# 2015 Project: Mission Blue
# Summary of Milagra Ridge

Park Stewardship Program
Golden Gate National Parks Conservancy
Building 201 Fort Mason
San Francisco, CA 94123

## SUMMARY


### Lupine Diversification

We monitored the survivorship of summer lupine (*Lupinus formosus*) and silver lupine (*Lupinus albifrons var. collinus*) that were planted in the 2013-2014 planting season as part of Project: Mission Blue. The goal of the project is to establish Mission blue butterfly host plant species, such as summer lupine, that are more resistant to the effects of the fungal pathogen than silver lupine. As of April 1, 2015 the average combined survivorship of both lupine species was 8%. The presence or absence of a water-infused polymer did not significantly influence survivorship for either species as a whole.

The 2014/15 planting season augmented existing lupine habitat and expanded planting in areas where lupines grew well from the previous planting season. The planting areas at the Quarry and the Gun and Bunker Zone were expanded by planting *L. albifrons* and *L. formosus.* It was important that we plant lupines there to augment the exiting lupine habitat. Similarly, both species were also planted on Lupine Ridge to augment the exiting lupine habitat. We planted **395 lupines** (mostly *L. albifrons*) and all with water-infused polymers.

### Fungal pathogen monitoring of *Lupinus albifrons*

We monitored silver leaf lupine (*Lupinus albifrons var. collinus*) at the Quarry for evidence of the fungal pathogen *Colletotrichum lupini*. In 2010, the pathogen infected 92% of the plants, with an average of 50% leaf damage per plant. This season, the pathogen continued to decline, infecting 36% of plants with an average of only 1% leaf damage per plant.

### Mission blue butterfly monitoring

The 2015 Mission blue butterfly monitoring season at Milagra Ridge began on March 17 and occurred every 7-10 days until May 16. We monitored fifteen permanent survey transects on nine different occasions but only detected Mission blue butterflies on two on-transect surveys on April 23 and April 30. Only three Mission blue butterflies were observed, the lowest distribution ever recorded at Milagra Ridge. All three observations were of male Mission blues. There were an additional two off-transect observations at Transects 2 and 3 (one male and one female). These latest observations indicate that the Mission blue butterfly is in extreme danger of extirpation at Milagra Ridge.

*(The Mission blue butterfly survey transects locations and maps are not provided to protect the location of the these sensitive species)*

## 1. INTRODUCTION

This report summarizes the results of Project: Mission Blue (Lupine Diversification Project) and lupine pathogen monitoring. This report also summarizes the findings of the 2015 Mission blue butterfly monitoring season and examines patterns of Mission blue butterfly abundance, distribution, and phenology over the last 20 years.

## 2. NATURAL HISTORY

Milagra Ridge (San Mateo County) supports one of the few remaining populations of the endangered Mission blue butterfly (*Icaricia icarioides missionensis*) in the Golden Gate National Recreation Area.

The Mission blue butterfly is a member of the Lycaenidae butterfly family. It is a univoltine butterfly with an adult flight period ranging from mid-March through late May at Milagra Ridge (Shoulder 1995; DiGirolamo 1996; Hereth 1997; Lucas 1998). The adult life span is approximately 6-10 days (USFWS 1994). During this time, adults will visit several plants for nectar, but are particularly fond of wild buckwheat (*Eriogonum latifolium*), golden aster (*Chrysopsis villosa*), blue dicks (*Brodiaea pulchella*), and Ithuriel's spear (*Brodiaea laxa*) (Arnold 1983). Mission blue butterflies have been documented as being a highly variable subspecies, which is likely a phenotypic intermediate between *Plebejus icarioides pardalis* and *Plebejus icarioides pheres* (Murphy 1985). It is also suggested that Mission blue butterflies can acquire varying morphological characteristics due to selective forces in different environments (Steiner 1990).

Mission blue butterflies use three perennial lupine species as host plants: silver lupine (*Lupinus albifrons var. collinus*), summer lupine (*Lupinus formosus*), and varied lupine (*Lupinus variicolor*), of which *L. albifrons var. collinus* is considered its preferred host plant (Arnold 1983; Murphy 1985). Unlike *L. albifrons var. collinus* and *L. variicolor*, which tend to grow on rocky outcrops among coastal brush grasslands at ridgeline elevations, *L. formosus* is found typically at lower elevations, in less exposed areas, and in continuous grasslands that are more protected in canyons (Arnold 1983; Murphy 1985). Of the three lupine species, *L. formosus* is not found at Milagra Ridge though it has been documented on neighboring ridges and valleys. Summer lupine has been introduced to Milagra Ridge as part of the lupine diversification project.

Females usually lay single eggs on the dorsal side of pubescent lupine leaves, but eggs may also be laid on stems, flowers, and seedpods. Eggs hatch within 6-10 days, and the first and second instar larvae feed on the mesophyll of the host plant. Approximately three weeks after eclosion, the second instar larvae begin an obligate diapause, usually in the duff at the base of the host plant. Diapause begins at about the same time that the host lupine shifts at its energy from leaf maintenance to flower and seed production (Arnold 1983). Larvae remain in through winter and emerge to continue feeding in spring into the third and fourth instar. Pupation occurs in the duff at the base of the host plant or at the base of other plants around the host plant (Arnold 1983).

During the third and fourth instars, ants such as *Prenolepis imparis* and *Formica lasioides* tend to larvae. The ants are attracted by a sugary secretion produced by late-instar larvae. In return, larvae are protected from various parasitoids including a species of Tachinid fly and a Braconid wasp. Eggs are also parasitized by three species of Hymenoptera. Rodents prey upon larvae and pupae, and many pupae die due to desiccation (Arnold 1983). Trampling of host plants, larvae, and pupae is also a threat to survivorship.

Despite the aforementioned factors, monitoring suggests that the most significant threat to the Mission blue butterfly at Milagra Ridge has been outbreaks of a fungal pathogen (*Colletotrichum lupini*) that causes anthracnose in *L. albifrons* host plants. In 1998, the fungal pathogen negatively affected up to 70% of *L. albifrons* individuals park-wide, followed by precipitous declines in overall Mission blue abundance in 1999 and 2000. While many of the lupine populations recovered after the fungal outbreak, the butterfly populations did not. The impact of the pathogen on butterfly populations is still being investigated, as is shown in some of the analyses used in this report. In 2010, Milagra Ridge experienced another fungal pathogen outbreak affecting *L. albifrons,* which was followed by a second decline in Mission blue sightings.

