callippe silverspot and Mission blue butterflies are found on the ridge top and north slopes of this area.

The mountain's higher northerly facing slopes are a complex of contiguous and isolated grasslands on the mountain's higher exposed ridges and balds. The largest contiguous prairie area is found on the north and west-facing slope along Radio Road. This area is generally identified as the Great Meadow. The San Bruno elfin butterfly is most often observed on the many isolated prairie grassland ridges and balds near the mountain's summit. Only the larger prairie areas are mapped.




**MAP 1**. The North Grasslands showing the Saddle, Northeast Grassland, primary coastal prairie grasslands, disturbed grasslands, and gorse areas.

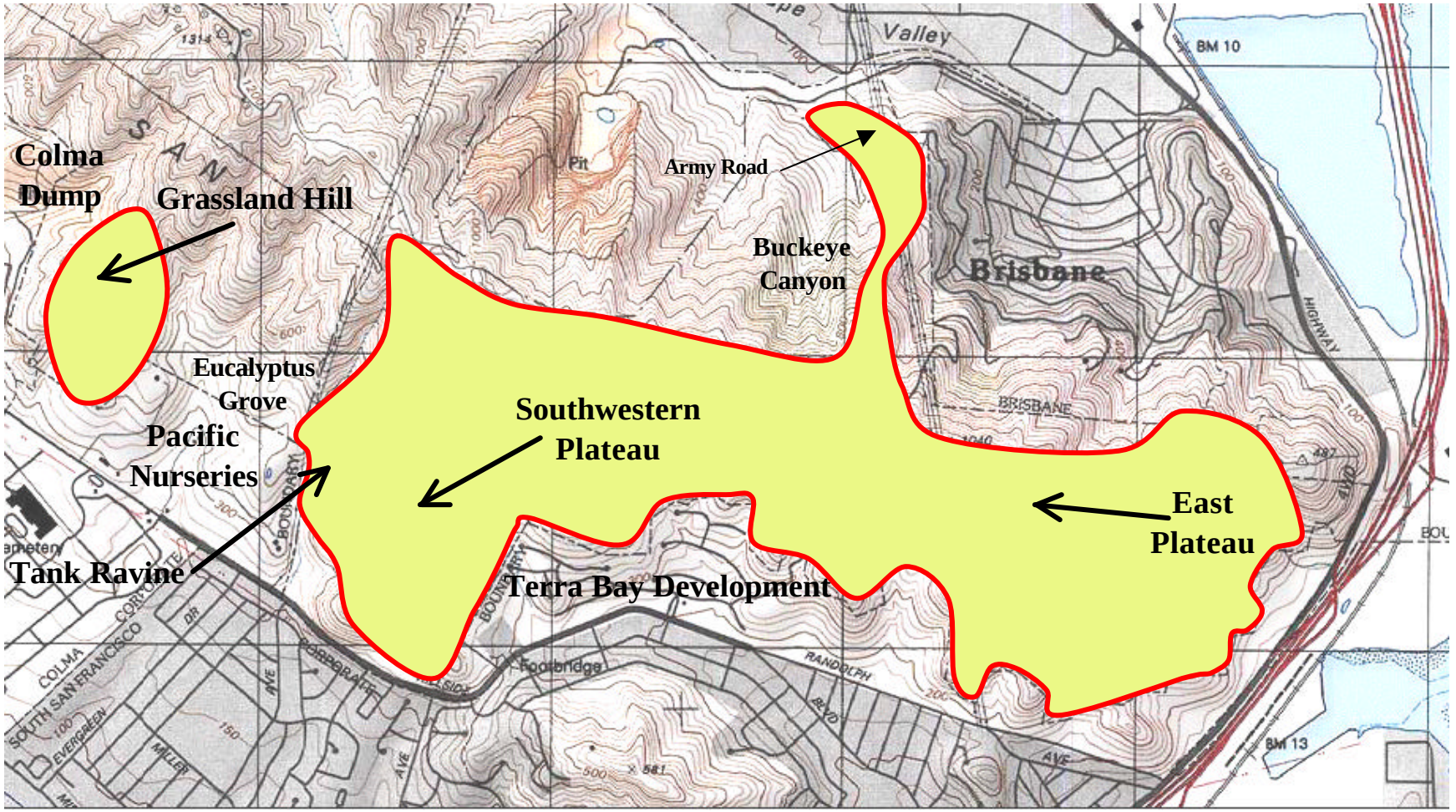
Composition: The coastal prairie plant community is a grassland typified by the presence of Idaho fescue (*Festuca idahoensis romerii*) and red fescue (*Festuca rubra*), California oatgrass (*Danthonia californica*), Pacific reedgrass (*Calamagrostis nutkaensis*), tufted hairgrass (*Deschampsia caespitosa holciformis*), junegrass (*Koeleria macrantha*), meadow barley (*Hordeum brachyantherum*), and coast bluegrass (*Poa unilateralis*). These grasses are associated with a rich variety of flowering herbaceous perennials and annuals including: yarrow (*Achillea millifolium*), blue violet (*Viola adunca*), Johnny-jump-ups (*V. pedunculata*), coast rock cress (*Arabis blepharophylla*), California plantain (*Plantago erecta*), seaside daisy (*Erigeron glaucus*), goldenrod (*Solidago spathulata*), stonecrop (*Sedum spathulifolium*), horkelia (*Horkelia californica*), acaena (*Acaena californica*), brownie thistle (*Cirsium quercetorum*), Franciscan wallflower (*Erysimum franciscanum*), blue larkspur (*Delphinium decorum*), suncups (*Camissonia ovata*), checkerbloom (*Sidalcea malvaeflora*), western ladies tresses (*Spiranthes romanzoffianum*), footsteps of spring (*Sanicula arctopoides*), cow clover (*Trifolium wormskioldii*), strawberry (*Fragaria chiloensis*), silver lupine (*Lupinus albifrons collinus*), *L. varicolor*, buttercup (*Ranunculus californicus*), blue-eyed grass (*Sisyrinchium bellum*), Douglas iris (*Iris doluglasiana*), golden aster (*Heterotheca bolanderi*/*Chrysopsis villosa*), pearly everlasting (*Anaphalis margaritacea*), and mule ears (*Wyethia angustifolia*).

The weedy/grassland area at the beginning of Radio Road is the disturbed area where the largest eucalyptus removal has taken place. Here the mountain's volunteer botanical garden is taking shape. Before Guadalupe Canyon Parkway was built, this area was part of the large heavily utilized rectangular pasture that once existed on both sides of the saddle summit and is known as Dairy Ravine.

Acreage: The acreage of the north saddle/northeast ridge grassland areas is approximately 170 acres. The approximate acreage of the larger prairie grassland areas on the mountain's northern slopes is 150 acres. The logged eucalyptus/Dairy Ravine area is approximately 40 acres.

***The Southeast Grassland***: The southeast grassland is the largest contiguous grassland on the mountain and covers over 900 acres (**Map 2**). The southeast grassland can best be described as a mixed coastal grassland. This grassland intergrades from a mixed scrub/grassland on the ridge east of Pacific Nurseries to a rich mixture of coastal prairie and valley needlegrass on the mountain's eastern end. The mid slope of the southeast ridge grassland generally has steep slopes (35-40%). The grassland of the southeast and east-facing slopes of the mountain intergrades with the coastal foothill needlegrass grassland plant community; however, the coastal prairie grasses continue to be abundant, particularly Idaho fescue, red fescue and California oatgrass. Both the Callippe silverspot and Mission blue butterflies are found on the ridgetop and slopes of the southeast ridge grassland.

