

Progress Report for the Mission Blue Butterfly at Twin Peaks Natural Area

Annual Report 2023

USFWS Permit TE-30659A-3

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January 2024

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Executive Summary

Success continues with the Mission blue butterfly (MBB) recovery project at Twin Peaks Natural Area. This report covers activities in 2023, the 15th season since the first translocation in 2009.

Based on analysis of population estimates for monitoring different life stages, we have concluded that egg monitoring provides reliable estimates and is relatively easy to conduct. MBB eggs are distinctive, and monitoring at this stage is not dependent on weather. The entire egg season was well documented, with the exception of about a week missed at the beginning.

Using the available egg data, the MBB population on Twin Peaks is estimated at 128 females in 2023. This is essentially the same as the ~120 females in 2022. This is down from 242 females in 2021, but up from 76 females in 2020, up from 59 females in 2019, 37 in 2018, and 89 in 2017. Based on the relatively high estimate for 2021, there were no adult translocations in 2022. At this point we intend **not** to translocate in 2024, and to document whether and how the population changes without additional inputs. If the estimated female population drops below 100 in 2024, we will recommend translocations in 2025. If we do translocate in 2025, we may ask to reserve the entire 40 female quota. This will of course be discussed with all stakeholders when appropriate.

Scrub removal to maintain grassland habitat and lupine planting to increase number, distribution, and species richness of host plants continue to be high priorities. Based on success with experimental lupine seeding, lupine seeding scaled up this year, with approximately 12,500 *Lupinus albifrons* and 4,500 *Lupinus formosus* seeds planted in late fall 2022. In fall 2023, Creekside Science supplied 0.75 lb *Lupinus albifrons* (~12,500 seeds) and 52 grams of *Lupinus formosus* (~1,250 seeds). Seeding started in November 2023. Funding for lupine propagation at the Creekside Science Conservation Nursery was provided through the USFWS Partners for Fish and Wildlife program. (Seeds were also shared and installed on San Bruno Mountain.)

Lupine mapping is planned for spring 2024. Our MBB population estimates are based on numbers of lupine in each management area, so updating this information is relevant for accurate estimates.

The San Francisco Recreation and Park Department (SFRPD) continues weed management on numerous target weed species, particularly ones that have the capacity to degrade lupine/grassland habitat.

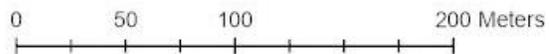
2023 MBB survey results

Larval surveys

Surveys are conducted for postdiapause larvae and their feeding evidence. Larval searches are done to determine phenological stage (i.e., to try to predict beginning of flight season). In 2023, four management areas were surveyed: Gardenside, Mission Bowl, Mission Flats, and Mission Ridge (Map 1). Surveys took place on March 20 and April 3, 2023. At each site, 30 randomly selected plants were searched. This yielded 240 plants searched in 2023.

During the surveys, feeding evidence was observed on 8 of 240 (3.3%) plants searched. When multiplied out by the number of lupines in each subarea (for more information see Table 3), we estimate 260 plants with feeding evidence (Tables 1-3). We note the difficulties of classifying feeding evidence and converting into a population estimate, so the variable numbers over time should be taken with caution.

No larvae were observed in 2023 (Figure 1).



Map 1. Twin Peaks management areas

Date	Site	# Random lupines with feeding evidence	Total # larvae observed	Total lupines surveyed for larvae	Lupine multiplier	Estimated lupines with feeding evidence (# random lupines w/ feeding evidence x lupine multiplier)
3/20/2023	Mission Bowl	0	0	30	14.9	0
3/20/2023	Mission Flats	0	0	30	43.2	0
3/20/2023	Mission Ridge	2	0	30	18.8	38
3/20/2023	Gardenside	0	0	30	14.0	0
4/3/2023	Mission Bowl	0	0	30	14.9	0
4/3/2023	Mission Flats	4	0	30	43.2	173
4/3/2023	Mission Ridge	2	0	30	18.8	38
4/3/2023	Gardenside	0	0	30	14.0	0
Total		8	0	240		211*

Table 1. Postdiapause larval feeding evidence survey results 2023. *The total of 211 does not double count the 2 larvae found on Mission Ridge on 3/20.

Year	Lupines with feeding evidence (%)
2023	3.3
2022	22.5
2021	6.7
2020	11.5
2019	3.9
2018	28.1
2017	2.1
2016	4.1
2015	5.5

Table 2. Overall rates of lupines with feeding evidence over time (Mission Bowl, Mission Flats, Mission Ridge, and Gardenside)

Year	Estimated # lupines with feeding evidence
2023	217
2022	703
2021	178
2020	351

Table 3. Estimated number of lupines with feeding evidence over time (Mission Bowl, Mission Flats, Mission Ridge, and Gardenside). Data are from 2020 only when larval searches became less frequent.

