Monitoring of Peirson's Milk-vetch in the Imperial Sand Dunes Recreation Area

U.S. Department of the Interior
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Cover photo of a Peirson’s Milk-vetch flower.

Photo by Camden Bruner, BLM.

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1. Preface

The original author of this report is Camden Bruner, Wildlife Biologist for the Bureau of Land Management (BLM), El Centro Field Office (2018). The report underwent revisions in 2020 by Kim Marsden, Botanist for the BLM CA Desert District Office and Peter DeJongh, Wildlife Biologist for the BLM El Centro Field Office.

This report documents 2018 monitoring efforts of Peirson's Milk-vetch (*Astragalus magdalenae* var. *peirsonii*) in the Imperial Sand Dunes Recreation Area as required annually by the Imperial Sand Dunes Recreation Area Management Plan. The monitoring study was designed by John Willoughby of the BLM, Tony McKinney of the U.S. Fish and Wildlife Service, and Andrew Trouette, formerly of the BLM. Data from a 2005 dunes-wide survey of Peirson's Milk-vetch was used to select macroplots for monitoring. This report documents the fifth year of monitoring of selected macroplots.

The monitoring conducted in 2014 and 2015 is documented in Willoughby (2015), the 2016 monitoring is documented in Willoughby (2017a), and the 2017 monitoring is documented in Willoughby (2017b).

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2. Introduction

In March 2018, the Bureau of Land Management (BLM) monitored the abundance of Peirson's Milk-vetch (*Astragalus magdalenae* var. *peirsonii*, hereafter referred to as PMV) in the Imperial Sand Dunes Recreation Area (Dunes), located in southeastern Imperial County, California. PMV is a Federally listed threatened species and a State-listed endangered species.

The Imperial Sand Dunes Recreation Area Management Plan prescribes two levels of monitoring for PMV, a full-scale approach when October-December precipitation in the Dunes is greater than 1.82 inches, and a less-intensive approach when precipitation during the October-December period is less than 1.82 inches (Figure 1). Nineteen macroplots, each 50m x 500m in size, were permanently established in areas representing the full range of PMV habitat in the Dunes, including areas both open and closed to off-highway vehicle (OHV) use. Six of these macroplots are required to be monitored in years in which the October-December precipitation is less than 1.82 inches, and all 19 macroplots are to be monitored in years in which the precipitation during that period equals or exceeds 1.82 inches. Annual monitoring of PMV in the Imperial Sand Dunes began in 2014; 2018 being the fifth year of the surveys.