Composition: Depending on the soil and exposure, common native grasses of the slopes below the southeast ridge include: Idaho fescue, red fescue, California oatgrass, Junegrass, purple needlegrass (*Nassella pulchra*), California brome (*Bromus carinatus*), blue wildrye (*Elymus glaucus*), California melic (*Melica californica*), thingrass (*Agrostis hallii*), California canarygrass (*Phalaris californica*), creeping wildrye (*Leymus triticoides*), and squirreltail (*Elymus multisetus*). Associated native broadleaf perennials include: yarrow, soap plant (*Chlorogalum pomeridianum*), triteleia (*Triteleia laxa*), blue dicks (*Dichelostemma pulchellum*), purple sanicle (*Sanicula bipinnatifida*), silver lupine, summer lupine (*L. formosus*), gumplant (*Grindelia hirsutula*), goldfields (*Lasthenia californica*), everlasting (*Gnaphalium chilense*), and California golden violet or Johnny-jump-ups. These slopes of the mountain have unique, pure colonies of




**MAP 2. The Southeast Grassland (outlined in red) showing the main plateaus, Pacific Nurseries, Tank Ravine and the Terra Bay Development.**

crimson sage (*Salvia spathacea*). The lower and mid slopes of this grassland above the Terra Bay development are currently being invaded by fennel. Fennel spreads quickly on disturbed soils (quarrying, construction) and thin soil areas (natural balds and ridgetops). It establishes easily in shrub and mesic (moist) grassland communities and spreads quickly after fire. A significant invasion of the noxious Bermuda buttercup (*Oxalis pes-caprae*) is also spreading up the slopes adjacent to Tank Ravine. Isolated Bermuda buttercup patches are also found along the ridge road on the southeast ridge grassland.

Plateaus: On the eastern end of the mountain between 600' to 1000' elevation, is a large 100-acre plateau with adjacent gentle slopes (20-25%). The vegetation of this plateau area is dominated by exotic weeds: thistles (*Silybum marianum, Cirsium vulgare, Carduus pycnocephalus*), filaree (*Erodium* spp.), and mustard (*Brassica rapa*) with a thick thatch of annual rye (*Lolium multiflorum*) and ripgut brome (*Bromus diandrus*). During the previous grazing period this area was a feeding/bedding area for cattle and was greatly overgrazed. A smaller grassland plateau (50 acres) exists on a lower ridge top (600') on the southwestern end of the grassland between the Terra Bay development west of Juncus Ravine and the Tank Ravine/Pacific Nurseries area. This grassland reaches all the way down to Hillside Blvd. Further west is a small disjunct mixed grassland area (39 acres) on another lower shoulder on the southwest side of the mountain (700') between the west powerline and the Colma landfill below the summit of the mountain. The gentle slope behind Pacific Nursery which links these two grassland plateaus was once a native grassland but is now dominated by an expanding second-growth bluegum eucalyptus grove.

***Other Isolated Grassland Areas***. Along the lower Guadalupe Canyon Parkway, below Crocker Avenue and the Pointe Pacific development are areas of mixed prairie grassland and coastal sage scrub on south and east facing slopes. These slopes link up with the last remnant of Dune Scrub on the mountain, above and adjacent to John F. Kennedy Elementary School. These areas comprise approximately 32 acres. The Mission blue butterfly has been observed in these areas for many years and occasional adult observations of the San Bruno elfin butterfly and the Callippe silverspot butterfly have also been recorded.

## Coastal Scrub and Woodland Elements

The western and central portion of San Bruno Mountain above 700 feet on both the steep north and south facing slopes below the summit/tower region is dominated by North Coastal Scrub, and ceanothus/manzanita scrub plant communities (*Baccharis-Artemisia-Rhamnus-Ceanothus-Arctostaphylos-Vaccinium* associations). The Coastal Scrub (*Baccharis-Artemisia*) is a dominant plant community on the mountain comprising over 60% of the mountains vegetation. On the steep south side of the mountain this plant community covers the western end and gradually thins out to mixed grassland near the west powerline ridge where the larger southeast ridge grassland begins. On the north side of the mountain, east of the west powerline ridge, Coastal Scrub is the dominant vegetation type mixed with fingers of coastal prairie grassland that are confined to the exposed ridge tops east of the quarry between Owl and Buckeye Canyons. Associated with the Coastal Scrub on the mountain's north side is a mixture of Buckeye (*Aesculus californica*), coast live oak (*Quercus agrifolia*), scrub interior live oak (*Q. wislizeni frutescens*), holly-leaved cherry (*Prunus ilicifolia*), toyon (*Heteromeles arbutifolia*), and grassland dominated by red and Idaho fescue, and accented by pure stands of California fescue (*Festuca californica*) and thickets of California huckleberry (*Vaccinium ovatum*).

A mixed native grassland corridor extends all the way from the mountain's southeast ridge summit down to Guadalupe Valley along the western boundary of Brisbane City Limits (Brisbane/ Army Road Interface). Callippe silverspot and Mission blue butterflies frequent this ridge as well as the mountain's main southeast ridge. Native and introduced woodland (*Quercus-Umbellularia-Eucalyptus-Acacia*) dominate the steep slopes and ravines above Brisbane Acres.

## Infrastructure

### Roads and Access

To introduce livestock to the mountain they would have to be physically shipped by truck into and out of the grassland areas. The main access to the north saddle area and north slope coastal prairie grassland areas is from the Park entrance. Livestock can be moved (trailed) between the east and west saddle areas (108 acres) and moved into the disturbed eucalyptus cut area (40 acres), the great meadow area, and adjacent ridges (82 acres) via the Guadalupe Canyon Parkway underpass and Radio Road. The access point to the northeast ridge is via an access road on Guadalupe Canyon Parkway. However, livestock could be trailed down from the Dairy Ravine on the old ranch road below Guadalupe Canyon.

Access to the southeast ridge grassland is limited to three locations from the base of the mountain. From the south side of the mountain the grassland can be accessed either by the Tank Ravine access road adjacent to Pacific Nursery or the access road off of Hillside Avenue west of the footbridge. The small disjunct grassland hilltop near the landfill (39 acres) can be reached from behind the Pacific Nursery. A historic twenty-acre grassland area behind the Pacific Nurseries is presently dominated by resprouted eucalyptus with only small patches of grassland remaining. On the north side of the mountain in Guadalupe Valley the southeast grassland can be accessed from the Department of Fish and Game property off of the quarry road. A powerline service road (Army Road) climbs up the east powerline ridge adjacent to Brisbane's western boundary. Depending on the Terra Bay Phase 3 development, access may be possible from the Bayshore Highway on the eastern side of the mountain.

### Fencing and Water Development

The historic fence infrastructure on the mountain is virtually non-existent. The only fence alignment that can be observed is the fence that runs along the old Brisbane corporate boundary. Some recent fencing exists behind the Phase 1 Terra Bay and Northeast Ridge developments, but the fencing is disjunct and not necessarily on the property line. The fencing behind the nursery area along the southwest boundary is intact but not in good repair as is the fencing around the grassland knob near the landfill and along the landfill access road.

There is no water development on the mountain. There is evidence that two or three water sources (springs and troughs) existed along the base of the southeast ridge where the Terra Bay Development now exists: lower Juncus Ravine, Cow Trough Ravine, and the ravine just west of the eastern powerline.

**The Stewardship Grazing Management Model**

Fire and Grazing are the two most important ecological processes that govern the structure, function, and composition of California's grassland, scrubland, and forested plant communities (Heady *et al.* 1977, Sampson 1952, Savory 1988). The native grasslands and coastal scrub communities evolved with fire and grazing long before European man's arrival (Lewis 1973, Biswell 1956). In pre-European times the populations of the native grazing species (rodents, rabbits, mule deer, elk, and antelope) responded to fire events and hunting/predator pressures. The composition and diversity of the contiguous native perennial grasslands and savannas that once dominated the coastal mountain valleys were shaped by the ebb and flow of fire and grazing (Edwards 1992). Concurrent with the disturbance and overutilization of California perennial grassland resources by western man is the arrival and dominance of the Mediterranean annual grasses and broadleaf weeds. Through the 18$^{th}$, 19$^{th}$, and 20$^{th}$ centuries each decade would bring a host of new exotic species to the California native grassland (Burchum 1957). Periods of more frequent and hotter fires, overgrazing, and disturbance has further fragmented the California native grassland ecosystem. With no grazing and no fire (no management) the native perennial grassland with all its associated plant, animal, and insect components is a critically endangered plant community.