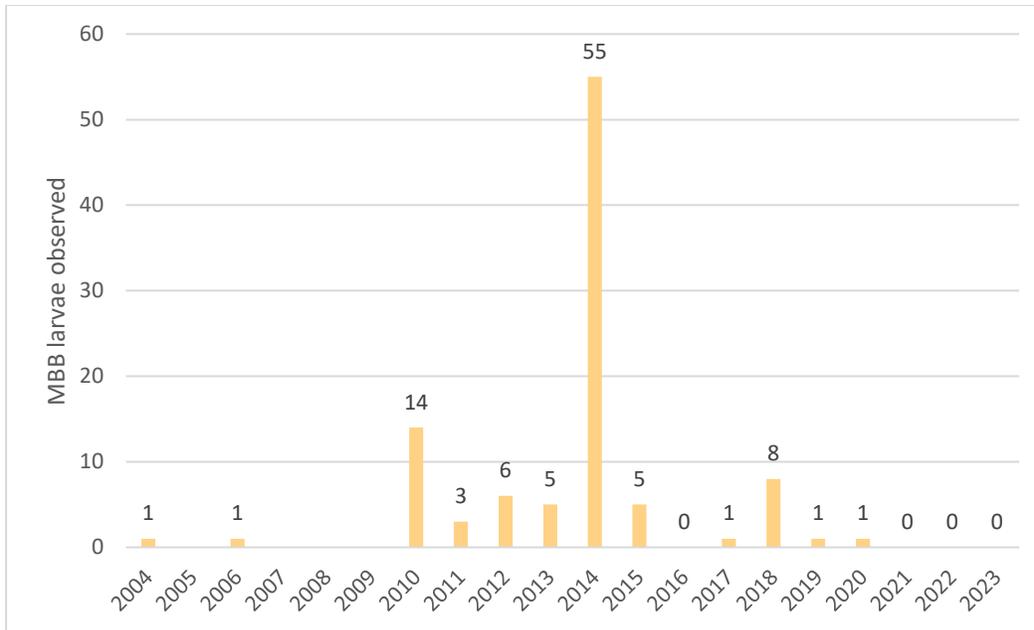


Figure 1. Post diapause MBB larvae observed at Twin Peaks over time. No surveys took place 2005, or 2007-2009. Note these observations were based on chance encounters during feeding evidence surveys and not formal surveys for larvae.

Adult surveys

Per previous reports, we concluded that egg surveys are the most reliable method for determining Mission blue butterfly abundance. No formal adult monitoring took place in 2023.

However, incidental observations were recorded in 2023 during egg monitoring. One adult of indeterminant sex was identified 4/24 Mission Flats, and the same each at Mission Bowl and Mission Flats May 1, 2023, for a total of three incidental adult observations.

Egg surveys and population estimates

Weiss et al. (2016) compared the accuracy of different population estimate methodologies based on surveying the three life stages: post diapause larvae, adults, and eggs. Estimates based on the three surveys gave similar results. Larval searches tend to yield very low numbers of larvae because larvae are well camouflaged and difficult to locate. Their feeding evidence can also be difficult to differentiate from other herbivory. Dampness on vegetation can further confound the searching. Adult surveys also tend to yield low numbers and are extremely weather dependent. Adult flight is limited by clouds, high winds, and cool temperatures, each of which are common during the flight season. Eggs are small but distinct and therefore straightforward to identify. They are present during all sorts of weather, increasing the ease of surveying. Because surveying all three stages is time-consuming, and the occupied habitat is relatively small, it was determined several years ago that egg estimates are the best sampling technique for Mission blues on Twin Peaks.

Since 2017, egg surveys were conducted at Gardenside, Mission Ridge, Mission Bowl, and Mission Flats. Eggs were counted on 30 randomly chosen lupines in each management area. To estimate the

population from the egg surveys, the number of lupines from the 2018 census is divided by 30 (representing the searched lupines) to yield the lupine multiplier. The lupine multiplier is multiplied by the sum of eggs found on the 30 plants to produce a total egg estimate for each management area. We assume complete turnover of eggs from week to week, and that each female lays 80 eggs over her lifespan (Weiss et al. 2017, 2016; Arnold 1983). The total eggs estimated is therefore divided by 80 to yield an estimated number for female population size. Translocated females are assumed to lay half the number of eggs as a resident female (40 eggs).

The details of data analysis for 2017-2022 are in previous reports, and will not be repeated here, except for summary statistics. Table 5 has complete 2023 data for the calculations of female numbers from fresh eggs.

2023 Egg counts

In 2023, the egg surveys started April 17 and extended to June 28, a very late season. The egg surveys were complete from the start of the season to the end. The first fresh egg was observed on April 17, fresh eggs peaked at 78 on May 8, and declined into mid-June. Hatched eggs appeared on May 15, and peaked at 67 on May 30, and trailed off with the last hatched eggs observed on June 28. Sample intervals averaged 6.8 days (range 5-8 days) (Figure 2). The ratio of hatched to fresh was 92% (Table 4). The weighted mean dates of fresh and hatched egg observations (defined as the mean of the curves in Figure 2) were May 7 and June 2 respectively, a difference of 24 days.

Eggs were found in all four subareas in 2023, with the highest count in Mission Flats (207 fresh eggs total). The lowest count was at Gardenside (5 fresh eggs total). Counts at Mission Ridge and Mission Bowl were 27 and 47 respectively.

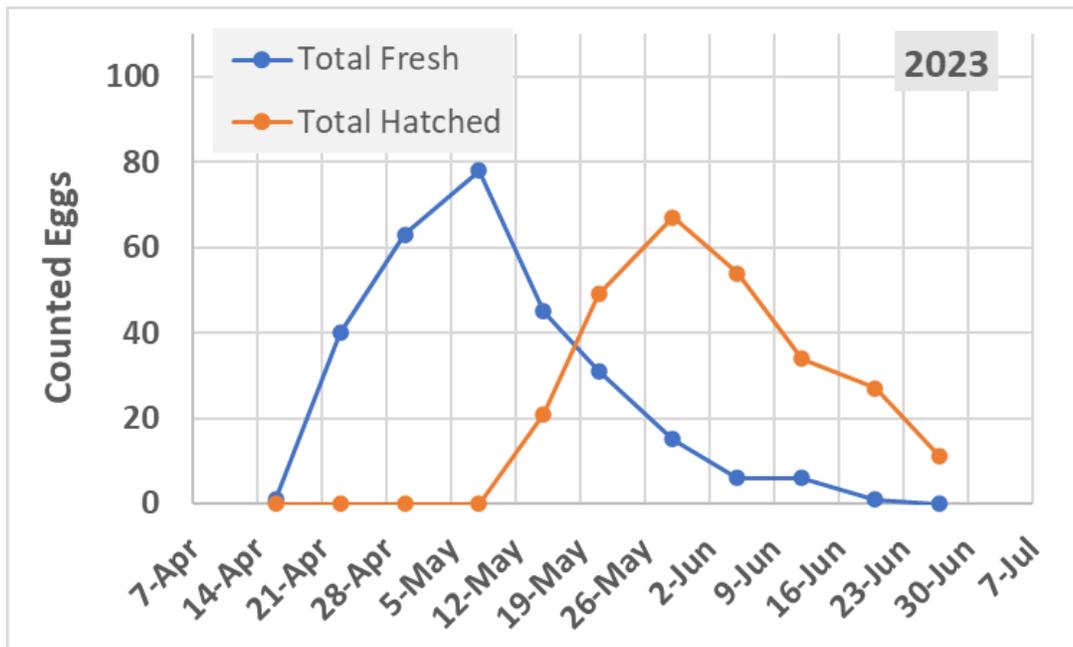


Figure 2. Egg counts 2023, separating out fresh and hatched eggs.