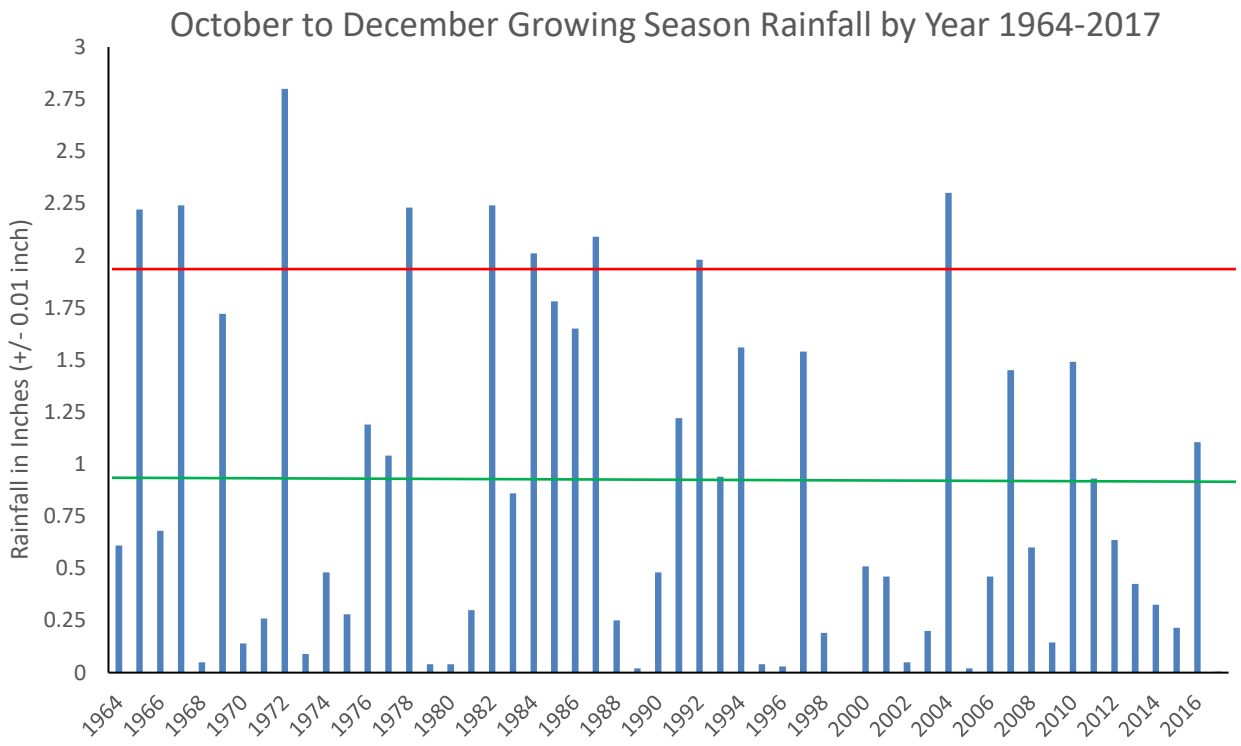

Figure 1. Total October-December growing season precipitation from 1964-2017 in the Imperial Sand Dunes. Precipitation values for growing seasons from 1964 to 2000 are the averages of seven Western Regional Climate Center (WRCC) weather stations in the vicinity of the Imperial Sand Dunes. The values for growing seasons 2001 to 2017 are the averages of the precipitation recorded by two Remote Area Weather Stations in the Imperial Sand Dunes (these stations were installed in November 2000). The bottom green line is at 0.93 inches or the average

October-December growing season precipitation of the 7 WRCC weather stations. The top red line is at 1.82 inches or 1 standard deviation above the average (standard deviation = 0.89 inches). Growing seasons with October-December precipitation higher than the standard deviation line are expected to be exceptional flowering years for Peirson's Milk-vetch. Monitoring during the spring following the 2004-2005 growing season (Willoughby 2005b) supports this expectation.

3. Methods

3.1 Monitoring Protocol

In 2014 nineteen permanent macroplots were established in areas representative of good PMV habitat within the Imperial Sand Dunes based on past occurrence data. Macroplots are 50m x 500m in size and are oriented southwest to northeast. The macroplots are divided into forty 25m x 25m cells called microplots (Figure 2).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21

Figure 2. 50m x 500m macroplot showing division of macroplot into forty 25m x 25m cells for data recording purposes. Cells are surveyed in the order they are numbered, from Cell 1 to Cell 40.

A cell size of 25m x 25m was chosen to mimic the cell sizes used in the 2003-2007 sampling of PMV (Willoughby 2004b, 2005a, 2005b, 2006, 2007). In those studies, long belt transects, 25m wide and between 2.35 and 7.73 km long were used to estimate the population size of PMV in each year. PMV were recorded in 25m segments along each belt transect, resulting in a dataset consisting of more than 339,000 cells in 2005, of which more than 26,116 supported one or more PMV plants. The 2005 data represents both the richest data set (in terms of number of cells surveyed) and the best estimate to date of the abundance and distribution of PMV in the Imperial Sand Dunes (Willoughby 2006; FWS 2008).

During the 2005 annual monitoring event, the dunes were divided into 16 separate sampling areas, each of which were sampled using a systematic random sampling scheme (Map 1).[1] Ten of these sampling areas were selected to be monitored in 2014 and in subsequent years based on the number of plants found in the 2005 survey. The chosen sampling areas run the full extent of the dunes from northwest to southeast; they include only the westernmost sampling areas because most PMV plants occupy these areas, which is also the reason most of the critical habitat is concentrated in there (Map 1).

The average amount of precipitation for the October-December growing season is 0.93 inches, based on growing season precipitation data recorded by seven Western Regional Climate Center weather stations in the vicinity of the Imperial Sand Dunes from 1964-2000. A growing season

[1] Note that the numbering system for the 16 sampling areas used in 2005 is missing the numbers 1, 2, 9, and 10. Sampling areas with those numbers were sampled in 2004 and proved to be too variable, so they were divided into smaller sampling areas for the 2014 sampling. New numbers were assigned to these smaller sampling areas.

precipitation total of 1.82 inches would be 0.89 inches or 1 standard deviation above the 1964-2000 average growing season precipitation levels.