The negative effects of uncontrolled, yearlong livestock grazing are well known. They include soil compaction, degraded riparian habitat, poor water quality, erosion, the elimination of native perennial grass, and wildlife habitat degradation. For the grassland itself, the effects of total rest from grazing (no grazing) can be just as damaging, where rank, undecomposed annual grass mulch smoothers and eventually eliminates the native perennial grasses as well as the wildflowers (Menke 1989). These problems can only be addressed through the reintroduction and the strategic use of fire and grazing. With grazing, the careful management of livestock numbers and the control of the season, frequency, duration, and intensity of grazing are utilized to attain specific landscape goals. The primary goal of a stewardship grazing program is the utilization of controlled livestock grazing as a tool to enhance and restore the health, diversity, and productivity of native grassland plant communities. Grazing cannot replace fire nor can fire replace grazing. They are both needed. This stewardship goal considers all facets of the grassland community: species diversity, wildlife richness, aquatic and riparian habitat quality, and the human community.

Stewardship grazing practices are beginning to be employed widely in California (EBRPD 2000). Private ranchers, University researchers, the Nature Conservancy, California State Parks, and other regional resource agencies are testing prescribed grazing programs to enhance native plant composition and diversity (Amme and Pitschel 1990, Amme 1999, Lis and Eggeman 2000). Since 1992 intermittent grazing, burning, rest, and combination treatments are being closely evaluated by researchers at the University of California, Davis, at the Jepson Prairie near Dixon, California (Menke 1992). The Nature Conservancy is utilizing controlled grazing as a conservation tool on numerous grassland preserves (Amme & Pitschel 1989). Private ranchers are experimenting with various grazing systems utilizing recent technological advances in electric fencing (Reeves and Morris 1999). Grazing duration and rest of each area or pasture is timed to enhance the recovery period of target native plants, especially the native perennial bunchgrasses (Amme 1995). The size and number of pastures, the number and class of livestock, and the timing of grazing events are critical components of a stewardship grazing program (Morris and Amme 1995).

## The Grazing Plan

**THE GOAL**: The greatest threat to the survival of the mountain's sensitive and endangered butterflies is the loss of herbaceous grassland habitat to encroaching coastal scrub and weeds, including annual grasses. In broad terms, the goal of the stewardship grazing program is to test and demonstrate the efficacy of controlled livestock grazing as a tool to enhance and restore the health, diversity, and productivity of native grassland plant communities. Specifically, the grazing program will target the rank annual grasses and weeds that suppress the diverse native herbaceous and perennial grass plant community and the low coastal scrub margins encroaching into the grassland areas. The grazing plan consists of two parts:

> ***3-Year Pilot Grazing Program*:** An initial 3-year prescribed grazing program will be established on priority areas to evaluate the response of exotic weeds and the native prairie vegetation to short late fall and early spring grazing effects.
>
> ***Infrastructure Improvement*:** The gradual 5-year development of a basic fence and water system infrastructure that will serve a long-term grazing program on the Saddle, Guadalupe Hills, and the large southeast grassland.

## 3-Year Pilot Grazing Program

The 3-year pilot grazing program describes: 1.) The type, combination, and numbers of livestock, 2.) The priority areas and treatment goals, 3.) Monitoring, 4.) Implementation, and 5.) Cost.

### Type, Combination, and Numbers of Livestock

The type, combination, and numbers of livestock are critical for implementing both the short range and long term goals. Cattle, goats and sheep graze differently and can impact the native plant community in different ways depending on how they are managed.

*Cattle*. The landscape goal, logistics of moving livestock, infrastructure, and forage resources make it virtually impossible for a cattle operation to exist in the saddle and the north slope coastal prairie area in the foreseeable future. Cattle cannot effectively reduce scrub cover through trampling and late-season browsing. Cattle graze with their tongue and teeth, similarly to elk. Like goats and sheep, there are many sizes and breeds of cattle. Cattle preferably graze the grasses and herbaceous vegetation. Generally, cattle require a large or productive grassland with substantial infrastructure (fencing and water) to be effective in stewardship grazing programs. Cattle can be effectively moved via temporary or permanent electric fence systems. Several grazing programs are currently being implemented in California. In these situations a permanent water infrastructure is necessary to bring water to each paddock or grazing area. The use of permanent and/or temporary electric fences for cattle grazing in an urban setting such that exists on the San Bruno Mountain's southeast ridge will be problematic for the park user, requiring commitment and cooperation of the community.

*Goats*. Currently, goat grazing is used by land management agencies to reduce the fire hazard (weed abatement) in urban-wildland interfaces. The goats are cared for and herded by

shepherds behind specially designed electric fences on a 24 hour, seven day a week basis. The goats are bred and trained to graze in dense herds, and can be easily moved through a landscape through a series of temporary electrically fenced areas or paddocks. Typically, for fire hazard reduction, between 400 to 700 goats are herded through areas to clear vegetation in the late spring and early summer. Goats are strong browsers of woody and weedy vegetation and can reduce the cover and vigor of unpalatable plants such as coyote brush, Himalayan blackberry, cape ivy, English ivy, fennel, horseweed, poison hemlock, yellow starthistle, etc. without any pretreatment. Intensive grazing, almost down to bare soil, is necessary for goats to have an effect on stripping shrub species (e.g., coyote brush, French broom). To effectively reduce taller shrubs and canopy species, additional costs are needed to cut and reduce brush to a size that is accessible to the goats. Grazing during late spring and summer has little or no effect on grassland species composition because most of the plants, especially the introduced annual grasses and weeds, have already completed their life cycle and gone to seed. The cost of grazing goats is approximately $750/acre. Reducing the number of goats does not necessarily save costs. The per acre cost utilizing 200 to 700 animals remains the same and may even increase with smaller animal numbers. In summary, the timing, intensity, and duration of goat grazing can be controlled extremely well and accurately without dependence on an extensive permanent fence and water delivery infrastructure.

*Sheep*. The utilization of sheep has the same advantages as goats, in that they can be effectively employed in a herding system where high animal numbers graze for brief periods of time. Sheep are generally heavier animals and consume much more forage/vegetation. Sheep favor herbaceous and grassland vegetation and browse woody vegetation only lightly. Sheep are currently being used by goat grazing businesses to augment grazing effectiveness.

The goal of the 3-year grazing program is to enhance the native species composition of selected grassland areas and not necessarily to heavily impact or target scrub species per se, or remove the potential summer fuel load. Utilizing goats and sheep together is an ideal combination to impact both grassland and low-lying shrubs. The capacity of the sheep to eat twice as much grassland forage as can goats will increase the herd's effectiveness. Utilizing large animal numbers may be more cost effective; however, better precision for monitoring purposes can be achieved with a smaller number of animals. A smaller number of animals will facilitate efficient and economical movement between treatment areas. Stocking rate and paddock size adjustments are easier to make. Rather than start with a larger number of animals the pilot program will develop the information to determine the most effective numbers and stocking densities in subsequent years. Therefore, utilizing a smaller number of animals will enable the program to efficiently evaluate different settings and circumstances.

The initial (First Year) recommended number and combination of animals is 120-150 animals comprised of 60% goats and 40% sheep. The stocking density is dependent upon the type and productivity of the vegetation. Temporary grazing areas or cells can vary between one to two acres per day. The grazing program will determine and adjust the size of the grazing cells. The livestock will graze small areas for the shortest duration possible. A shepherd will provide Twenty-four hour supervision. The animals are controlled and moved with the use of movable electric fences. Water requirements are served with a mobile water tank and trough. Briefly, grazing treatments will be periodic: either **once** in the late fall (October-November) or the early spring (March-April) growing season, or both. The grazing treatments will be applied to approximately 35-40 acres of selected grassland areas each year. Monitoring plots will be established and recorded prior to, during, and after the grazing treatments over the three-year

period. A ten-meter square exclosure (100 $m^2$) will be excluded from grazing and monitored as a control in each treatment area.