Comparisons with other years include ratios of hatched/fresh eggs (Table 4) and total counted eggs (Figure 3). Most years show a complete sequence of rising then falling egg counts, and much lower numbers. The incompleteness of the 2020 data (orange line) is apparent with the mid-season start of the egg counts, and the high ratio (419%) of hatched/fresh relative to other years (47-84%).

The weighted mean dates of fresh egg observation show a range from 4/3 (2022) to 5/9 (2018, 2019, and 2023), and the difference between fresh and hatched observations was 11 (2017) to 24 (2023) days.

Year	Fresh	Hatched	Hatched: Fresh Ratio	Fresh Date	Hatched Date	Difference
2017	474	290	61%	5/4	5/15	11
2018	112	53	47%	5/9	5/23	14
2019	368	209	57%	5/9	5/25	16
2020	68	285	419%	N/A	N/A	N/A
2021	854	716	84%	4/26	5/18	21
2022	339	288	85%	4/3	4/21	18
2023	286	263	92%	5/9	6/2	24

Table 4. Total fresh and hatched eggs observed 2017-2023. In 2020, the incomplete data do not provide a reliable estimate (N/A). The “Fresh Date” and “Hatched Date” are weighted means, calculated by the proportion of yearly eggs on each date.

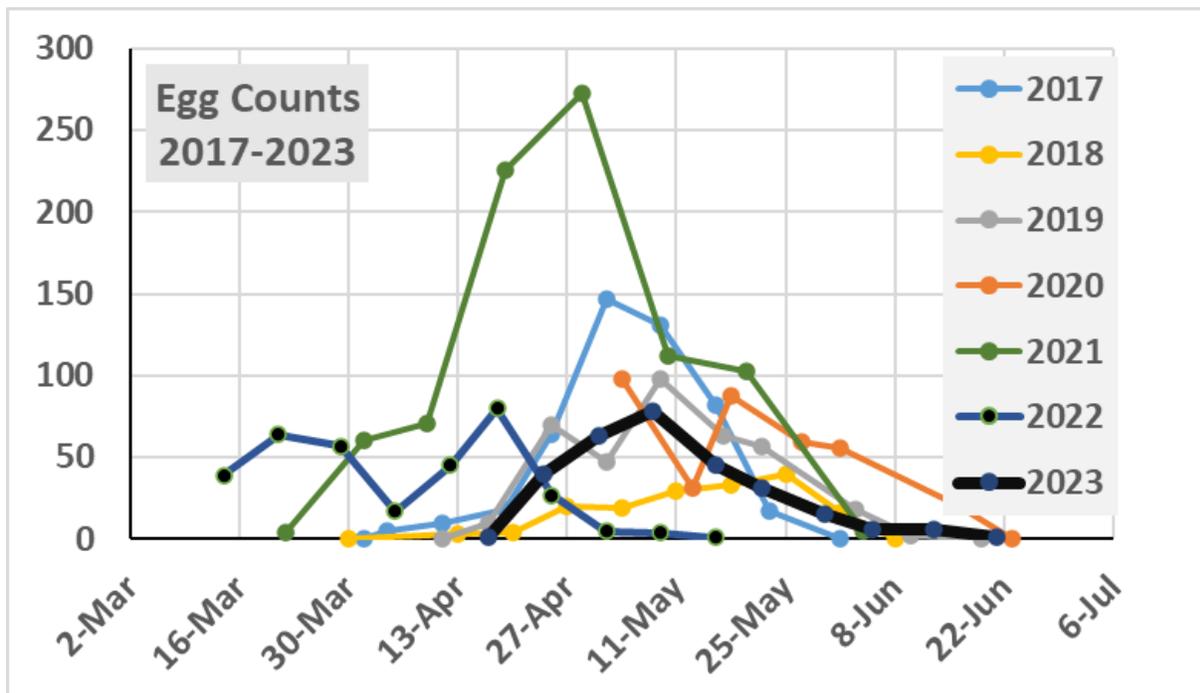


Figure 3. Weekly egg counts on random plants 2017-2023. 2017-2019 and 2021-2023 are fresh eggs only, 2020 includes hatched eggs. These are the data used for population estimates in each year.

2023 Population estimate

The 2023 calculations in Table 5 used only fresh eggs on the random plants and estimated a total of 128 female butterflies. Because virtually the whole season was sampled, this is a robust number (there were likely few eggs one week before Mar 13). Alternative methods using the program INCA, discussed in the 2019 Twin Peaks report and reports on Milagra Ridge (Weiss 2019, 2020), gave similar numbers, so the simpler egg count method continues to be used in the absence of great divergence in estimates. INCA estimates for 2017, 2018, 2019, 2020, and 2022 using all are shown in Appendix A.

Assuming that the Twin Peaks MBB population consists of an equal number of males and females, the total population is estimated to be at ~256 MBB individuals. This population estimate is more than 12 times higher than the threshold for demographic stochasticity (20 total males and females) and five times higher than the threshold for short-term genetic drift and inbreeding concerns (50 total males plus females). This population estimate is ~50% of the population size (500) that is recommended for resistance to environmental stochasticity (that threshold was almost met in 2021 when the total population estimate [males + females] was 484).

Date	Gardenside	Mission Bowl	Mission Flats	Mission Ridge	Total
4/17	0	0	1	0	1
4/24	0	10	30	0	40
5/1	1	14	36	12	63
5/8	0	13	55	10	78
5/16	0	3	38	4	0
5/22	0	2	29	0	45
5/30	0	4	10	1	31
6/5	0	1	5	0	15
6/13	3	0	3	0	6
6/21	1	0	0	0	6
6/28	0	0	0	0	1
Total eggs surveyed	5	47	207	27	286
Lupines mapped 2018	419	446	1295	563	
Lupine multiplier (lupines mapped/30 lupines surveyed)	14.0	14.9	43.2	18.8	
Total eggs estimated (total eggs surveyed x lupine multiplier)	70	700	8942	508	10,220
Females (80 eggs)	1	9	112	6	128

Table 5. 2023 fresh egg data and estimates of females based on lupine multiplier.