Table 1 lists the general locations, number of macroplots, and the criteria used to distribute the nineteen permanent PMV macroplots among the 10 sampling areas in the Imperial Sand Dunes. In years with October-December precipitation above 1.82 inches, all 19 of these macroplots will be monitored.

Table 1. Distribution of 19 Peirson's milk-vetch monitoring macroplots in the Imperial Sand Dunes. The table lists sampling areas from north to south (see Map 1).

Sampling Area	Number of Macroplots	Criteria
13	1	One macroplot in the Mammoth Wash area of the Dunes in critical habitat north of the area that was closed between 2000 and 2013.
14	1	One macroplot in the Mammoth Wash area of the Dunes in critical habitat inside the area closed between 2000 and 2013.
15	1	One macroplot in critical habitat in the northern part of the Wilderness.
16	1	One macroplot in critical habitat in the southern part of the Wilderness.
3	2	One macroplot outside the former closure area and one inside. This is outside of critical habitat but in an area that supported plants in 2005.
4	2	One macroplot outside both former closure areas and one inside the former large central closure. This is outside of critical habitat but in an area that supported plants in 2005.
7	3	As all of this sampling area was closed between 2000 and 2013 the macroplots will be evenly distributed in critical habitat from north to south.
18	3	As all of this sampling area was closed between 2000 and 2013 the macroplots will be evenly distributed in critical habitat from north to south.
19	4	Three macroplots evenly distributed between the north and south parts of the sampling area in the critical habitat area north of the former OHV corridor to Patton Valley (with one just north of the corridor) and one macroplot in the critical habitat area south of the former corridor.
11	1	One macroplot in the critical habitat area in this sampling area.

In years with October-December precipitation less than 1.82 inches, six of the 19 selected macroplots will be monitored. Table 2 lists the general locations, number of macroplots, and the criteria used to distribute these six PMV macroplots among the 10 sampling areas in the Imperial Sand Dunes.

Table 2. Monitoring macroplots to be censused in low rainfall years.

Sampling Area	Number of Macroplots	Criteria
13	0	
14	0	
15	0	
16	0	
3	1	The macroplot inside the former closure area would be monitored. The reason for this is that the area closed was chosen based on it supporting more plants in the 1998 study (Willoughby 1998).
4	1	The macroplot inside the former central closure area would be monitored. The reason for this is that the area closed was chosen based on it supporting more plants in the 1998 study.
7	1	The middle of the three macroplots in this sampling area will be censused.
18	1	The middle of the three macroplots in this sampling area will be censused.
19	2	Because of potential concerns related to the vehicle corridor to Patton Valley (closed in summer 2014) near the boundary between critical habitat subunits 3A and 3B, the macroplots just north and south of the former corridor will be censused.
11	0	

Based on these general criteria, Tony McKinney, GIS expert with the Carlsbad Fish and Wildlife Service Office, used the 2005 monitoring data to create specific locations for each of the 19 macroplots (Map 2). See Willoughby (2015) for the methods employed to determine specific macroplot locations. Table 3 lists the 19 macroplots and shows their location relative to the 2005 sampling areas; Map 2 depicts their locations in the Imperial Sand Dunes.

Table 3. Macroplots and their positions in the Imperial Sand Dunes. X's show the macroplots to be monitored according to the October-December precipitation threshold.

Macroplot	Sampling Area	October-December Precipitation		Location
		< 1.82 inches	> 1.82 inches	
1	13		X	In critical habitat
2	14		X	In critical habitat
3	15		X	In North Algodones Wilderness
4	16		X	In North Algodones Wilderness
5	3		X	In area never closed to OHV use
6	3	X	X	In area closed to OHV use 2000-2014
7	4		X	In area never closed to OHV use
8	4	X	X	In area closed to OHV use 2000-2014
9	7		X	In critical habitat in northern part of sampling area
10	7	X	X	In critical habitat in middle part of sampling area
11	7		X	In critical habitat in southern part of sampling area
12	18		X	In critical habitat in northern part of sampling area
13	18	X	X	In critical habitat in middle part of sampling area
14	18		X	In critical habitat in southern part of sampling area
15	19	X	X	In critical habitat just north of former vehicle corridor to Patton Valley (north part of sampling area)
16	19	X	X	In critical habitat just south of former vehicle corridor to Patton Valley (north part of sampling area)
17	19		X	In critical habitat in middle part of sampling area
18	19		X	In critical habitat in southern part of sampling area
19	11		X	In critical habitat in southern part of sampling area

A complete census of PMV was conducted in each macroplot for the following variables: (1) seedlings and young, nonflowering plants, (2) flowering plants, (3) total number of plants present (4) number of plants greater than 1 year old, (5) number of plants showing damage from OHVs, and (6) number of plants showing damage from sources other than OHVs. In addition to these six PMV variables, the number of OHV tracks was also recorded. These seven variables were recorded separately for each 25m x 25m cell.