## 3. SURVEYS AND LUPINE PLANTING

### 3.1 *Fungal pathogen monitoring of* Lupinus albifrons

In 2010, a fungal pathogen was detected at Milagra Ridge during monitoring activities and was identified as *Colletotrichum lupini*, a fungus that causes anthracnose (Figure 1) (Trouillas 2010). Of the three lupine host plants species, *L. albifrons var. collinus* seems to be most susceptible to the fungal pathogen. This is one of the same pathogens that was thought to be involved in the large-scale dieback of silver lupine in 1999 (Phystophere Research 1998).

**Figure 1.** The characteristics of anthracnose caused by the fungal pathogen, *Colletotrichum lupini* include vegetative dieback, leaf wilting, and a 'curly-cue' growth pattern of the flower stem as shown in this silver lupine inflorescence.

Since 2010, PSP has monitored for the fungal pathogen at the Quarry because this location has consistently supported the most Mission blue butterflies and was most impacted by the pathogen. We surveyed 20% of the silver leaf lupines. For each plant, we recorded the plant's size and the percent of dieback according to standardized categories

At the Quarry subsite in 2010, the fungal pathogen *Colletotrichum lupini* infected 92% of *L. albifrons* plants, with an average of 50% of the leaves damaged per plant. This season, the pathogen was still present, but its effects were less drastic than during its initial outbreak, infecting 36% of plants with an average of 1% of the leaves damaged per plant (Figure 2). According to Leagnavar (2012), the pathogen was detected in other lupine patches at Milagra Ridge but at low levels (< 5%) in 2012. This season, the pathogen did not appear to affect other lupine patches at Milagra Ridge. Since the pathogen is still present at the Quarry, it is important to continue disinfecting procedures after upon leaving the Quarry in order to prevent its spread.

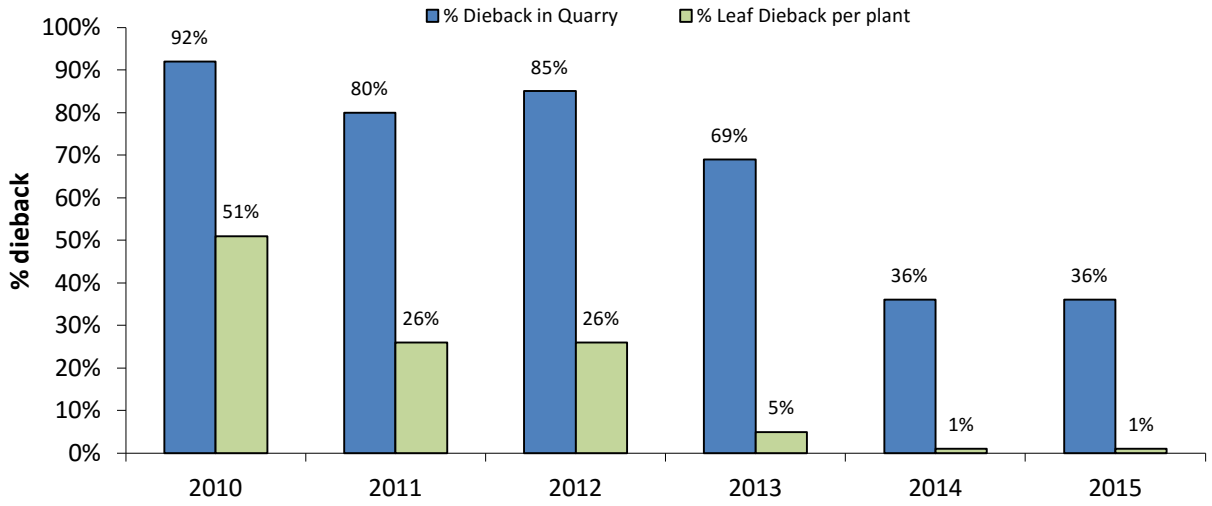



**FIGURE 2.** Milagra Ridge. Lupine dieback per year at the Quarry subsite.

### 3.2 *Lupine Diversification*

Since 2011, Price Sheppy, Community Programs Manager with the Park Stewardship Program, supported by California Garden Clubs Inc., has led efforts to diversify the lupine population at Milagra Ridge. This partnership is called Project: Mission Blue. At Milagra Ridge, *L. albifrons var. collinus* is the most abundant host plant species, making the butterfly populations that rely solely on this species vulnerable to extirpation if a significant fungal outbreak were to occur. Accordingly, the goal of the project is to protect the Mission blue butterfly by introducing multiple host plant species to Milagra Ridge in order to build a

**FIGURE 3.** *Lupinus variicolor* outplanted at the Quarry as part of the *Lupine Diversification Project*.

more resilient ecosystem. Diversifying the lupine population with *L. formosus* and *L. variicolor*, which have been shown to be less susceptible to the fungal pathogen, is intended to buffer against the effects of the pathogen

### 3.2.1 *Planting Season 2013/2014 Survey Results*

In 2013/14, the Park Stewardship Program outplanted *L. albifrons* and *L. formosus* throughout Milagra Ridge in order to establish diverse habitat patches that will connect the most robust Mission blue populations. In addition, half of the lupines were planted with water-infused polymer which slowly breakdown and release water to the plant. The goal was to see whether or not the presence of absence of the polymer affected lupine survivorship. For each lupine, above-ground caging was installed and snail and slug repellant was applied to reduce mortality due to herbivory.

The survivorship of each species planted in 2013/2014 was monitored in April 2015, almost a year after planting. The average survivorship in 2015 for both species together was 8% (Figure 4). Average survivorship declined in almost every plot since initial monitoring in April 2014 (Figure 5). Lupines planted in at the Quarry and in the Gun and Bunker Zone did well whereas lupines planted in rocky and compact areas such as Nike Basin did not. The presence or absence of a water polymer did not result in a strong difference in survivorship for either species

**Figure 4: Lupine Diversification Project Survivorship Monitoring – 2013-2014 planting**

*Note: The plot numbers in the graph below are based on the assigned plot numbers from the maps on the following page.*