Eggs on release plants

There were no releases in 2023.

Population Trends 2009-2023

The estimated number of total females is plotted on a log scale, (Figure 4). The logarithmic scale is the appropriate method for evaluating population dynamics and demographic rates, as it properly represents proportional changes in population size (Rockwood 2015).

The estimated female population was essentially the same in 2022 and 2023 (from 121 to 128), well within the fluctuation range observed in MBB populations (Weiss et al. 2015, MacDonald et al. 2012, Hellman et al. 2003).

Figure 4 and Table 6 show the estimates and the number of translocated females each year since 2009. From the original introduction of 22 females in 2009 the population increased to a peak of resident ~140 females in 2014. The steep decline to 27 in 2015 was followed by population growth to 89 in 2017, followed by a decline to 37 in 2018. The resident population doubled from 2018 (37) to 2020 (76) (but note that the population was likely underestimated in 2020 because of the late start of the egg monitoring season), and a peak of 242 in 2021. In 2022 and 2023, the estimate was 121 and 128 females, respectively.

The effective egg contribution of translocated females (disregarding 2009, when there was nearly no resident population, and the contribution was close to 100%) has ranged from 8% (2021) to 30% (2011) of the total eggs. This assumes translocated females have laid half their eggs on SBM, essentially halving their egg contribution on Twin Peaks. These percentages should be kept in mind when planning further translocations (see discussion below).

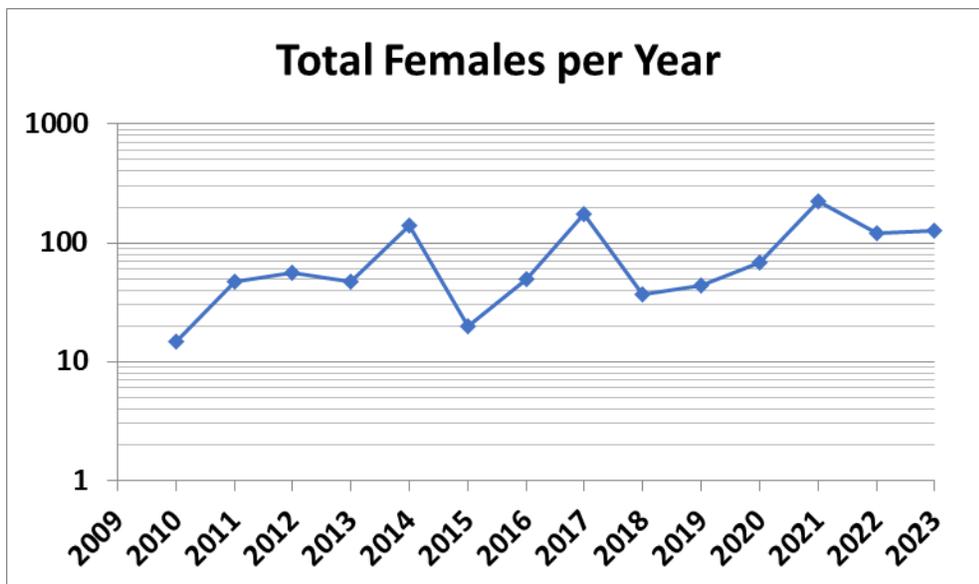


Figure 4. Estimated females from egg counts on a logarithmic scale

Year	Total eggs	Introduced Females	Eggs introduced (40 eggs/female)	Resident Females (80 eggs/female)	Percentage introduced eggs
2009	880	22	880	0	100%
2010	1,168	0	0	15	0%
2011	5,354	40	1,600	47	30%
2012	4,952	11	440	56	9%
2013	5,288	38	1,520	47	29%
2014	11,216	0	0	140	0%
2015	2,116	13	520	20	25%
2016	5,131	29	1,160	50	23%
2017	13,838	0	0	173	0%
2018	2,943	0	0	37	0%
2019	4,267	20	800	43	19%
2020	6,211	20	800	68	13%
2021	19,379	40	1,600	222	8%
2022	9,603	0	0	120	0%
2023	10,211	0	0	128	0%

Table 6. Estimated females from egg counts plus the number of translocated females

The proportion of the overall population in each management area has fluctuated over the last decade (Figure 5). In 2023, 88% of the population was estimated to be in Mission Flats, up from 67% in 2022. The fraction in Gardenside decreased to 0.7% in 2023 from 1.4% in 2022; the fraction on Mission Bowl decreased to 7% in 2023 from 15% in 2022; and the fraction on Mission Ridge decreased to 5% in 2023 from 16% in 2022.

Over the entire 2010-2023 period, the population has expanded into more management areas. Deliberate releases re-established MBB in Mission Flats and Mission Ridge in 2010. Releases starting in 2011 re-established MBB at Gardenside. In 2015, butterflies had passively recruited into Mission Bowl, followed by translocations in 2016, 2019, 2020, and 2021. Mission Flats supported 67% of the population in 2022 and 88% in 2023, its highest percentages since 2010. The large number of lupines (1295) in Mission Flats leads to a high multiplier (43.2) for the egg counts on the 30 random plants – the other subareas have multipliers between 14 and 18.8 (Table 5). Gardenside had the greatest proportion in 2013, 2014, 2018, and 2019, but in 2022 and 2023 it supported only ~1% of the population.

We note that the number of lupines, hence the lupine multiplier, has likely changed since the last lupine census in 2018. The next 5-year lupine census was recommended for 2023, especially with all the recent lupine planting, seeding, high early rainfall, and natural recruitment after scrub removal. We are hopeful this may take place in 2024.