Macroplots are located using a global positioning system (GPS) with waypoints entered into each GPS unit corresponding to the beginning and end of each 25m x 25m cell. Figure 3 shows the numbering system used in 2018.

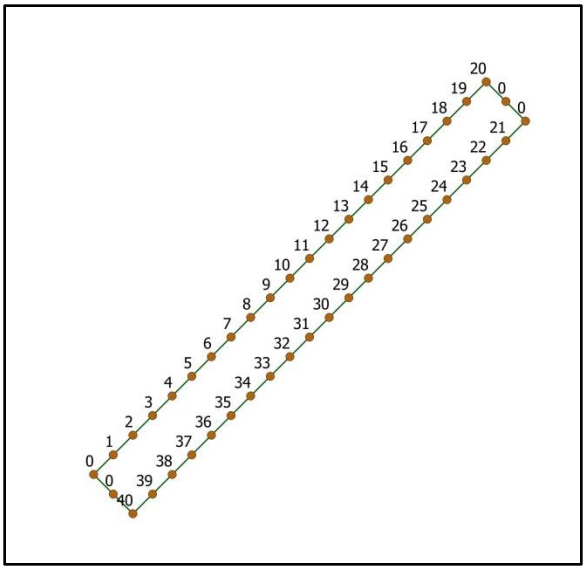

Figure 3. Waypoint numbering system used in 2018 for monitoring each macroplot. The waypoints numbered 0 are for navigation purposes only and have no data recorded for them.

3.2 Data Collection 2014-2016

During the 2014-2016 monitoring seasons the GPS-based 40 cell monitoring system was implemented. The observers began monitoring at the 0 point at the southwest corner along the upper edge of the macroplot. They then set the GPS unit to navigate towards waypoint 1. Observer 1 (with the GPS) stayed on the top (left edge) of the belt transect, while the second observer stayed 25m away from Observer 1 on the right edge of the transect (if there was a third observer, that observer traversed the center of the belt). These observers then counted and recorded the number of plants/OHV tracks in each of the specified categories for the cell ending at waypoint 1 (this is Cell 1; see Figure 2). Those values were recorded in the GPS unit as waypoint 1. The observers continued recording data for cells 2-20 (the top row of cells) and navigated down to waypoint 0 at the southeast corner of the lower edge of the macroplot. Observer 1 continued down the lower (left) edge of the macroplot while Observer 2 stayed 25m away on the right edge of the transect (which is the middle of the macroplot). This continued until the data for the last cell is recorded as waypoint 40 (this is Cell 40; see Figure 2).

3.3 Data Collection 2017-2018

The system used to collect data was modified for the 2017-2018 monitoring seasons to improve efficiency in monitoring and data-entry. Before 2017, Trimble GeoExplorer 7 GPS devices were used to navigate and record data. Data entry on the Trimble devices is non-intuitive and inflexible, leading to numerous frustrating situations. For example, while many cells exhibited zero observations of various variables (e.g. zero flowering plants in the cell), the device was not able to record a zero in any data field for a given cell. These fields had to be left blank, appearing incomplete and leading to confusion in interpreting the downloaded data. Additionally, the Trimble operating platform is complex, and for those without experience and familiarity, it can

enable permanent mistakes, one of which led to the complete loss of data for three macroplots in 2016.

To overcome these problems, a new data recording technique was implemented in 2017. Trimble units were replaced with Apple iPads for field navigation and data recording. The iPads were connected via Bluetooth to a Dual Universal GPS Receiver which amplifies the GPS signal, making its accuracy comparable to that of a Trimble GeoExplorer 7. The Collector for ArcGIS application for iPad (ESRI 2016) was used to directly enter data from each cell into a custom-built ArcGIS Online database. Paper data forms were also used during the 2017-2018 surveys to backup all data collected. As a quality control measure, the data on the paper forms were compared with the electronic data collected using the Collector for ArcGIS application.