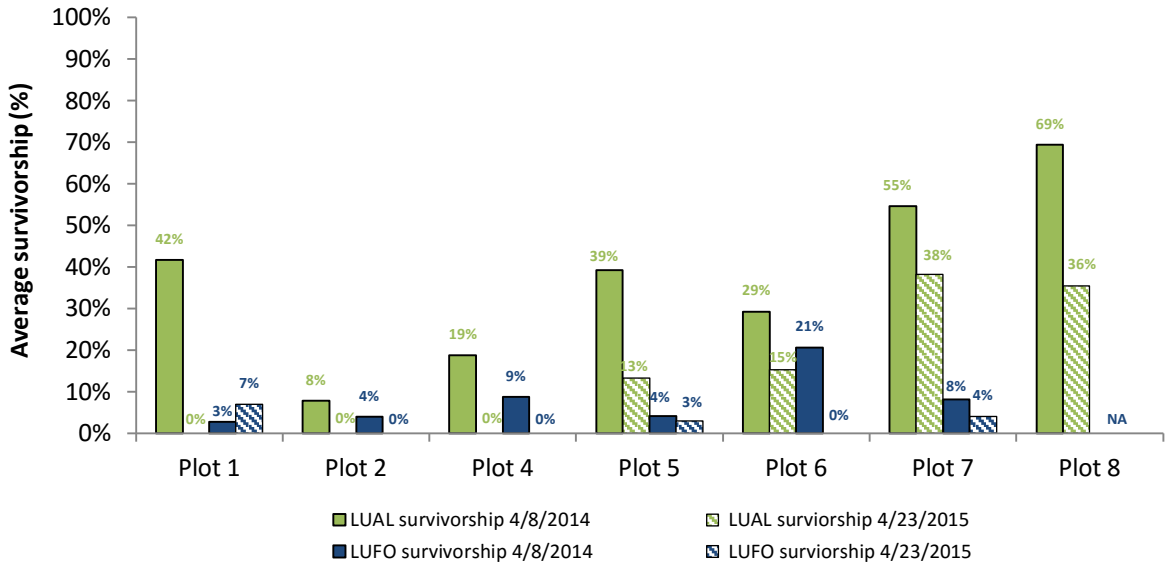
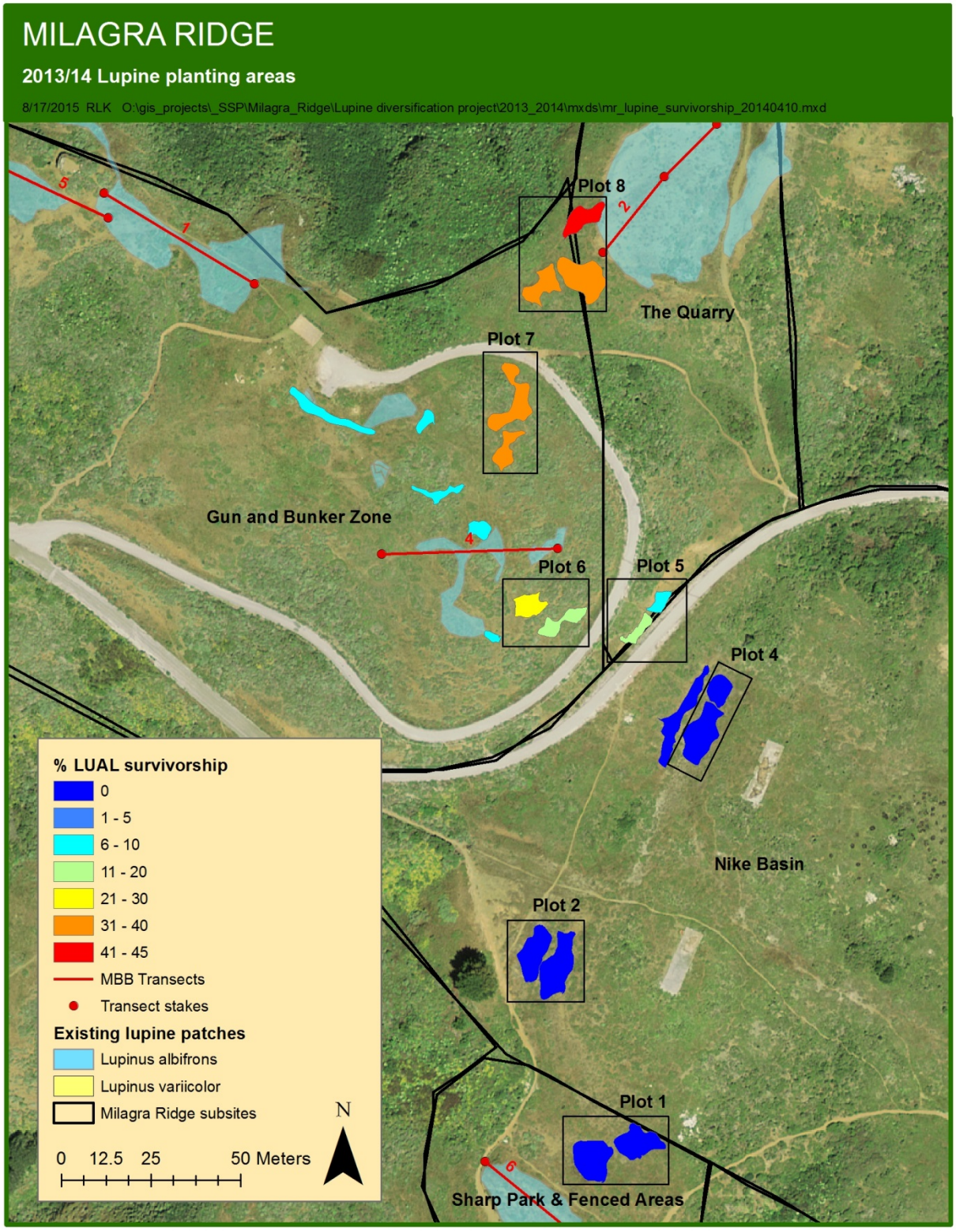