## Priority Areas and Treatment Goals

The pilot grazing program will treat parts of five priority areas over a three year period: Dairy Ravine, The Saddle, Northeast Ridge, Tank Ravine, and the Brisbane/Army Road Interface along Brisbane's western boundary. Each of these areas has a suite of species and exposures with typical settings and constraints related to past land management practices and disturbance.

### Dairy Ravine

The Dairy Ravine area is approximately 40 acres (**Figure 1**. Dairy Ravine) and includes the large 20 acre area where the eucalyptus were removed in 1995 (Disturbed Grassland), the eastern ridge of prairie and prairie/scrub interface, and a northern knoll where second growth eucalyptus have been recently cut and removed. The Callippe silverspot, San Bruno elfin, and Mission blue butterflies are observed along the eastern ridge area. At the base of the ridge above Fern Rock/Wax Myrtle Ravine is a small isolated population of *Sedum spathulifolium*, the larval host of the San Bruno elfin butterfly. The vegetation bordering and below this ridge and surrounding the Volunteer Botanic Garden is heavily dominated by common and noxious exotic weeds including mustards, poison hemlock, English ivy, cape weed, Himalayan blackberry, velvet grass, Bermuda buttercup, etc. Weed growth and abundance is also increasing in the recently cleared knoll.

The primary purpose for treating this area is to evaluate controlled early spring and late fall grazing effects on disturbed grassland and prairie/scrub interface. The concentrations of rank noxious weedy areas will be targeted as well as the weedy grassland areas. Pilot test areas along the western side of the ridge and stable prairie margins will be treated and monitored to chart vegetation change. Some target areas will be treated in the spring only. Other target areas will be treated in the fall only, and others will be treated in both the spring and the fall. Grazing treatments will take place within the areas marked in the illustration but not necessarily the whole area each year. Approximately 10 to 15 acres of Dairy Ravine will be treated each year. Grazing Dairy Ravine will be coordinated with other parts of the mountain. The livestock can be moved into Dairy Ravine from the Saddle area or vice versa. The Northeast Ridge grassland can be reached from the Saddle and Dairy Ravine by either crossing Guadalupe Canyon Parkway or via the old eucalyptus lined ranch road.

### The Saddle

The Saddle includes approximately 30 acres of prairie grassland, prairie/scrub interface, and disturbed grassland where gorse has been recently removed (**Figure 2**. The Saddle). The Callippe silverspot and Mission blue butterflies are observed in this area and its margins. The California golden violet and silver bush lupine, host plants for the Callippe silverspot butterfly and the Mission blue butterfly respectively, are found on exposed sites where competition from annual grasses is less. The brushy grassland just north of the mowed picnic area is currently heavily invaded by Himalayan blackberry, coyote brush, seedling live oaks, and rank growth of velvet grass. Gorse has recently been removed from a south-facing swale area east of the paved

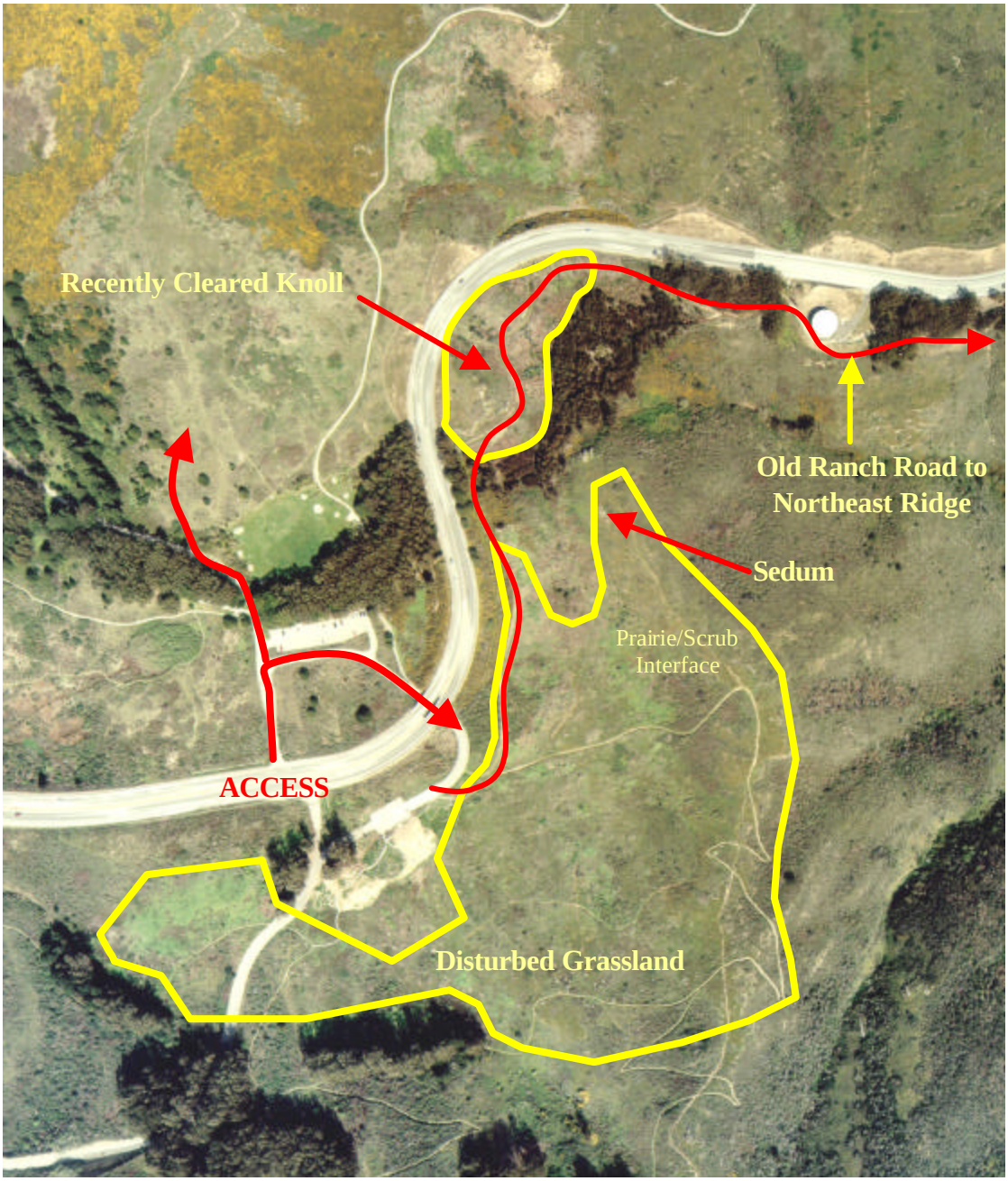



**FIGURE 1. DAIRY RAVINE**
Controlled late fall and early spring grazing effects on
disturbed grassland and prairie/scrub interface
40 Acres