A new, more precise method of circumscribing cell boundaries was also initiated in 2017. Instead of simply using the GPS units to approximate the boundaries of the cells, measuring tapes were used to more accurately measure the 25m sides of each cell. Pin flags were employed to mark a macroplot centerline at each microplot corner to help guide surveyors in counting plants. Because locating the corners of each cell was still dependent on the accuracy of the GPS units, the actual cell boundaries varied by a meter or so between years, but a source of variability (inconsistent cell boundaries) was removed through this effort.

3.4 Precipitation Data Collection

Precipitation data were obtained from two Remote Area Weather Stations (RAWS) in the Imperial Sand Dunes, one located in the northern half of the dunes at the Cahuilla Ranger Station near State Highway 78 on the western edge of the dunes and the other at the Buttercup Ranger Station in the southern part of the dunes south of Interstate 8. The locations of the two ranger stations are shown in Map 3.

4. Results

4.1 Precipitation

From October-December 2017 there was 1.03 inches of precipitation recorded at the Buttercup Ranger Station RAWS and 1.06 inches of precipitation recorded at the Cahuilla Ranger Station RAWS. This averages to 1.05 inches of precipitation for the Imperial Sand Dunes, well below the 1.82-inch threshold for implementing increased monitoring. Therefore, monitoring was required to be completed for only the six macroplots as shown in Table 3. An additional macroplot, Macroplot 19, was surveyed for BLM GIS staff to continue to practice implementing the new data recording system described in section *3.3 Data Collection 2017-2018*. Because Macroplot 19 was surveyed according to protocol, the results are included in this report.

It is worth noting that the RAWS recorded an exceptionally large rain event in September 2017. Averaged between the two stations, the Imperial Sand Dunes received 1.32 inches of rain in less than a 48-hour period. This is the largest rain event recorded in the dunes since January 2010.

This was the only noteworthy rain event occurring around the 2017-2018 PMV growing season, which is typically defined as October-March. From October 2017 to March 2018 precipitation was well below the monthly average for the Imperial Sand Dunes as illustrated in Figure 4. In fact, precipitation during the 2017-2018 growing season was the lowest recorded during a growing season since the RAWS began collecting data in 2001 as documented in Table 4.