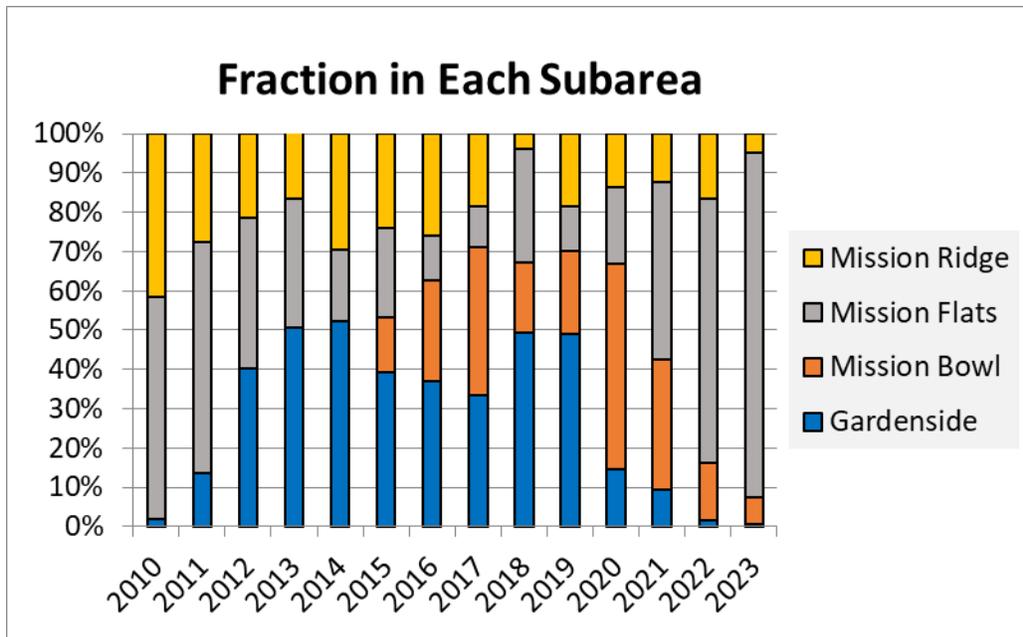


Figure 5. Percentage of eggs found in each management area (2010-2022)

Use of multiple lupine species

Lupinus albifrons is the most common lupine found on Twin Peaks, comprising 79% of the lupines in the 2018 census. *L. formosus* and *L. variicolor* are important alternate hosts when the fungal pathogen attacks and causes anthracnose symptoms in *L. albifrons*. The loss of *L. albifrons* corresponded to the large MBB population declines and extirpations at Twin Peaks before this project started in 2009, as well as at other MBB populations on San Bruno Mountain, Milagra Ridge, Marin Headlands, and Sweeney Ridge (MacDonald et al. 2012).

Starting in 2019, explicit attention was paid to counting eggs on *Lupinus formosus*, which has been intentionally out-planted on Twin Peaks to increase lupine species diversification. In 2022, five *L. formosus* plants were searched each week in each subarea. A total of 16 fresh and 7 hatched eggs were observed on *L. formosus* in 2023, indicating that this lupine species is consistently used despite its relative rarity compared with *L. albifrons* (Table 7). It is not possible with the present data to determine if MBB prefer *L. formosus* on average over *L. albifrons* or if there is a temporal aspect to host plant preference. Because of plantings and seeding, the 2018 *L. formosus* census numbers are very out of date, adding to the urgency of a 5-year lupine recount.

Only one egg was observed on *L. variicolor* in 2022, in Mission Bowl. A recount of *L. variicolor* is also another reason for a 2024 lupine census.

Site	Total <i>L. formosus</i> plants in area (2018)	<i>L. formosus</i> searched each week	Fresh eggs on searched plants	Hatched eggs on searched plants
Gardenside	11	5	1	0
Mission Bowl	12	5	0	0
Mission Flats	25	5	8	5
Mission Ridge	21	5	7	2
South Peak	N/A	0	N/A	N/A
Total	69		16	7

Table 7. MBB eggs on *Lupinus formosus* in 2023

Adult translocations

In 2023, no adults were translocated to Twin Peaks (Table 8).

Year	Females	Males	Total
2009	22	0	22
2010	0	0	0
2011	40	20	60
2012	11	5	16
2013	38	20	58
2014	0	0	0
2015	13	9	22
2016	29	15	44
2017	n/a	n/a	n/a
2018	n/a	n/a	n/a
2019	20	10	30
2020	18	9	27
2021	38	21	59
2022	0	0	0
2023	0	0	0
Total	229	109	338

Table 8. MBB translocations to Twin Peaks (2009-2023)

Habitat management

Fire

An accidental fire burned the southern tip of Mission Flats July 4, 2022. Relatively few lupines were harmed. The fire mostly burned extensive patches of coyote brush expanding the grassland habitat. SFRPD staff performed follow-up herbicide applications (spray and cut & daub) on the burned coyote brush once it resprouted. This area (and others) was targeted with lupine seeding, nectar plants, and bunchgrasses in fall 2022 and 2023.

Lupine seeding experiment

The population of MBB at Twin Peaks depends on a diverse and thriving population of lupines. With the effort that is required to manage the habitat at Twin Peaks, land managers and conservation scientists are interested in developing techniques for lupine population augmentation that produce the greatest benefit for the least amount of effort. Outplanting individual plants requires significant resources as opposed to seeding.

As part of the Disney Butterfly Conservation Initiative funding, lupine seeds were collected and propagated at the Creekside Science Conservation Nursery. Seeds were experimentally planted in December 2019, and monitored in May 2020, 2021, and 2022. Results can be found in last year's progress report (Niederer et al. 2023). Based on success in the experiment, operational lupine seeding began in late 2022 and continued in late 2023.

Operational lupine seeding

In 2022, Creekside Science Conservation Nursery provided SFRPD with one pound (~16,500 seeds) of *Lupinus albifrons* and 0.5 pounds (~5,500 seeds) of *Lupinus formosus* to plant at both Twin Peaks (~75%) and McLaren Park (~25%). Half of the seeds were scarified in a Thumblers' rock tumbler for at least 48 hours with coarse grit and pea gravel to ensure quicker germination, while the other half were untreated to favor seedbanking if the year was dry. About 12,500 *Lupinus albifrons* and 4,500 *Lupinus formosus* seeds were installed at Twin Peaks in late fall 2022, plus some *Lupinus variicolor* from SFRPD collections. Seeds were planted individually after poking a hole with a small hand tool like a chopstick or screwdriver (poke and plug method). Small handheld seed dispensers facilitated the seeding process. SFRPD, Creekside Science, and CNPS volunteers did the seeding. Seeds were planted not in well-defined plots, but were deployed to create better contiguity of host plant patches in the recently burned area of Mission Flats, at Mission Bowl, Mission Ridge, Gardenside, and along the eastern corridor being developed between Mission Ridge and Gardenside. As of January 2023, impressive amounts of germination had been observed. No formal survey of survivorship was performed. While dieoff was qualitatively noted as the year progressed, staff found it evident that a much greater establishment of lupines was achieved by seeding than could be possible by planting.