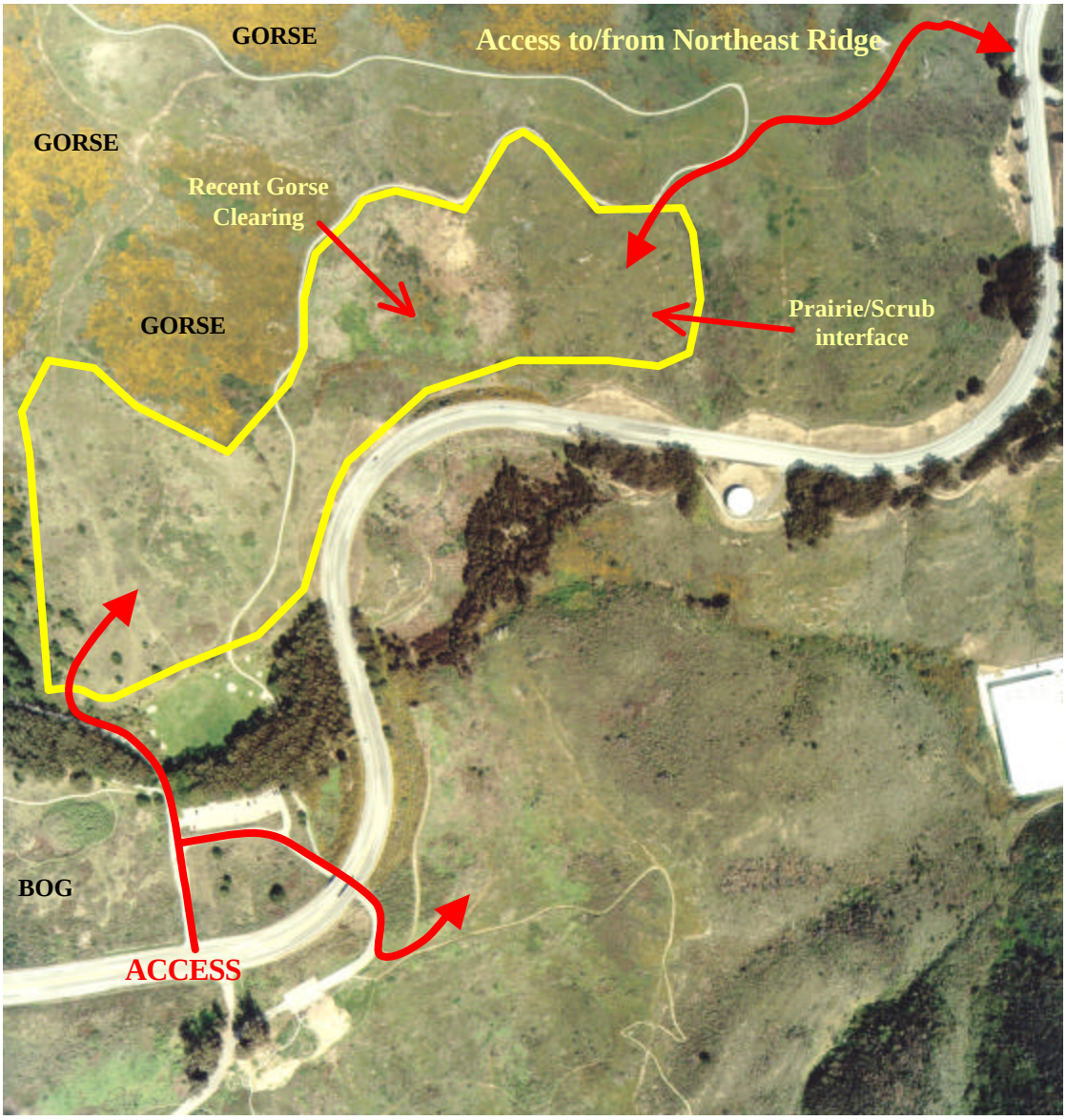



**FIGURE 2. THE SADDLE**
Controlled early spring grazing effects on
disturbed prairie grassland and coastal sage scrub interface
30 Acres

trail and a mixed prairie and prairie/scrub interface is found on the eastern end of the site outlined in the illustration.

The primary purpose for treating this area is to evaluate controlled early spring and late fall grazing effects on disturbed grassland and prairie/scrub interface. An auxiliary reason to graze this area is to also observe the effect of grazing on mature and seedling gorse plants. Some target areas will be treated in the spring only. Other target areas will be treated in the fall only, and others will be treated in both the spring and the fall. Approximately 6 to 12 acres will be treated each year. As mentioned above, the grazing of this area will be coordinated with both Dairy Ravine and the Northeast Grassland as livestock can be safely trailed between these areas. Monitoring will include exclosed reference plots and permanent transects.

**Northeast Ridge**

The Northeast Ridge grassland is a large 75-85 acre grassland with north, south, east, and west exposures (**Figure 3**. Northeast Ridge). This grassland is bounded by Guadalupe Canyon Parkway on the north and the Northeast Ridge housing development on the east, south and west sides. The thinner, rocky soils and exposed sites have native coastal prairie elements and the lower slopes and deeper soils are dominated by annual grasses and weeds. Both the Callippe silverspot butterfly and the Mission blue butterfly are observed along the ridges and margins of this grassland. Similar to the Saddle, California golden violet and silver bush lupine are found on exposed sites where competition from annual grasses is less.

The primary purpose for treating this area is to evaluate controlled early spring and late fall grazing effects on prairie grassland, specifically, the areas where annual weed and grass competition is suppressing the native herbaceous flowering species. Some target areas will be treated in the spring only. Other target areas will be treated in the fall only, and others will be treated in both the spring and the fall. Approximately 10 to 15 acres will be treated each year. The grazing of this area can be coordinated with both Dairy Ravine and the Saddle areas. Monitoring will include exclosed reference plots and permanent transects.

**Tank Ravine**

Tank Ravine is located on the western corner of the large Southeast Grassland area on the south side of the mountain (**Figure 4**. Tank Ravine). Tank Ravine is a relatively protected area and weather conditions on this side of the mountain are not as cool or foggy as it is on the saddle area. A level bench behind Pacific Nurseries west of Tank Ravine is covered with second growth bluegum eucalyptus with a few isolated grasslands. The western interface with Pacific Nurseries and Tank Ravine is literally swamped by a stand of mustard all the way to the seasonal creek. Tank Ravine is a source of concern to biologists because of a large and growing infestation of Bermuda buttercup that constitutes a critical threat to the mountain's grassland resources. Infestations of Bermuda buttercup completely dominate disturbed grassland and also invade coastal scrub habitat. Bermuda buttercup also dominates annual grasses and other weeds. Callippe silverspot butterfly and the Mission blue butterfly are found higher above Tank Ravine on the southwestern grassland plateau.

The primary purpose for treating this area is to evaluate controlled early fall grazing effects on Bermuda buttercup. The goats and sheep will be moved into the grassland areas behind and adjacent to the eucalyptus. From this staging area, the animals can be moved to