**Figure 5: Survivorship Monitoring of Planting Areas – 2013-2014 planting**

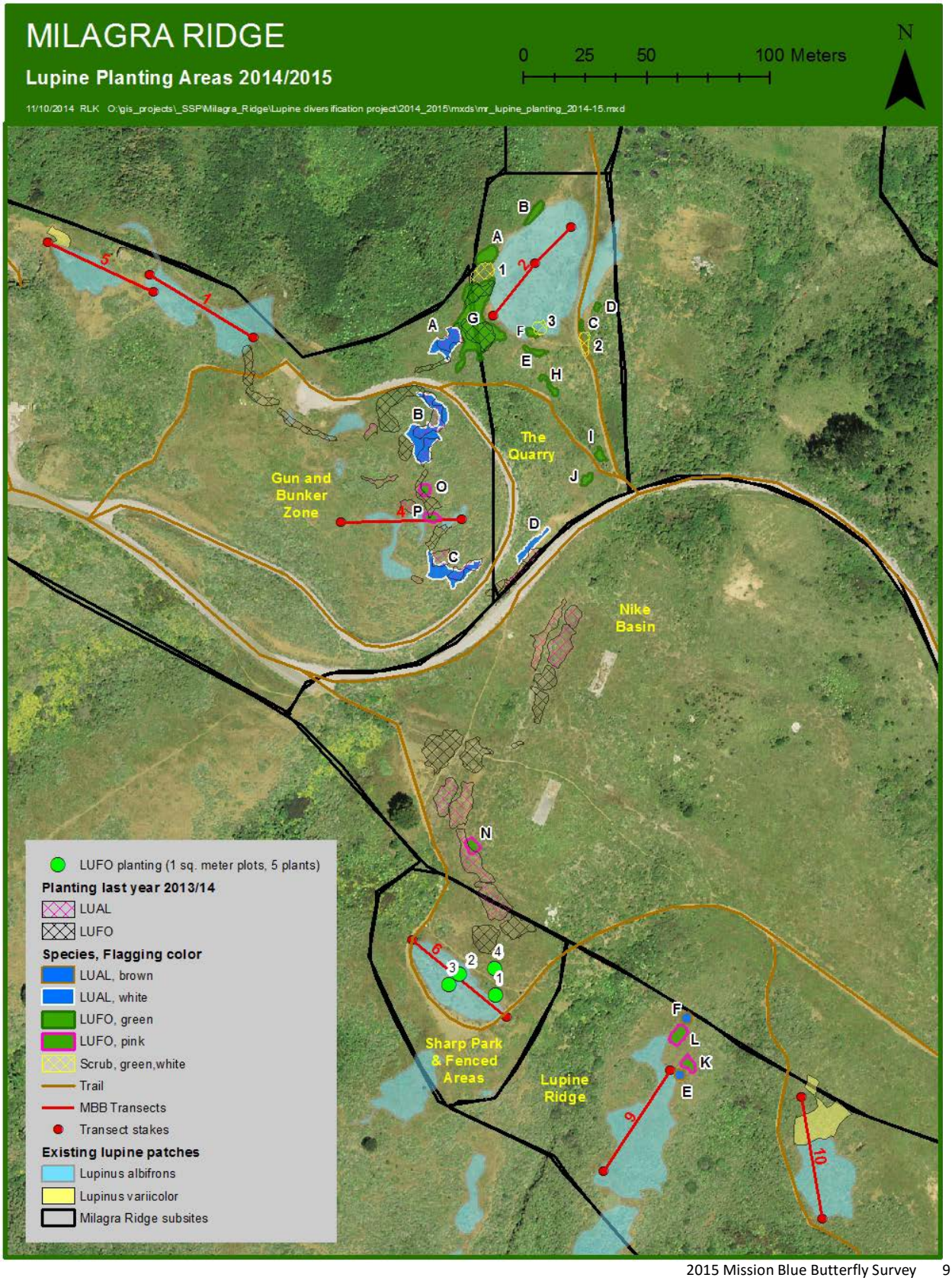


### *3.2.2 Planting Season 2014/2015*

The goal for the 2014/15 planting season was to augment existing lupine habitat and to expand planting in areas where lupines grew well from the previous planting season (Figure 6). The planting areas at the Quarry and the Gun and Bunker Zone were expanded by planting *L. albifrons* and *L. formosus.* It was important that we plant lupines there to augment the exiting lupine habitat. Similarly, both species were also planted on Lupine Ridge to augment the exiting lupine habitat. We planted **395 lupines** (mostly *L. albifrons*) and all with water-infused polymers. Like the previous planting season, all lupines were caged and *Sluggo* was applied. During this planting season, the lupines were watered twice a month throughout the year during dry months or on an as needed basis. The survivorship of the 2014/15 lupine plantings have not been monitored but will be in the spring of 2016.

In the 2014-2015 planting season, we planted *L. albifrons* and *L. formosus* in winter 2014 and all plants were planted with water-infused polymers, caged, and *Sluggo* was applied. By December 2014, all of the *L. formosus* grown at San Bruno Mountain were outplanted and a few *L. albifrons* from the Marin Headlands nursery were planted. Planting was halted due to park-wide concerns related to *phytophthora*. Lupine planting resumed in July 2015 and all remaining lupines that survived in the Marin Headlands nursey were outplanted. Lupines were watered and *Sluggo* was applied once every two weeks during dry months or on an as needed basis. Lupine "maintenance" paused in September after the lupines naturally senesced. Survivorship of lupines planted in the 2014-2015 season will be analyzed in the spring of 2016.

**Figure 6: Lupine Planting Areas – 2014-2015**



## 4. MISSION BLUE BUTTERFLY SURVEY

*(The Mission blue butterfly survey transects locations and maps are not provided to protect the location of the these sensitive species)*

### 4.1.1 *Abundance*

Relative abundance of Mission blue butterflies decreased from last season. In 2015, only three butterflies were recorded on all transects at Milagra Ridge, a decrease from twenty two individuals in 2014 and eight individuals in 2013 (Figure 7). All observations were male on the legacy transects (Figure 8). The two off-transect observations consisted of one male and the only female observation of the year, and all were recorded on the legacy transects. Diane Darling and Margaret Gooddale (experienced monitors since 2006) also monitored for the Mission blue this year. Diane observed one male near Transect 2 on April 2 but she was not confident in her observation and it was never confirmed.

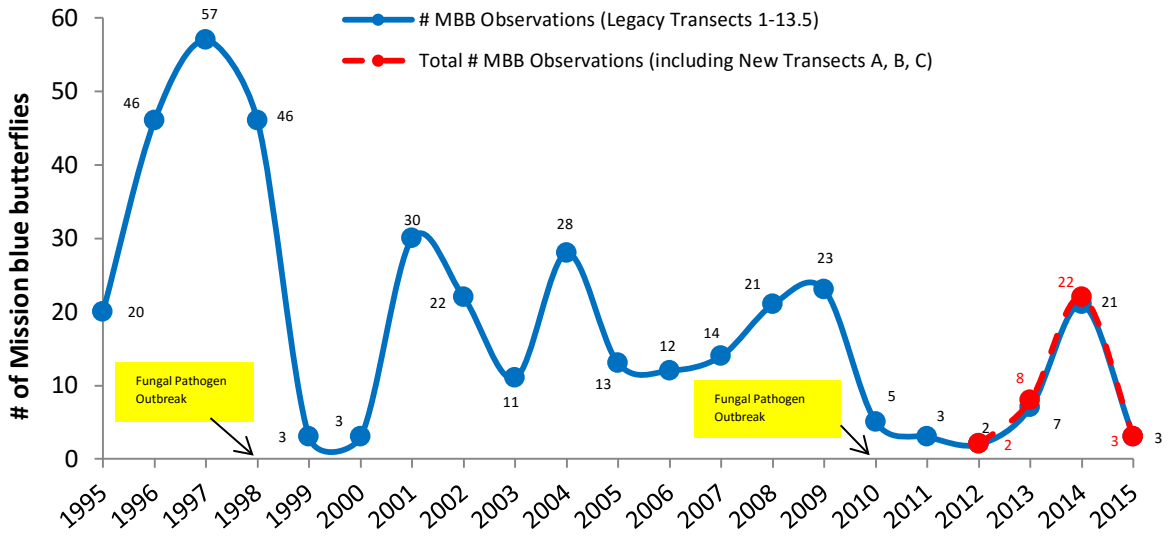



**FIGURE 7.** Milagra Ridge. Mission blue butterfly observations per year. The relative abundance of Mission blue butterflies increased since 2013, peaked in 2014 and has since declined.