In fall 2023, Creekside Science supplied 0.75 lb *Lupinus albifrons* (~12,500 seeds) and 52 grams of *Lupinus formosus* (~1,250 seeds). Half of each were scarified as above. Installation began November 17, 2023, continued on December 5, and was completed December 14. Seeds were deployed in the newly

opened scrub-removal areas extending north from Mission Ridge into the eastern corridor, in the Mission Flats area, and also in the zone connecting Mission Bowl to Mission Ridge.

Seeds were part of the USFWS Partners for Fish and Wildlife project, which paid for lupine propagation at the Creekside Science Conservation Nursery in 2023. Seeds were installed and shared with partners on San Bruno Mountain as well.

SFRPD staff planted four seed plots with jute fabric along the east side of Twin Peaks between Mission Ridge and Gardenside in 2022 to encourage a habitat corridor. Scarified seeds of all three host plants grown by Creekside Science Conservation Nursery were used, as well as a mix of grasses and nectar plants: *Bromus carinatus*, *Lomatium dasycarpum*, *Lupinus albifrons*, *Lupinus formosus*, *Lupinus variicolor*, *Monardella villosa*, *Phacelia californica*, and *Stipa pulchra*. SFRPD and Creekside staff continued direct lupine seeding along with nectar plants and bunchgrasses in these general areas without jute seed plots in 2023.

Scrub management

Scrub encroachment into the grassland has been documented in previous reports as a significant issue for preservation of Mission blue butterfly habitat at Twin Peaks. Reducing scrub encroachment into the grasslands and providing habitat corridors between management areas is an ongoing and long-term management goal at Twin Peaks.

To reduce scrub encroachment and expand essential coastal prairie grassland in Mission blue habitat, SFRPD controlled aggressively-growing coyote bush (*Baccharis pilularis*) in areas within and adjacent to known Mission blue butterfly habitat. In particular, emphasis was placed on controlling coyote brush at habitat edges pushing south to north to eventually create a corridor between the Mission Ridge and Gardenside subsites. Coyote brush was judiciously sprayed or cut & daubed with herbicide to prevent resprouting. California blackberry was sprayed and hedged also to make space for coastal prairie grassland habitat. Scrub removal areas were seeded with lupines and bunchgrasses to hasten grassland habitat conversion. In 2023, SFRPD and contractors Habitat Potential performed initial conversion of approximately 2000 square feet of scrub pushing north from Mission Ridge into the Eastern Corridor.

Grass cutting

To increase access for the Mission blue butterflies to their host and nectar plants, SFRPD staff performed extensive grass-shearing throughout the habitat, particularly around lupine plants. SFRPD staff managed tall weedy annual grasses, mainly *Avena fatua* and *Briza maxima*.

Weed control

Weed control continues to be a priority for habitat management. A combination of mechanical and chemical control was employed to drastically reduce propagule pressure in the Twin Peaks habitat. The primary weeds targeted included *Oxalis pes-caprae*, *Ehrharta erecta*, *Foeniculum vulgare*, *Delairea odorata*, *Genista monspessulana*, *Cotoneaster* sp., *Conium maculatum*, *Anthriscus caucalis*, *Carduus pycnocephalus*, *Raphanus sativus*, *Hirschfeldia incana*, *Brassica rapa*, *Lobularia maritima*, *Plantago*

lanceolata, *Hypochaeris radicata*, *Echium pininana*, *Hedera* sp., and *Calendula arvensis*. Staff spent more than 400 hours managing weeds at Twin Peaks in 2022. Volunteers with the Yerba Buena chapter of the California Native Plant Society were back to aid in weed reduction. Volunteers spent more than 100 hours hand-removing radish, mustard, alyssum, and English plantain. These weeds were also managed throughout Twin Peaks by SFRPD staff, as well as ongoing annual treatment of *Oxalis pes-caprae* and other weeds that cannot be effectively controlled by hand.

Seed collection

SFRPD Natural Resources staff collected seeds from Mission blue host and nectar plants (Photo 1). Some seeds were used to propagate nursery stock for planting while others have been saved for future nursery propagation and for direct seeding. The use of “Organza” bags to capture explosively dehiscent lupine seed has been somewhat successful, although seed predation and rot have been disadvantages of this collection method.



Photo 1. Lupine seed collection in early summer

Planting

SFRPD planted 200 host/nectar plants, all in the Mission Bowl/Ridge area on December 14, 2023 (Table 9). All plants were from one-gallon pots. With the indigenous composition of lupines at Twin Peaks dominated by *Lupinus albifrons*, SFRPD continues to try to diversify the selection of host plants to expand phenotypic and genetic range of potential hosts.

Species	Number planted
<i>Lupinus albifrons</i> var. <i>collinus</i>	40
<i>Lupinus formosus</i> var. <i>formosus</i>	40
<i>Lupinus variicolor</i>	40
<i>Stipa pulchra</i>	40
<i>Phacelia californica</i>	40
Total	200

Table 9. Lupine and host plantings at Mission Bowl and Mission Ridge, 2023

On site to date, a total of 2,597 lupines have been planted (Table 10).

	Gardenside	Mission Bowl	Mission Flats	Mission Ridge	Other Sites	Total
<i>Lupinus albifrons</i>	137	197	235	266	65	860
<i>Lupinus formosus</i>	186	203	269	360	7	985
<i>Lupinus variicolor</i>	137	128	182	276	69	752
Total	460	528	686	902	141	2717

Table 10. Total lupines planted, 2002-2022

Trail maintenance and social trail management

Regular trail maintenance (mainly line-trimming) was performed to a standard of excellence. Snow fencing was installed in the Mission Bowl area and in the Eastern Corridor to limit social trail use, and this was mostly effective. Overall, social trails are becoming an increasing problem in Mission blue habitat and potential habitat primarily due to mountain biking. This is a difficult problem to address in this highly used urban park, and while there are plans to close the most negatively impacting social trail (top to bottom in the middle of Mission Ridge), installation of split-rail is on hold until a large capital project comes to fruition.