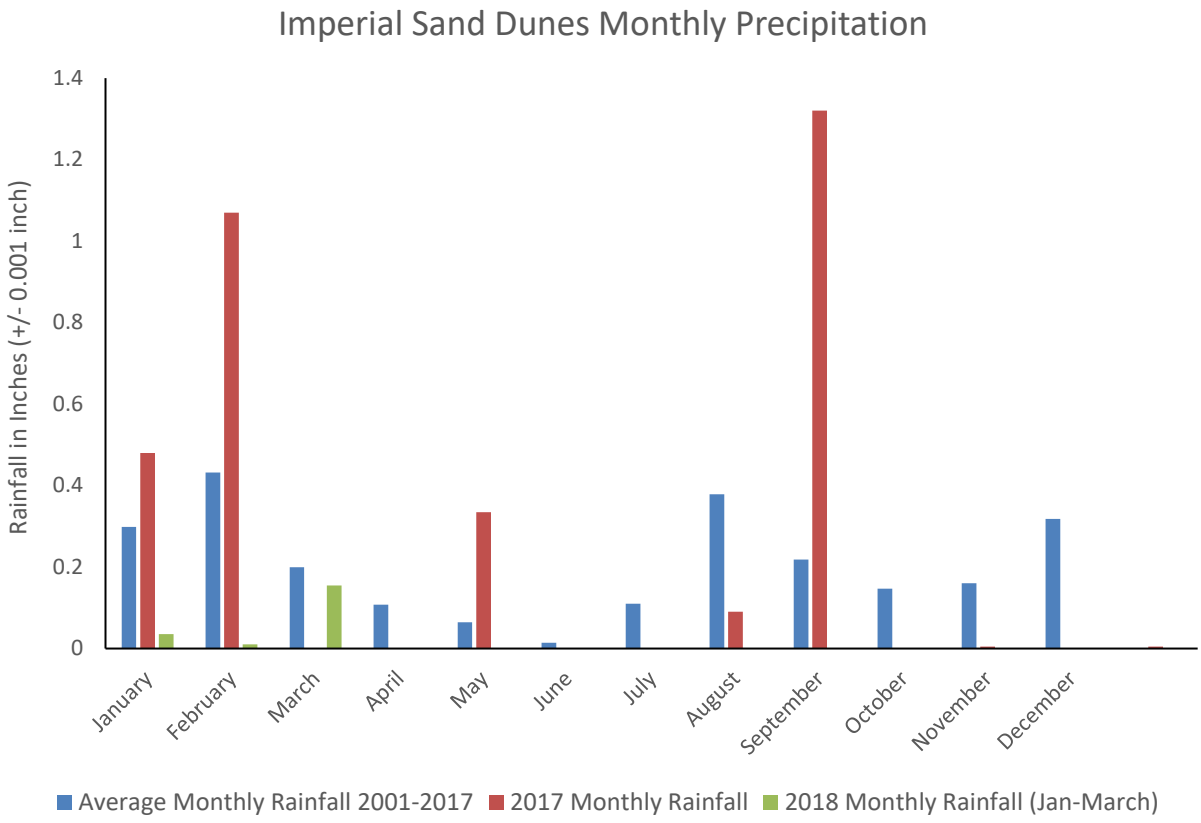

Figure 4. Average monthly rainfall for the Imperial Sand Dunes recorded by the RAWS from 2001-2017, the 2017 monthly rainfall totals, and the 2018 monthly rainfall totals from January-March (the most current data as of writing this report). An above average rain event occurred in September 2017, although rainfall for the rest of 2017 and the beginning of 2018 was below average.

Table 4. Growing season precipitation recorded by the RAWS within the Imperial Sand Dunes. Values for the Imperial Sand Dunes are approximated by averaging precipitation totals from the Buttercup and Cahuilla RAWS stations. The "Total Growing Season Precipitation" column is therefore the sum of the RAWS station averages for each growing season. This table represents the most complete dataset of growing season precipitation specific to the Imperial Sand Dunes since the RAWS began recording precipitation data in November 2000. Precipitation data is recorded in inches.

Growing Season	Oct-Dec Precipitation	Jan-March Precipitation	Total Growing Season Precipitation
2001-2002	0.46	0	0.46
2002-2003	0.05	1.33	1.38
2003-2004	0.195	1.17	1.365
2004-2005	2.295	2.455	4.75
2005-2006	0.02	0.195	0.215
2006-2007	0.46	0.085	0.545
2007-2008	1.405	0.505	1.91
2008-2009	0.62	0.445	1.065
2009-2010	0.145	3.3	3.445
2010-2011	1.33	0.675	2.005
2011-2012	0.93	0.54	1.47
2012-2013	0.635	0.755	1.39
2013-2014	0.425	0.03	0.455
2014-2015	0.325	0.975	1.3
2015-2016	0.215	0.5	0.715
2016-2017	1.125	1.515	2.64
2017-2018	0.005	0.2	0.205
2018-2019	1.055	0.875	1.93

4.2 Monitoring Effort

Seven macroplots were monitored between March 27 and 30, 2018, as shown in Table 5.

Table 5. Monitoring dates and observers in 2018.

Macroplot	Date Monitored	Observers
19	3/27/2018	Camden Bruner, Jeff Sahagun, Jerimiah Dicken, Ashton Johnston
6 & 8	3/28/2018	Camden Bruner, Azariah Smith, David Clemmer
10 & 13	3/29/2018	Camden Bruner, Sara Miller, Matthew Salkiewicz
15 & 16	3/30/2018	Camden Bruner, Matthew Salkiewicz

A Jeep Rubicon was used to access Macroplots 10, 13, 15, 16, and 19. A side-by-side OHV was used to access Macroplots 6 and 8 as they are in larger dunes not easily accessed by other types

of vehicles. BLM Park Rangers who are specially trained to drive OHVs within the Dunes provided the needed expertise to safely access Macroplots 6 and 8.

Weather conditions were generally mild during the 2018 monitoring effort (Table 6). A strong wind event the first day of surveys forced observers to use goggles while out in the sand; only gentle winds occurred for the rest of the survey effort. Temperatures generally ranged between 25-32 degrees Celsius (77-89.6 degrees Fahrenheit); the final day of monitoring was the hottest with temperatures reaching 35 degrees Celsius (95 degrees Fahrenheit).

During the 2018 monitoring year GPS tracking was used, which yielded additional data regarding the effort required to complete the monitoring (Table 6). For each macroplot surveyed, every individual observer walked an average of 2.7 miles with an average of 583-foot elevation change in 2018. The distance walked by each observer likely changes from year to year depending on the number of PMV present. More plants require more walking within the plots to accurately count the population. Including drive time within the Dunes, it took an average of 4 hours and 52 minutes to survey each macroplot.