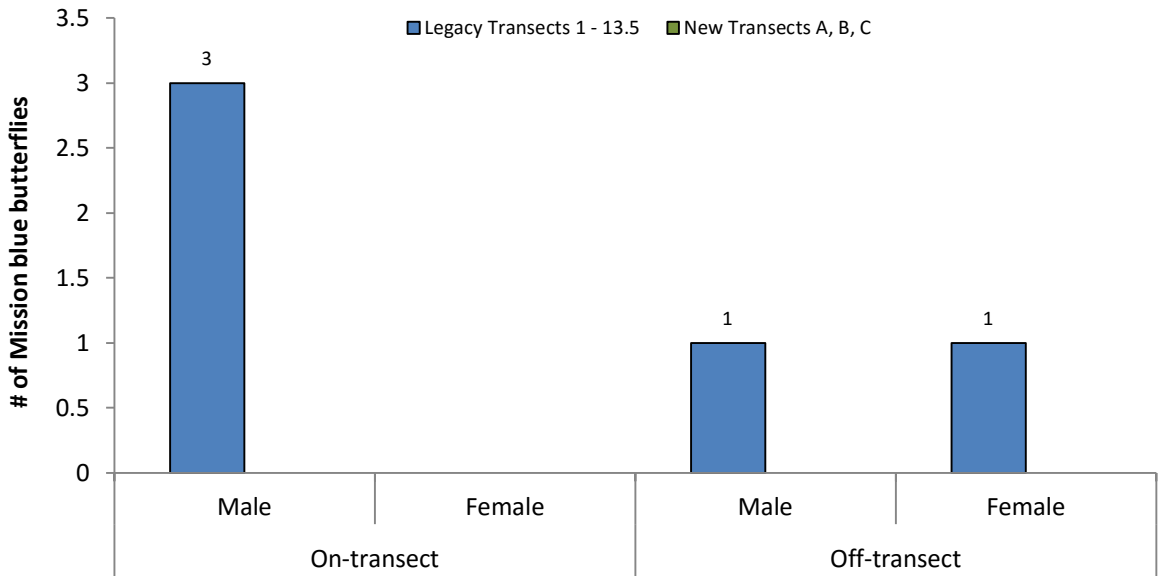



**FIGURE 8.** Milagra Ridge. The relative abundance of Mission blue butterflies observed in 2015.

Following a fungal pathogen outbreak in 1998, the relative abundance of butterflies significantly declined from pre-pathogen years (considering on-transect observations only). After 2000, relative abundance began increasing until another pathogen outbreak in 2010, after which relative abundance again declined. In 2015 the relative abundance is at its lowest since 2012 (Figure 9). Despite the spike of observations in 2014, the overall trend since 1995 is one of decline.

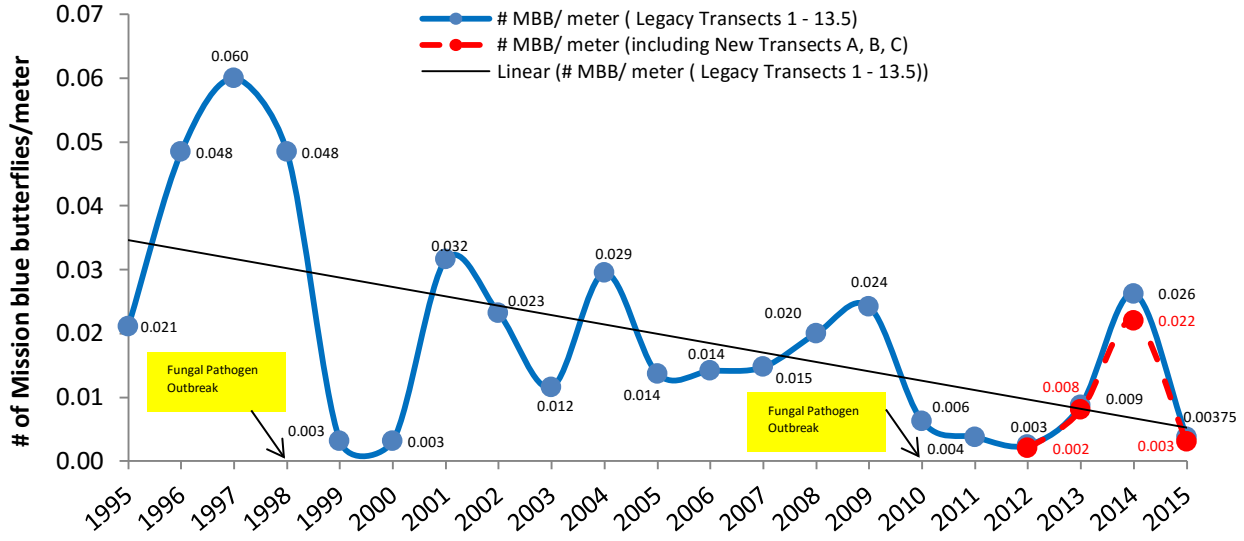



**FIGURE 9.** Milagra Ridge. Frequency of Mission blue butterfly observations per year at transect locations.

### 4.1.2 *Distribution*

In addition to the decline in Mission blue butterfly relative abundance, the number of transects on which the butterflies were observed also declined (Figure 10). In 2015, Mission blue butterflies were observed on only one transect, a decline from five transects in 2014 and three transects in 2013.