Anticipated tasks for 2024

Translocations

- Based on egg numbers in 2023 and a population estimate of ~128 females, a translocation is not absolutely necessary. Since GGNRA is likely translocating to Sweeney Ridge, a maximum of 20 females could be translocated to Twin Peaks, which would be <10% boost to egg output if the population remained the same, more than that if the population were to decline.
- If there were translocations in 2024, concentrating on Gardenside where the population was quite low in 2022 and 2023 would be an effective strategy.
- An alternative worth discussing would be to internally translocate a few butterflies from Mission Flat to Gardenside.

- But there is value in letting the population alone this season, since the estimated numbers are well above the demographic and short-term genetic viability thresholds. And, if resources are limited, redoing the lupine census/mapping would be a priority.

Lupine census and mapping

- The last lupine census was in 2018, five years ago, and the numbers are outdated, throwing population estimates and habitat availability off by some unknown factor. A resurvey would be highly desirable with the amount of stewardship – brush control, lupine planting, and lupine seeding - that has occurred over five years, as well as the natural dynamics of extant lupine populations. A lupine resurvey will provide some level of effectiveness to stewardship and allow more precise population estimates.

MBB surveys

- Continue post diapause larval surveys solely as phenological checks indicating onset of flight season. Conduct this survey in March.
- Conduct egg surveys one week after the first adult is observed and continue conducting them every 7 days in all four management areas throughout the egg season. The 2021 season provides an excellent template for future surveys because it captured the entire flight season.
- Continue to note larval feeding evidence and adult observations during egg surveys and other field activities.
- Continue to monitor lupine seeding experiment.

Habitat management

- Plant and seed MBB host and nectar plants within and adjacent to known MBB habitat to link habitats (Gardenside, Mission Ridge and Mission Bowl). The closure of the eastern roadway presents an opportunity to link east-facing MBB habitat, and explore opportunities for further habitat connections on the eastern side.
- Continue to install lupine seeds of all three species within and adjacent to known MBB habitat, especially on thin, rocky soils like roadcuts. Diversify extant stands of *L. albifrons* with *L. variicolor* and *L. formosus* throughout the occupied habitat.
- Collect host and nectar seeds in the spring and summer as seeds mature.
- As resources are available, clip annual grass in MBB habitat to improve sight lines for adult butterflies, especially in areas where grasses are tall and have high cover.
- Continue to re-establish lupine grasslands by removing encroaching coyote brush to create connectivity between subpopulations. Creating more habitat in areas connected to the core butterfly areas continues to be a priority.
- Hand weed invasive plants (*Brassica rapa*, *Calendula* sp., *Carduus pycnocephalus*, *Echium candicans*, *Ehrharta erecta*, *Euphorbia characias*, *Genista monspessulana*, *Cytisus* spp., *Hirschfeldia incana*, *Plantago lanceolata*, *Conium maculatum*, *Delairea odorata*, *Raphanus sativus*, *Alyssum alyssoides* and *Phalaris aquatica*) from grasslands and near sensitive MBB habitat, prioritizing areas near known occupied MBB habitat.
- Spot treat or cut and daub with herbicides invasive plants growing within MBB habitat (*Carduus pycnocephalus*, *Centranthus ruber*, *Cotoneaster* sp., *Ehrharta erecta*, *Lathyrus latifolius*, *Plantago lanceolata*, and *Oxalis pes-caprae*).
- Continue to experiment with alternative treatments for control of *Oxalis pes-caprae* and other invasives growing in non-sensitive areas adjacent to MBB habitat.
- Discourage social trail developments in sensitive MBB habitat. During COVID-19 pandemic park users created numerous social trails to distance themselves from other hikers. These unwanted

social trails required ongoing monitoring and closures as needed. Closures included installing temporary fencing and/or stacking brush to direct hikers to desired paths.

Conclusion

The Mission blue population on Twin Peaks was estimated at 128 females in 2023, similar to the ~120 females in 2022. This is down from 242 females in 2021, but up from 76 females in 2020 and 59 in 2019. If the number of males is equal to the number of females, the total population is estimated to be 256. The population is more than an order of magnitude higher than the threshold for demographic stochasticity (20 total males and females) and the threshold for short-term genetic drift and inbreeding concerns (50 total males plus females). The population estimate is about 50% of the population size (500) that is recommended for resistance to environmental stochasticity.

Repeating the lupine mapping/census is a high priority, given the 6-year interval since the previous mapping effort, and changes in the habitat (including planting/seeding lupines).

Translocations in 2024 are not strictly necessary given the size of the 2023 population. Splitting the 40 female quota (egg output of 20 females) with the Sweeney Ridge project (National Park Service and Golden Gate National Parks Conservancy) would limit the demographic impact of a translocation to <10% of the current population of ~130, perhaps more (20%) if the population declined to 50 in 2024. At this point we intend **not** to translocate in 2024, and to document whether and how the population changes without additional inputs. If the estimated female population drops below 100 in 2024, we will recommend translocations in 2025. If we do translocate in 2025, we may ask to reserve the entire 40 female quota. This will of course be discussed with all stakeholders when appropriate.

Creekside Science finished up our multi-year grant through the Disney Butterfly Conservation Initiative (partnering with University of Florida) – this grant funded the lupine seed production beds and the experiments through 2022.

Funding for lupine propagation at the Creekside Science Conservation Nursery was provided through the USFWS Partners for Fish and Wildlife program. (Seeds were also shared and installed on San Bruno Mountain.)

Seeding both *L. albifrons* and *L. formosus* is an important step in habitat improvement and resiliency, since the *L. albifrons* is susceptible to fungal anthracnose and aboveground die-off in some years. Now that we have observed multiple years of data indicating high egg loads on *L. formosus* (albeit with a very small sample size), continuing to establish more of this species in suitable areas is a path to increase species diversity. *L. variicolor* seeds will be added to operational seeding in the future as seed supplies allow. Creekside Science will continue to monitor the seeding experiment as funding allows.