Table 6. Daily wind speeds and temperature range for each day of monitoring. The distance walked by each observer, elevation change, and duration of fieldwork is also shown by survey day. Only 1 macroplot was surveyed on 3/27/2018, 2 macroplots were surveyed every other day during the monitoring period.

Date	Wind Speed	Temperature Range	Distance Walked	Elevation Change	Duration of Field Work
3/27/2018	21 mph	22-26°C	3.1 miles	560 ft	5 hours
3/28/2018	6 mph	25-31°C	5.4 miles	1140 ft	11 hours
3/29/2018	5 mph	29-34°C	6.2 miles	1240 ft	10 hours
3/30/2018	4 mph	30-35°C	4.3 miles	1140 ft	8 hours

4.3 Peirson's Milk-vetch

A total of 8,837 PMV were counted during the 2018 monitoring effort. Over 99.8% of the plants observed were mature plants, not seedlings or young plants, indicating they had germinated in the spring of 2017 or earlier. Of the 8,837 plants observed, 470 were living plants greater than 1 year of age and 7 were seedlings. 8,314 were recorded as exhibiting non-OHV damage, yet the vast majority of these were mature plants that had died but were still rooted in place; they were dried and brown though largely intact (Table 7). It is presumed that these plants are 2017 plants that had flowered and set seed before 2018 monitoring took place in March. It is likely they died from lack of rain from October 2017-March 2018.

Table 7. A summary, by macroplot, of PMV plants counted in six categories, the number of OHV tracks, the number of cells occupied by PMV, and the number of cells with OHV tracks in 2018. Macroplot 19 is not required for annual monitoring and was included as a practice plot.

Macro plot	Number of Seedlings	Number Flowering	Total	Number > 1 yr	Number w/ OHV Damage	Number w/ Other Damage or Dead	Number of OHV Tracks	Number of Cells Occupied by PMV	Number of Cells w/ OHV Tracks
6	2	2	64	8	0	55	24	9	4
8	5	0	18	10	1	3	34	6	11
10	0	3	921	55	6	859	0	11	1
13	0	19	6498	232	38	6228	0	28	0
15	0	7	475	42	3	426	0	22	0
16	0	1	196	26	2	168	0	12	0
19	0	6	665	97	0	575	86	21	12
Total	**7**	**38**	**8837**	**470**	**50**	**8314**	**144**	**109**	**28**

4.3 OHV Impacts and Tracks

Of the 280 microplots monitored, 10% (28 microplots) had OHV tracks present. In total, 144 OHV tracks were recorded within the 7 macroplots. OHV tracks were not evenly distributed across the plots; Macroplot 19 had 86 vehicle tracks (61% of the total tracks recorded across all 7 macroplots). Macroplot 19 also had 12 microplots with OHV tracks, 43% of the total number of microplots with OHV tracks.

A Border Patrol truck was observed driving through Macroplot 19 during the annual monitoring session and for the second year in a row a Border Patrol ground sensor was present in the macroplot. OHV tracks recorded in Macroplot 19 all headed towards the international border through a pass in the dunes. These tracks appear to be from truck tires, not sand tires or dirt bike tires typically associated with OHV use, therefore, all are attributed to Border Patrol vehicles.

Macroplots 6 and 8 are open to OHV use. Between these two macroplots, 58 OHV tracks were recorded representing 40% of the total tracks located during this monitoring effort. These tracks were in 15 different microplots.

A total of 50 PMV plants were located with OHV damage. These plants had obvious broken stems and signs of crushing although they did not all directly correspond with visible OHV tracks. The most OHV damage was recorded in Macroplot 13 which has consistently had the highest number of total plants. Macroplots 6 and 8 are open to OHV use; only 1 PMV showing OHV damage was recorded in Macroplot 8.

4.5 Non-OHV Impacts

Non-native insects have been identified as a potential concern for PMV. Surveyors made a conscious effort to inspect plants for the presence of insects or insect damage during the 2018 survey effort. No non-native species were identified on or near PMV plants and no insect damaged was observed. Insect absence may be influenced by below average precipitation. It is recommended to continue monitoring PMV for insects and insect damage during future surveys.

4.6 Other Special Status Species

Aside from PMV, five species of conservation concern were observed during the annual monitoring effort. These species and their conservation status are summarized in Table 8.