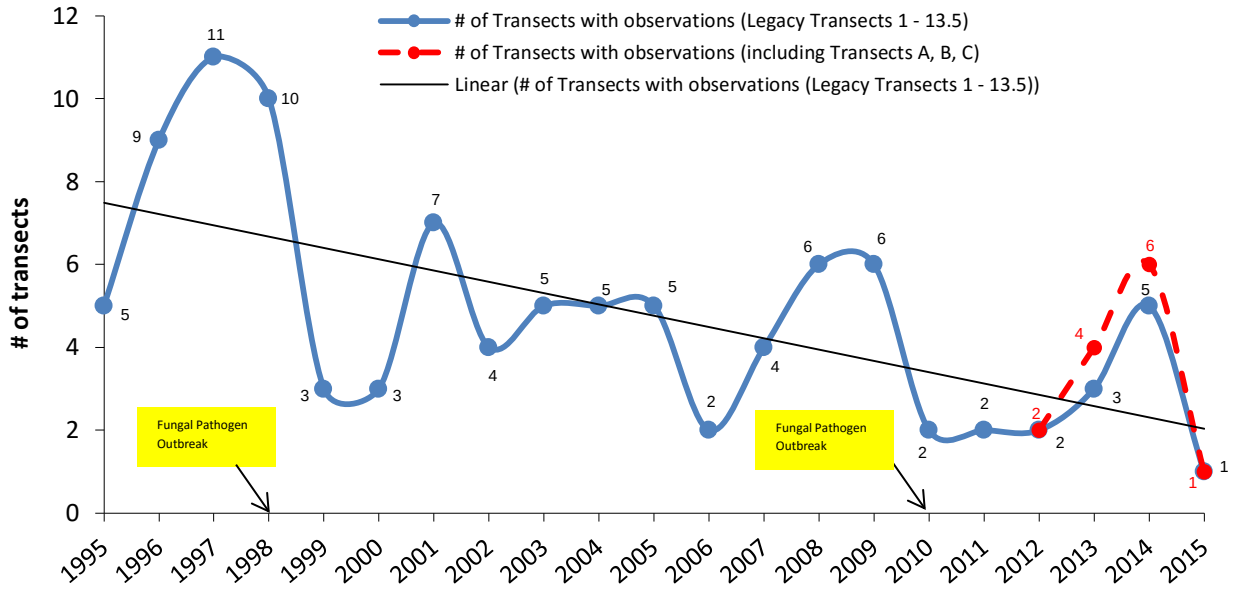



**FIGURE 10.** Milagra Ridge. Number of transects with on-transect Mission blue butterfly observations.

This is the lowest distribution ever recorded at Milagra Ridge, with on-transect observations of Mission blue butterflies only seen on Transect 2 (Figure 11). Off-transect observations were also seen on Transects 2 and 3. Transect 2 has always had the highest percentage of on-transect observations (64% in 2014), but never before have all observations been concentrated here. Distribution has decreased overall since monitoring began in 1995. While 2014 marked a large increase in distribution (five transects), distribution was at an all time low in 2015.

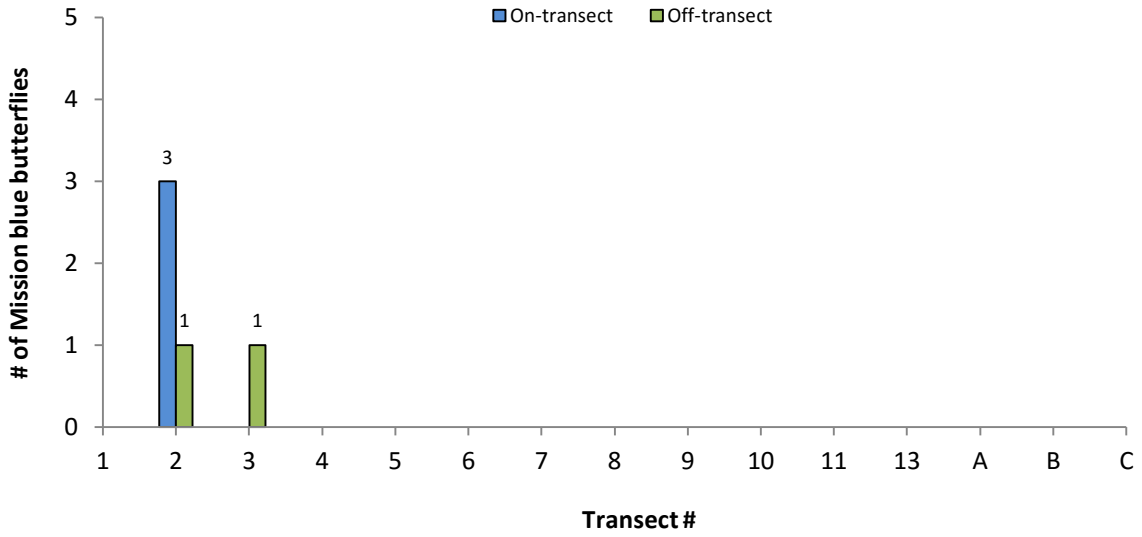



**FIGURE 11**. Milagra Ridge. Number of Mission blue butterflies observed on- and off-transect per transect in 2015.

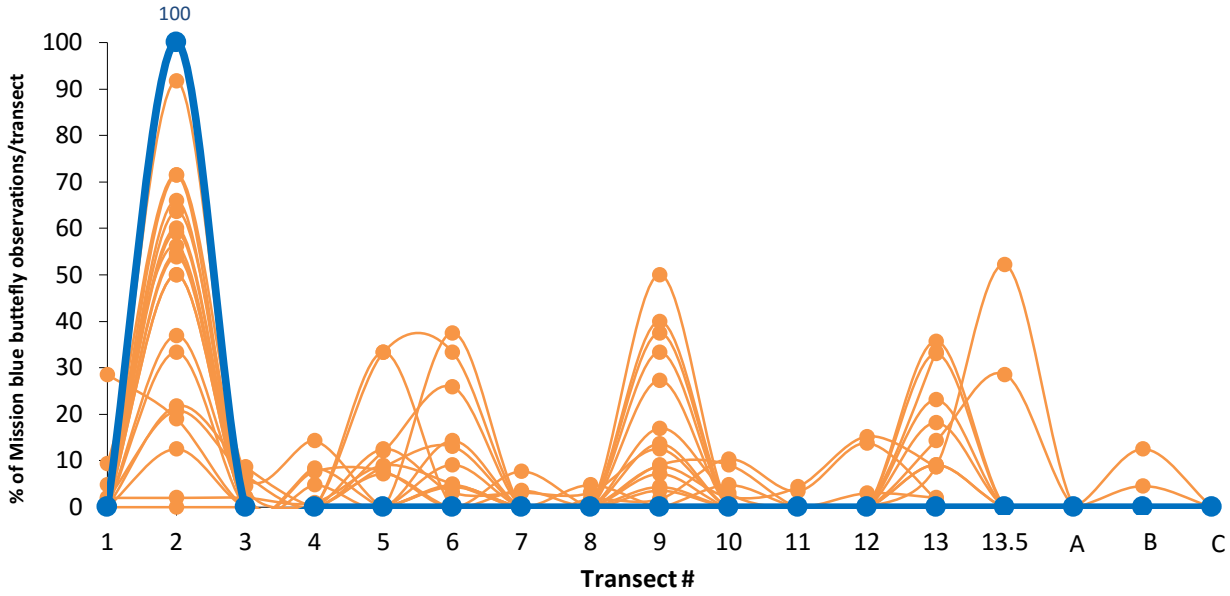



**FIGURE 12**. Milagra Ridge. Percent of Mission blue butterfly on-transect observations per transect since 1995. Observations in 2015 are symbolized in blue.