Reducing scrub, connecting and expanding grassland habitat and increasing lupines numbers, distribution, and species richness continues to be important priorities at Twin Peaks. We are excited to continue sharing information with the staff at GGNRA who do similar and highly regarded work with MBB.

We want to thank the Disney Butterfly Conservation Initiative, the University of Florida, and Partners for Fish and Wildlife (USFWS) for funding lupine-related projects in key Mission blue habitats.

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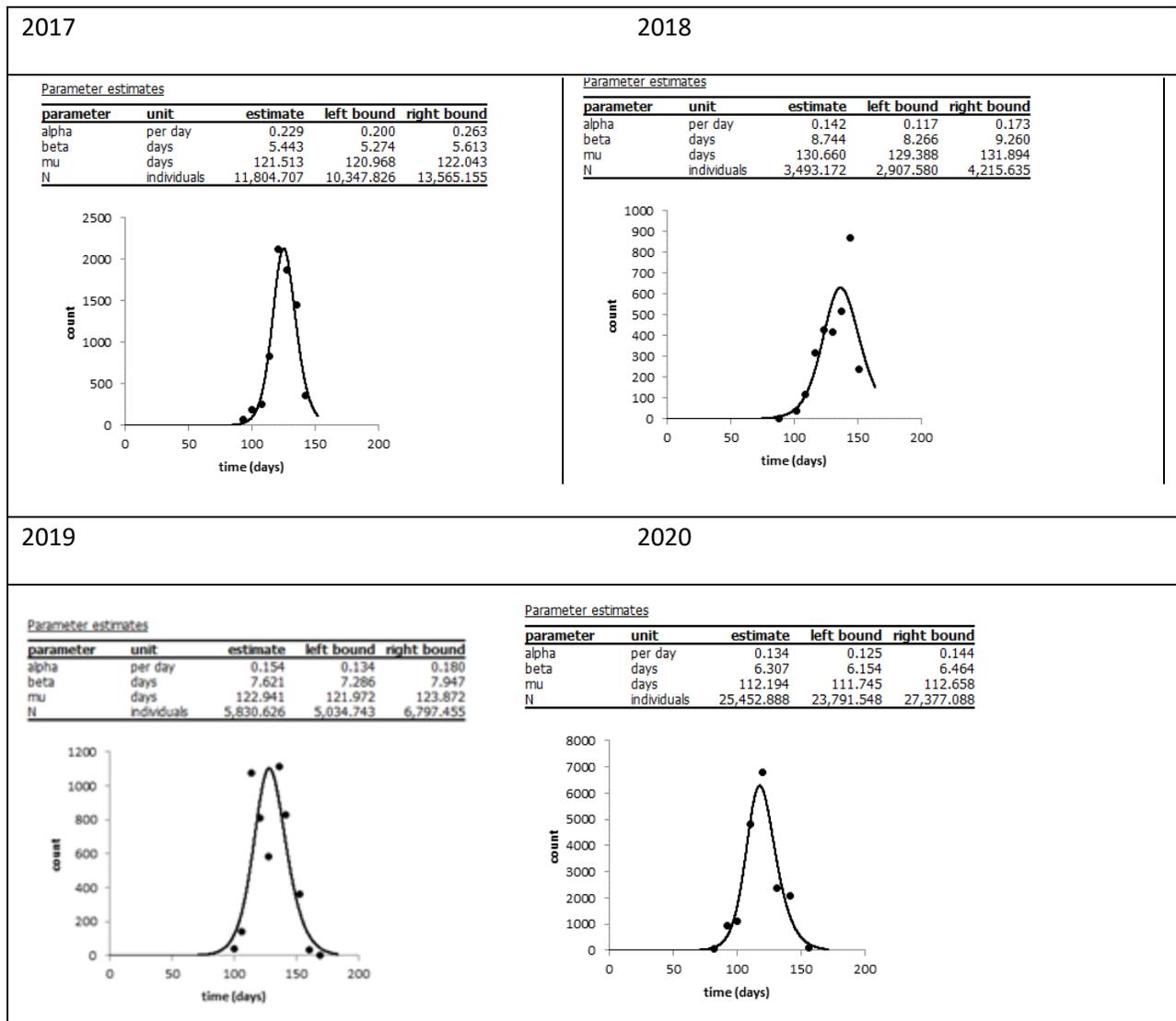
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Appendix A: Graphical results from INCA analysis of egg counts, 2017-2022

All four subareas of Twin Peaks were aggregated, and the total eggs estimated (weighted sum by lupine multiplier) each day were the inputs. INCA was run with standard settings, and the solutions converged in 2017, 2018, 2019, and 2020, so that confidence intervals for parameters could mostly be calculated. In 2022, the solution did not converge, and the intermediate fit is shown without confidence intervals. In 2020, the late start to the egg monitoring season did not allow for estimation. The differences between the INCA and raw egg estimates are shown in the table below. They agree within 73-117%, and we conclude that the extra complexity and assumptions of INCA are not warranted at this point.

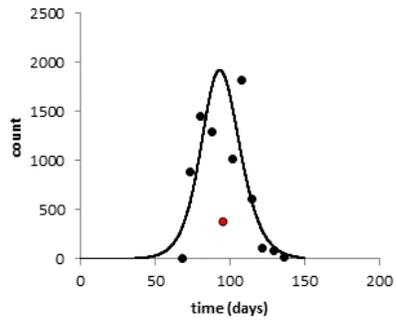
Results for Twin Peaks Egg Estimates 2017-2020, 2022. (No figure was made for 2021 because data were only collected starting mid-season.)



2022

Parameter estimates

parameter	unit	estimate
alpha	per day	0.174
beta	days	7.781
mu	days	88.404
N	individuals	11,460.870



Comparison with "raw" egg count estimates

Year	INCA	Raw	Raw/INCA Ratio
2017	11,804	13,838	117%
2018	3,493	2,953	85%
2019	5,830	4,267	73%
2020	N/A	N/A	N/A
2021	25,452	19,379	70%
2022	11,400	9,603	84%