**FIGURE 3. NORTHEAST RIDGE**
Controlled late fall and early spring grazing effects on prairie grassland
75 Acres

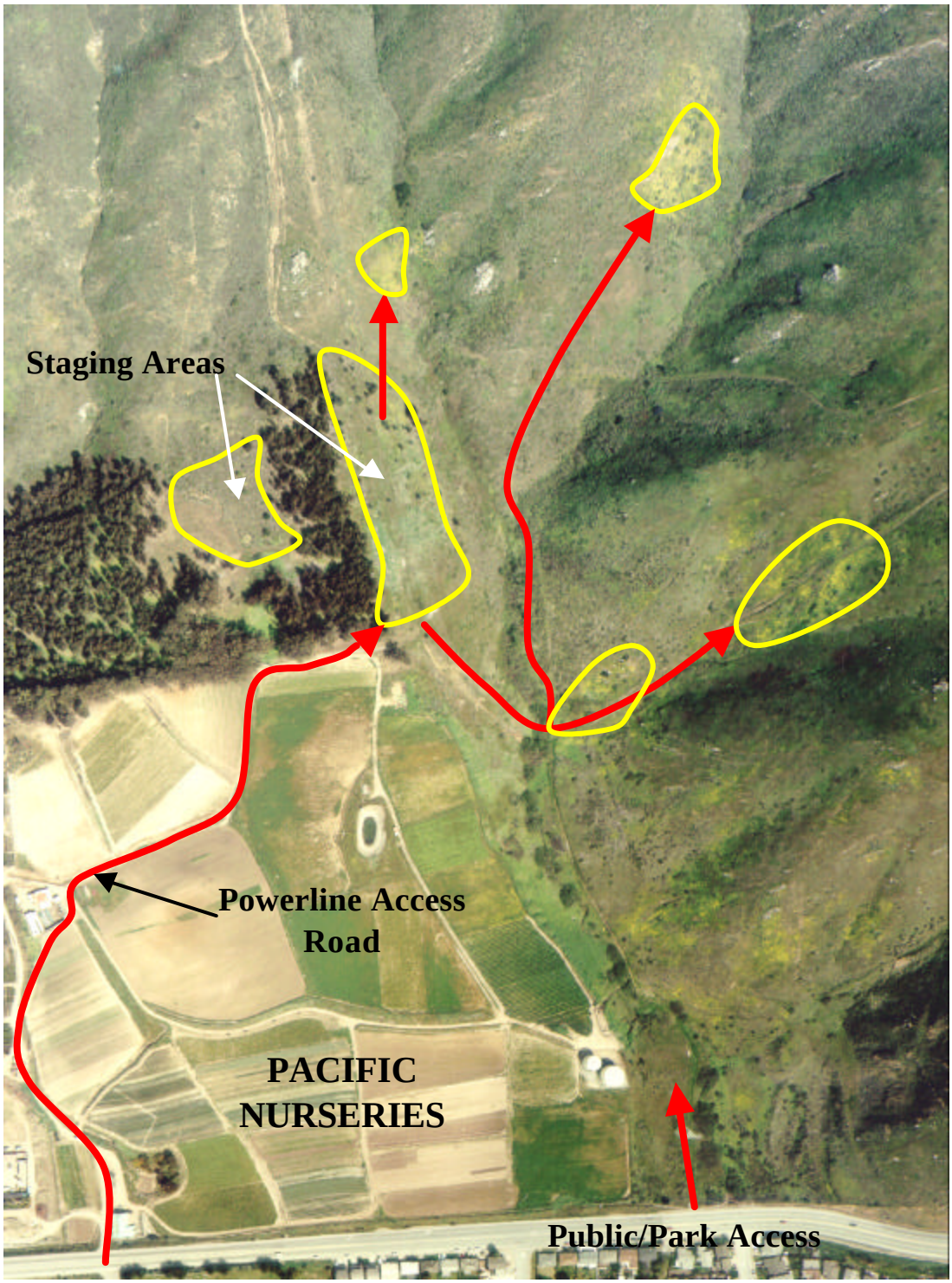



**FIGURE 4. TANK RAVINE**
Controlled late fall grazing effects on Bermuda buttercup, annual grasses, and fennel
4-5 Acres

predetermined Bermuda buttercup infestations. Approximately 4-5 acres will be treated. The grazing strategy is based on the Bermuda buttercup's life cycle. Bermuda buttercup does not form viable fruit or seed but it does multiply by underground corms that are primarily spread via small burrowing rodents. In early fall the corms sprout and the plants begin to grow. As soon as the plants begin to flower (December/January) corm multiplication initiates. If the plants are pulled, sprayed, or grazed below the base early in its growing cycle (October/November) the mother plants are killed and multiplication is prevented. The specific purpose for grazing Tank Ravine is to graze the Bermuda buttercup infestations in the early fall (October/November) for three years.

**Brisbane/Army Road Interface**

The Brisbane/Army Road Interface is the western boundary of Brisbane along the east powerline route (**Figure 5**. Brisbane/Army Road Interface). This area is a native prairie grassland that is connected to the mountain's Southeast Grassland. Coyote brush and French broom are actively encroaching on this site. A heavy thatch of rattlesnake grass exists on the eastern slopes. Both San Bruno Mountain Park and the Department of Fish and Game (DFG) manage portions of this area.

The primary purpose for treating this area is to evaluate early spring and late fall grazing effects on disturbed prairie grassland, and French broom. Areas where annual weed and grass competition is suppressing the native herbaceous flowering species will be treated. Some target areas will be treated in the spring only. Other target areas will be treated in the fall only, and others will be treated in both the spring and the fall. Approximately 10 to 15 acres will be treated each year.

## Monitoring and Data Analysis

Monitoring the results of the grazing treatments is an essential component to a stewardship grazing program. When measuring the impact of livestock grazing on vegetation change, the establishment of permanent plots and transects is a strong tool to determine treatment effects and species trend over time. Plots are pre-selected and measured in the spring (or fall) before grazing treatments and in the following spring (or fall) one year later just prior to the next grazing treatment. In every area an exclosure or reference area will not be grazed so the yearly impact on the vegetation can be compared to untreated control areas.

In grassland habitat, a fast and efficient way to measure cover, species diversity information and physical ecological parameters is by placing a number of 1/10-meter quadrats (20 cm X 50 cm) along a permanent tape transect. The quadrats are laid perpendicular to the tape in a predetermined way and the presence of all species within the quadrat is recorded. This will give both frequency and diversity (species/area) for the area. Other vital information that can be derived from a quadrat include the presence of insects and larva, animal scat, ground disturbance due to burrowing animals, the basal area of a perennial bunchgrass, the diameter and number of stems of a coyote bush base, and the number and size of key habitat plants (Viola, Lupinus, Sedum, etc.)

In order to determine the intensity of grazing, the size of individual paddocks, the number of animals, and the duration of grazing within each paddock will be recorded. Animal behavior and forage preference will also be noted during the grazing treatments. Residual dry matter