Poor flight ability and distance between habitat patches are the most significant hurdles preventing Mission blue butterfly dispersal. Establishing connectivity between Transect 2 and other transects is more important than ever because it has the highest number of butterfly observations. The closest transects to Transect 2 are Transects 1, 5, and 4, which have not supported butterflies in recent years. One mission blue was observed off-transect near Transect 3, which has not had any butterflies since 2008.

### 4.1.3 *Phenology*

During the nine week monitoring season, Mission blue butterflies were observed on-transect on only two different monitoring days: April 23 and 30. Off-transect observations were made on April 2 and April 9 (Figure 13). The Mission blue flight season is defined as the first and last week butterflies were observed on-transect and the weeks in between, regardless of whether butterflies were observed. This year the season was only two weeks, which was one week shorter than in 2014 (Figure 14). Overall, the length of the flight season has declined since 1995 (Figure 15).

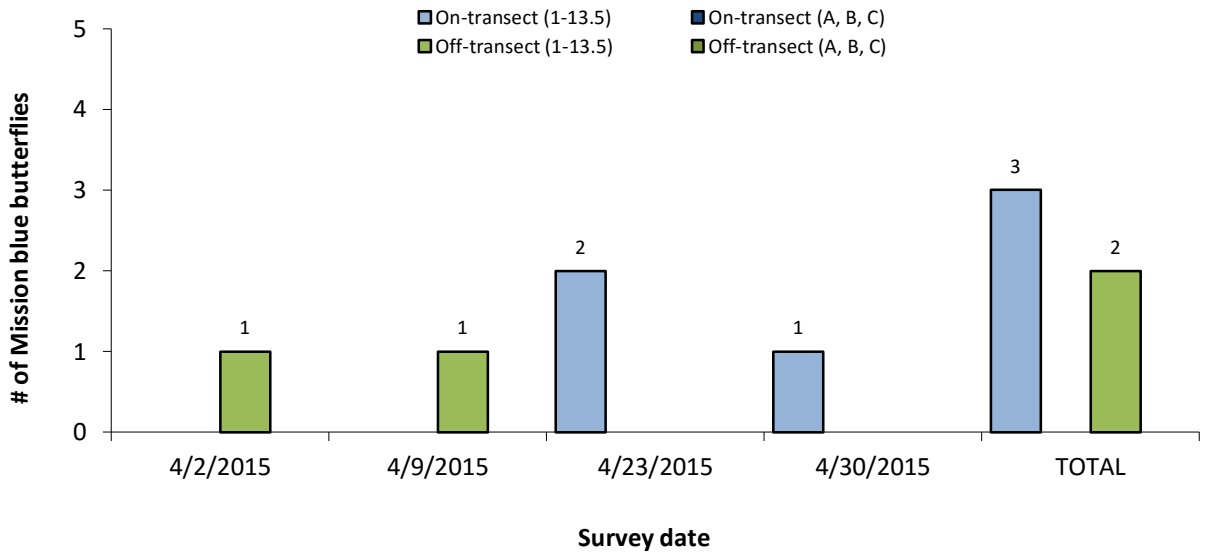



**FIGURE 13.** Milagra Ridge**.** On- and off-transect Mission blue observations by survey date in 2015.

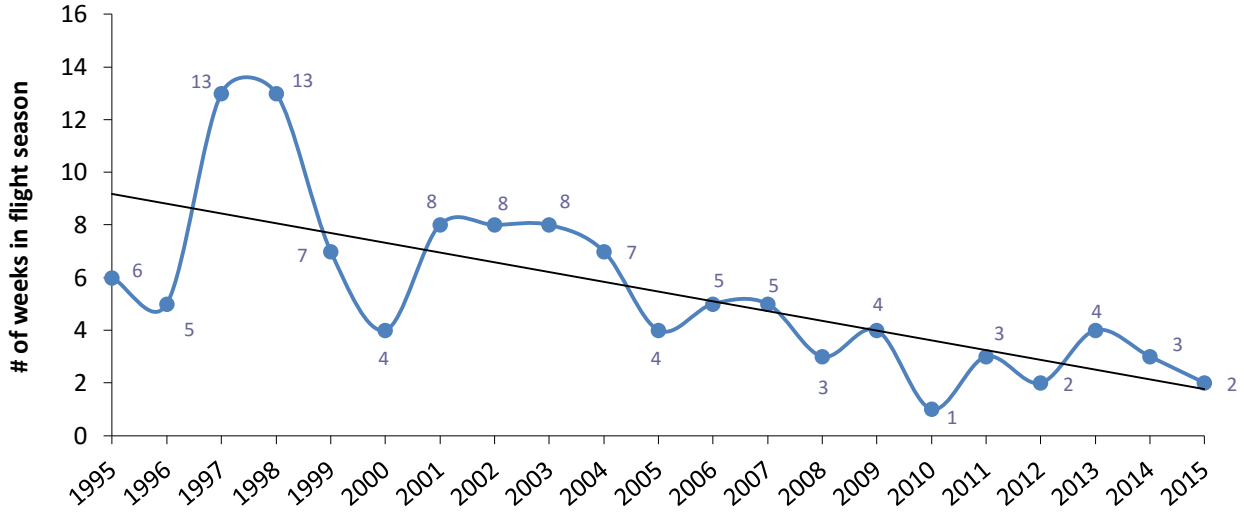



**FIGURE 14.** Milagra Ridge**.** Annual flight season comparison.

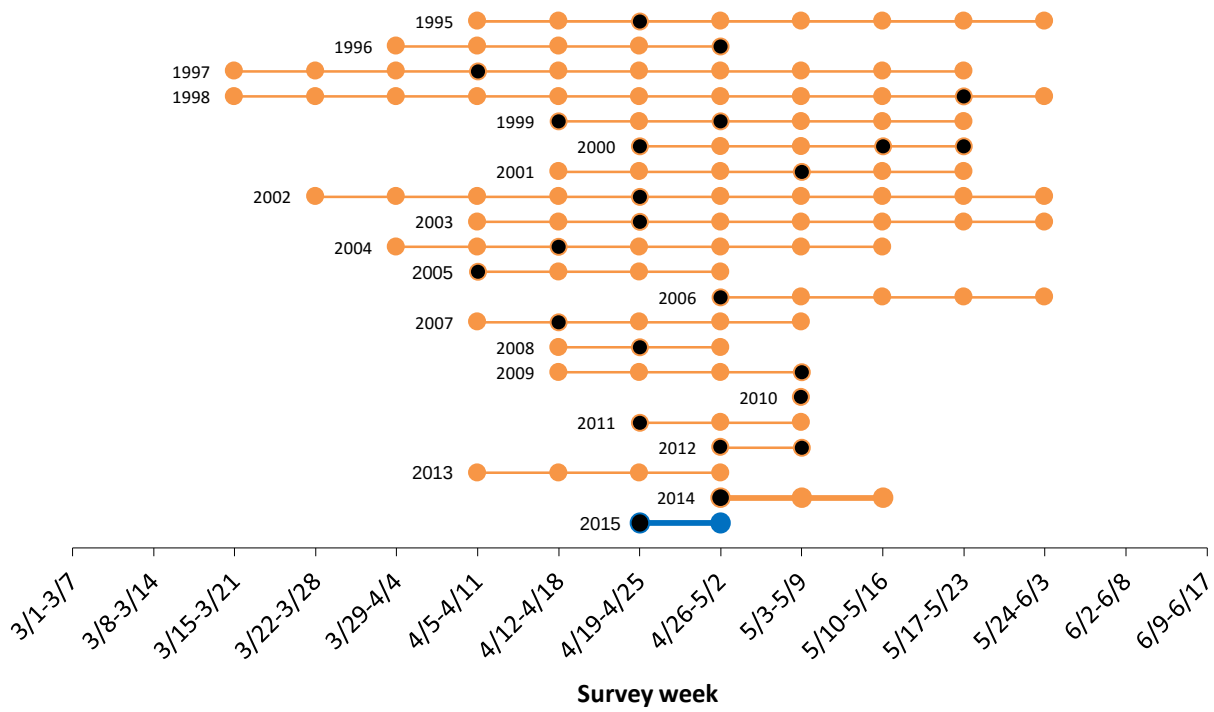



**FIGURE 15.** Milagra Ridge. Annual comparison of flight season duration. The peak in observations each season is presented in black. Multiple peaks represented equal number of observations.

## 5. CONCLUSION

Within a flight season of only two weeks, only three male Mission blue butterflies were observed on only one transect during the 2015 monitoring season. These declines in flight season, relative abundance and distribution indicate that the Mission blue butterfly is in extreme danger of extirpation at Milagra Ridge.

## 6. RECOMMENDATIONS

### 6.1 *Lupine Planting*

Mission blue butterflies are still endangered and on the brink of collapse at Milagra Ridge. Continued planting of lupines to increase the lupine populations is critical in keeping these populations alive.

### 6.2 *Lupine Survivorship Monitoring*

Monitor lupines from the 2014-2015 planting season in the spring of 2016 to determine survivorship. Remove cages on healthy lupines prior to the 2016 flight season and monitor for eggs to see if butterflies are colonizing revegetated patches. Cease application of *Sluggo* at least two weeks prior to

removing cages and before the flight season. This will ensure that any Mission blue larvae or adults would not come into contact with *Sluggo* when occupying lupine plants that were outplanted. Continue to establish *L. formosus* in preparation for Mission blue butterfly reintroduction efforts.