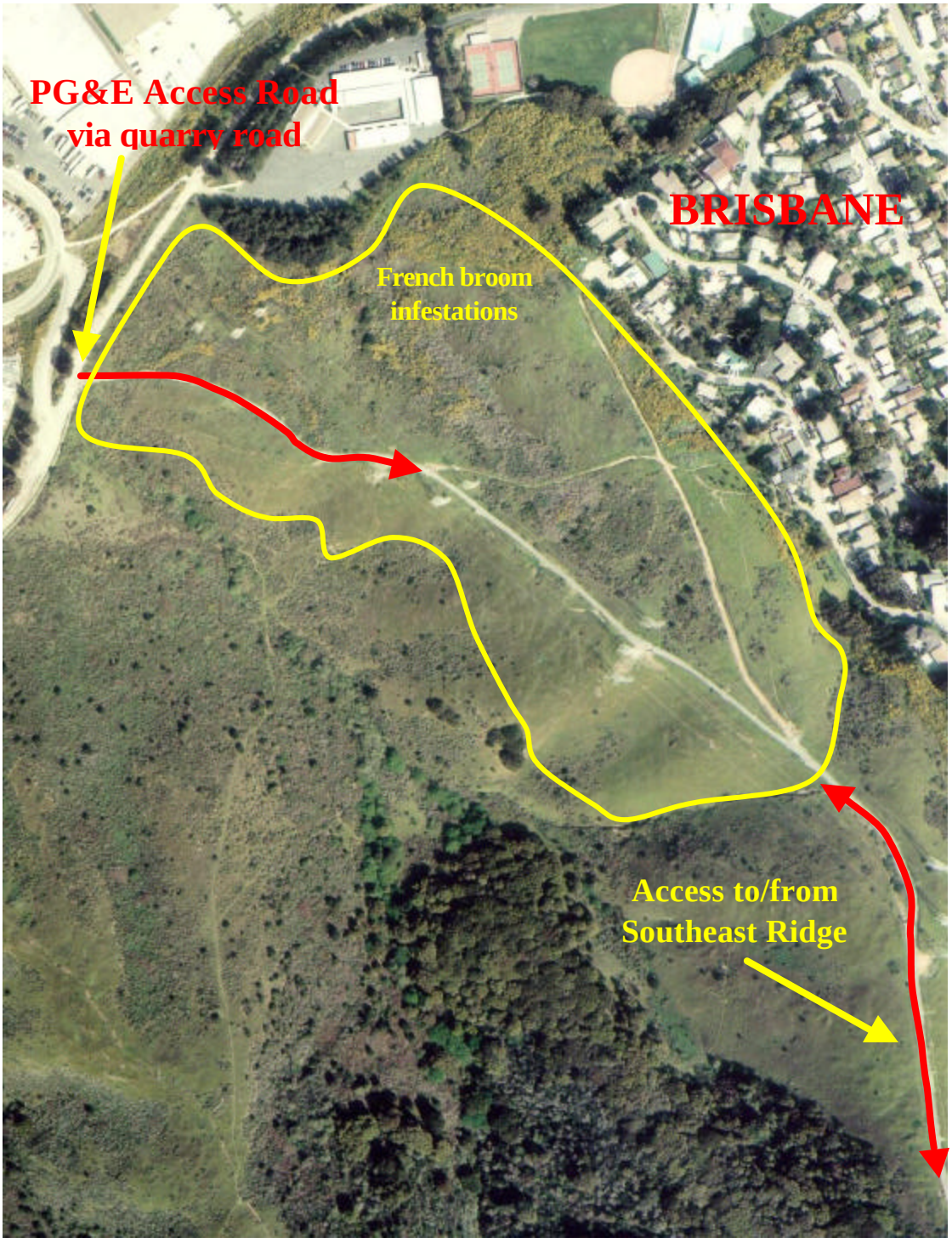



**FIGURE 5. BRISBANE/ARMY ROAD INTERFACE**
Controlled late fall and spring grazing effects on
coastal prairie, and French broom
60 Acers

(RDM) will be taken within treatment areas and controls. Several permanent photo points will be located within the grazing treatment areas and photographed before and after treatments.

A sub-area within a proposed grazing treatment area will be chosen. The area must have target species and habitat including lupines, prairie grassland, coastal scrub, broom, etc. A baseline will be established along the boundary of the chosen area (base of slope, etc.) and perpendicular transects will be marked. The first transect starting point is randomly chosen, and the following transects are placed at set distances apart along the baseline. The end points of each transect are permanently marked. Several (20 cm X 50 cm) quadrats will be placed at set distances apart along each of the transects. For plants that fall within the quadrat, their percent cover will be measured using cover classes (Daubenmire 1959). For targeted plants that do not fall within the quadrat, the distance from the center of the quadrat to the targeted plant is measured. This combined method allows for smaller quadrats to be used, while still obtaining data on important species that fall outside the quadrats. Within each treatment area a 10 m X 10 m exclosure will be installed for controls. The control areas will have the same types of data recorded as treatment areas.

Within the systematic sampling macroplot, data will be analyzed to compare species composition, percent cover, and distance (number and density of targeted species). Before and after grazing data will be compared using the paired *t*-test. To compare data between the treatment areas (macroplot) and controls (exclosures), the independent *t*-test will be used. Multiple years of data will be analyzed using ANOVA.

**Sensitive Plants**

There are several threatened, endangered, or otherwise sensitive plants in grassland and coastal scrub locations on San Bruno Mountain that need to be surveyed for before grazing treatments are implemented. The DFG California Natural Diversity Data Base (CNDDB) and the Flora of the San Bruno Mountains (McClintock *et al.*1990) have excellent information and locations of these plant species. It is important to evaluate the response of these plants to grazing treatments early in the program. These plants include: Diablo helianthella (*Helianthella castanea*), San Francisco gum plant (*Grindelia hirsutula maritima*), San Francisco owl's clover (*Triphysaria floribunda*), white-rayed pentachaeta (*Pentachaeta bellidiflora*), Kellogg's horkelia (*Horkelia cuneata sericea*), San Francisco campion (*Silene verecunda verecunda*), California lessingia (*Lessingia germanorum chamisso*), coast rock cress (*Arabis blepharophyulla*), San Francisco collinsia (*Collinsia franciscana*), San Francisco wallflower (*Erysimum franciscanum*), spine-flower (*Chorizanthe cuspidate*), and popcorn flower (*Plagiobothrys chorisianus*).

## Implementation

**Oversight Team**

An oversight team should manage the 3-year pilot grazing program. The primary purpose of the oversight team is to select the grazing contractor, to establish and measure the monitoring plots, and to document the program. The oversight team should include biologists and restorationists familiar with the mountain's ecology and sensitive plant and animal species. The team will need to coordinate input from the San Mateo County Parks Department, U.S. Fish and Wildlife Service (USFWS), the California Department of Fish and Game (DFG), Friends of San Bruno Mountain, and knowledgeable people from the community. To implement the plan

outlined in this report it will be necessary for the team to lay out the treatment paddocks and establish the control exclosures and monitoring plots. Perhaps the most important duty of the oversight team is to make decisions and adjustments based on the on-going monitoring program.

## Cost

The pilot grazing program includes moving livestock to and from the mountain during two seasons a year, as well as the labor and material to manage the animals full time, move fencing, provide water and supplemental feed, and conduct an efficient but robust monitoring program. The livestock would be grazing on the mountain a total of 8 to 10 weeks per year. The monitoring program is necessary to assure the goals and success criteria are being met and appropriate adjustments are implemented. The budget cost for this pilot program per year is $45,000 for implementation and $5,000 for monitoring. The program would cost **$ 150,000 for 3 years.**

### Infrastructure Improvements (*Long Range Planning*)

During the three years when the pilot goat grazing program is being conducted, permanent infrastructure improvements need to be planned and coordinated. In order to assure a successful and economic long-range stewardship grazing program, a permanent boundary fence system and a dependable water delivery system needs to be built for the Southeast Ridge grassland and the smaller Guadalupe Hills grassland.

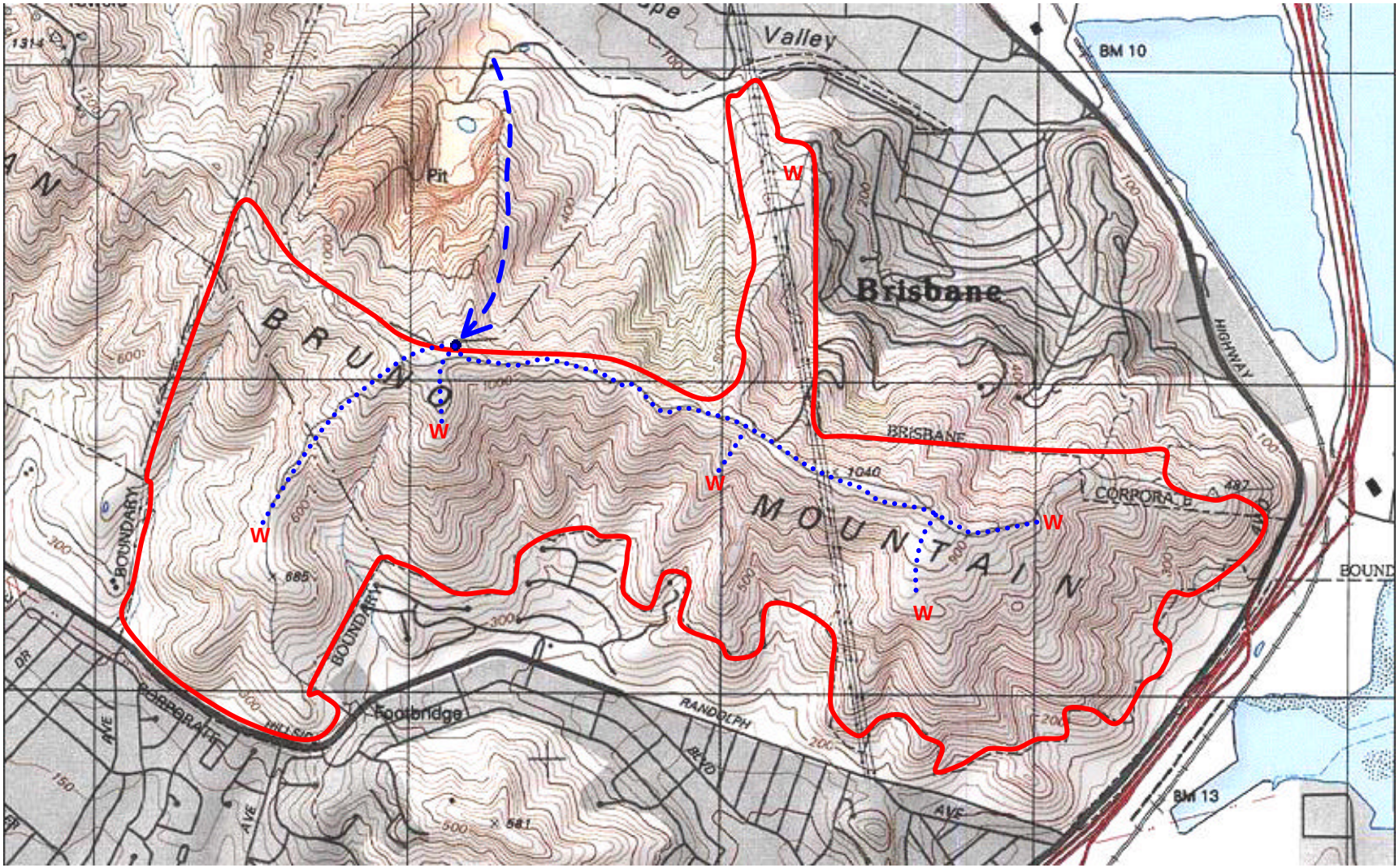
Fence: For the Southeast Ridge grassland there must be a continuous fence along the urban boundary. This fence boundary would include (See **Map 3**):