### *6.1 Fungal Pathogen*

Maintain disinfection procedures at all transects to prevent further spread of pathogens.

## REFERENCES


Arnold, Richard A. 1983. Ecological Studies of Six Endangered Butterflies (Lepidoptera, Lycaenidae): Island biogeography, patch dynamics, and the design of habitat preserves. UC Publications in Entomology, Volume 99. UC Press.

Bennett, Susie, Crooker, Christina, Sheppy, Price. 2013. Lupine Diversification Project to buffer again negative impacts of fungal pathogen on Mission blue butterflies: background, proposal, and compliance analysis. Golden Gate National Recreation Area,

DiGirolamo, Lisa. 1996. 1996 Survey on the Status of the Endangered Mission Blue Butterfly on Milagra Ridge in the Golden Gate National Recreation Area. Golden Gate National Parks Association, Golden Gate National Recreation Area.

Hereth, Cristine. 1997. Mission Blue Butterfly Monitoring Report - Milagra Ridge. Golden Gate National Parks Association, Golden Gate National Recreation Area.

Kwan, Ruby. 2015. Draft Summary Report, 2013-2014 Lupine Survivorship, Lupine Diversification Project, Milagra Ridge. Golden Gate National Parks Conservancy, Golden Gate National Recreation Area.

Leagnavar, Tida, Whitty, Eira, Crooker, Christina. 2013. 2012 Mission Blue Butterfly Survey, Milagra Ridge. Golden Gate National Parks Conservancy, Golden Gate National Recreation Area.

Lindzey, Summer. 2006. Mission Blue Butterfly Survey Milagra Ridge. Golden Gate National Parks Conservancy. Golden Gate National Recreation Area.

Lucas, Shannon. 1998. Mission Blue Butterfly Habitat Monitoring - Marin Headlands and Milagra Ridge. National Park Service Report, Golden Gate National Recreation Area.

Murphy, Dennis D. 1985. Report on the status of *Plebejus icarioides Missionensis* in the Skyline College Vicinity of San Mateo County, California.

Phytosphere Research. 1998. Preliminary Assessment of Lupinus Albifrons Decline on GGNRA Lands.

Shoulders, Carolyn. 1995. The 1995 Mission Blue Butterfly Census At Milagra Ridge, Pacifica, CA. Golden Gate National Parks Association, Golden Gate National Recreation Area.

Steiner, John. 1990. Bay Area Butterflies; the Distribution and Natural History of San Francisco Region Rhopalocera. MS Thesis, California State University Hayward.

Thomas Reid Associates. 1982. Endangered Species Survey. San Bruno Mountain Biological Study – 1980 and 1981.

Trouillas, Florent. E-mail to Samuel Abercrombie. May 12, 2010.

US Fish and Wildlife, 1984. Recovery Plan for the San Bruno Elfin and Mission Blue Butterflies. U.S. Fish and Wildlife Service, Portland, Oregon. 81pp.