- The Brisbane corporate boundary (Brisbane Acres);
- The Terra Bay Phase 1-3 development boundary;
- The Park boundary along Hillside Boulevard; a northwestern fence alignment that links Tank Ravine to the ridge top along the western powerline alignment;
- A ridge fence that runs along the north side of the ridge above the quarry, Owl Canyon, and Buckeye Canyon;
- The north slope ridge grassland in the Brisbane/Army Road interface area along the eastern powerline.

The smaller Guadalupe Hills fence is not illustrated.

The fence should follow the ecological boundary of the grassland within the HCP area and not necessarily the current ownership boundaries. This means, for example, that grassland within the Terra Bay and Brisbane ownership will be included in the overall grazing management of the larger grassland. The design, location and cost for building the fence will need the cooperation and partnership of all boundary property owners on both sides of the fence. This applies to the boundary fence for the Guadalupe Hills where the Northwest Development is the primary boundary partner.

Ideally, the fence system should be built in a phased 5 year program, different sections at different times depending on the need of the developing pilot grazing program. For example, the fencing can be broken into five separate segments:




**MAP 3**. Conceptual fence and water system infrastructure for the Southeast Ridge grassland. The water sources are from the quarry and City of Brisbane. Water system shows six water troughs **W** and a buried 6000 gallon tank (cistern). The main line serves the cistern ---> and the secondary water lines ..... serve the water troughs along the ridge road and secondary ridges.

1.) A 2 mile segment along the eastern boundary of Pacific Nursery (Tank Ravine) and along Hillside Blvd. on Park property,
2.) A 3.6 mile segment along the back of the Terra Bay Development reaching around to the east side connecting to the City of Brisbane boundary,
3.) A 2 mile segment along the Brisbane Corporate Boundary from Bay Shore Blvd. to Guadalupe Valley,
4.) An internal 2.4 mile fence from the quarry road vicinity up the mountain (west of Army Road) to the ridge, west along the ridge top, and down the western boundary of the Southeast Ridge grassland along the western powerline alignment to the northeast corner of Pacific Nursery, and
5.) The 1.5 mile perimeter fence around the Guadalupe Hill grassland (not illustrated).

A ½ mile fence segment along Brisbane's western border will need to be designed to prevent trespass and disturbance of home backyards and provide access to a popular trailhead to the Buckeye Canyon and the Southeast Ridge grassland for local mountain hikers. Initially, large breaks will be left in the fence where trails, roads, or human passage is allowed onto the mountain. These gaps can be closed temporarily with temporary fencing when grazing operations are conducted for periodic livestock management. As the trail system and grazing program develop, the fence system can be completed and eventually permanent self-closing gates will be built in strategic locations.

Water: Just as important as the boundary fencing to a permanent long-range grazing program, is the establishment of a basic permanent water system for grazing these two fenced grassland units of the mountain. For the Guadalupe Hills grassland grazing area a water system can be hooked up to the existing water system that serves the Northeast Ridge Development. For the larger Southeast Ridge grassland, a buried water tank/cistern along the crest of the southeast ridge will be necessary so water can eventually be supplied to various strategically placed watering troughs. The conceptual map (**Map 3**) shows the cistern, source, and main service lines. The buried cistern is located in a saddle near or inside the quarry boundary. The source for the cistern will come from a permanently buried water line from the quarry operation. The quarry has an established tank and water source not far below this point. The water tank/cistern at the proposed site could double as a source of water that could be used to mitigate and restore the land after the quarry is abandoned. It is possible that a second buried cistern placed near the top of the eastern ridge crest can be served by a buried water line from the existing Terra Bay development water tank. The cost for establishing the second tank could come from the Terra Bay development as mitigation for the phased development. Water will have to be pumped to the ridgeline cisterns.

A grazing program utilizing up to 400 goats and/or sheep (or equivalent animals) will require from 1500 to 2500 gallons of clean water per day during the dry season; less when the forage is green or wet. A modest 4-6000 gallon tank can serve the water needs of a stewardship grazing program. Minimally, a water trough system being served by a main 4-6000 gallon water tank can provide 8-10 gallons of water a minute to optimally sustain livestock during peak watering periods. The tank will recharge during the night. A larger tank can double as a source of water for controlling a wildfire as well as a tool to conduct a prescribed fire program with added safety.

At the present time there is no water source for the Dairy Ravine area. A water source in this area would greatly facilitate a periodic grazing program in the saddle area south of Guadalupe Canyon Parkway.

**Costs**

*Fencing*. Approximately 11.4 miles of fencing will be needed to encompass the perimeter of the Southeast Ridge and Guadalupe Hills grasslands. Several rural professional fence builders were contacted for fence building cost estimates. The cost for fence construction varies with the terrain, rockiness, and access by equipment. The basic purpose of the fence is to prevent the escape of small to medium-sized livestock. The best type of fence for this use and terrain is the traditional California "field fence": a 4½ foot high combination woven wire fence (39") topped with three strands of barbed or smooth wire. The fence is constructed with 8 ft. metal t-posts 10 feet apart. Every 100 ft. a wooden post or galvanized pipe "post" is used for strength. A professional ranch fence contractor can construct a high quality fence for $4.50 per lineal foot. The potential cost for 11.4 miles of fence could be as high as $54,000 per year for 5 years or **$270,000 over a 5 year period**.

*Water System.* The rise in elevation from either the Terra Bay water tank or the quarry to the top of the ridge is approximately 800 ft. The water system will require a special pump and "schedule 80" PVC pipe able to withstand over 300 pounds of pressure. A submersible high-pressure 5-horse power pump can pump at a modest 5 gallons per minute rate. This will recharge an empty 6000 gallon tank in 20 hours. A pilot control circuit is necessary to trip the pump when water begins to draw down. The pump will need a housing, and a special "clay valve" should be used to prevent pipe hammering. An above ground 6000 gallon water tank can cost $2,500.00. A buried 6000 gallon tank can cost up to $5000.00 installed. Good quality water troughs cost approximately $350.00 each. The basic materials and labor cost for a single tank water system with pump, electrical, pipes, buried tank, and six water troughs could be as much as **$75,000**.

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