Table 8. Species of conservation concern observed during surveys are listed with their federal status, State of California status, and California Native Plant Society ranking.

Common Name	Scientific Name	Federal Status	State Status	CNPS Rank
Wiggins' Croton	*Croton wigginsii*	BLM Sensitive	Rare	List 2.2
Algodones Dunes Sunflower	*Helianthus niveus* ssp. *tephrodes*	BLM Sensitive	Endangered	List 1B.2
Giant Spanish Needle	*Palafoxia arida* var. *gigantea*	BLM Sensitive		List 1B.3
Sand Food	*Pholisma sonorae*	BLM Sensitive		List 1B.2
Colorado Desert Fringe-toed Lizard	*Uma notata*	BLM Sensitive		N/A

The numbers of each species of conservation concern were recorded during the monitoring of Macroplots 6, 8, 10, 13, and 19. Due to the low number of surveyors conducting the monitoring effort in Macroplots 15 and 16, notes on species of conservation concern in those macroplots were not recorded. A summary of the number of species of conservation concern by macroplot is shown in Table 9.

Table 9. The number of each species of conservation concern observed by macroplot. Sand Food was counted not by individual stems/ovate heads but rather by cluster as it is not known if each ovate head is an individual or rather one stem of the larger plant. Note: Macroplot 19 was surveyed on a colder morning than other macroplots which may have resulted in incidental observations of Colorado Desert fringe-toed lizard.

Macroplot Number	Fringe-toed Lizard	Wiggin's Croton	Algodones Dunes Sunflower	Giant Spanish Needle	Sand Food
6	4	16	8	0	0
8	3	74	1	3	0
10	9	155	10	0	1
13	24	654	195	0	2
19	0*	276	11	0	3

5. Discussion

5.1 Distribution and Abundance

In terms of habitat for PMV within the Imperial Sand Dunes, suitable habitat only exists for the species within the simple crescentic dunes on the western side of the dune system and in the compound crescentic dunes in the center of the dune system (Willoughby 2005b). On a microhabitat scale, PMV occurs primarily on northwest facing windward dune slopes with a 5 to 15 degree angle and in dune bowls where there is less sand movement and more consistency in the dune topography; dune slip faces and dune crests often aren't suitable for the species as these areas change rapidly with the wind and experience dramatic continual sand movements .

While the macroplots used for monitoring were initially selected based on the presence of PMV, during any given monitoring year a large percentage of each macroplot is not suitable habitat for PMV given the current microhabitat dune topography present there. Of the 40 microplots within each macroplot, an average of only 15.57 were occupied with PMV during the 2018 monitoring effort (Table 10). This is consistent with past years of monitoring and demonstrates how many of the microplots may not be occupied habitat for the species during any given monitoring year. This can be attributed to sand movement on a local scale or simply the result of many growing seasons without good rainfall. It likely may be a combination of both. -. In Macroplot 13, PMV occupied 28 microplots, which is well above average. Macroplot 13 also supported an average of 228 PMV per occupied microplot which was well above 2018 averages. This suggests, among other factors, that during 2018, Macroplot 13 had a higher percentage of suitable habitat for PMV than the other plots. Macroplots 6 and 8 were found to be well below the average number of occupied microplots and the average number PMV per occupied microplot. This is likely partially influenced by the amount of suitable habitat present given the current dune topography though there are likely other factors at play.

Table 10. Average number of microplots occupied with PMV by macroplot as well as the average number of PMV per occupied microplot.

Macroplot Number	Number of Occupied Microplots	Average Number of PMV per Occupied Microplot
6	9	7
8	6	3
10	11	66
13	28	228
15	22	21
16	12	16
19	21	23
Average:	**15.57**	**52**

Of the total 8,837 PMV plants located during the 2018 monitoring effort; 94% (8,314) were recorded as Non-OHV Damage. This is misleading, as all standing dead plants were recorded in this category. Unfortunately, there was also a small number of living plants exhibiting non-OHV damage that was counted in this category. Therefore, it is impossible to discern exactly how many plants were recorded as standing dead and how many were recorded as living with non-OHV damage. However, due to the lower numbers of seedlings and >1-year old plants (7 and 470, respectively) it is clear that the vast majority of plants recorded in this category were standing dead. Care will be taken in subsequent years to avoid these data recording issues.

The majority of plants recorded, therefore, likely remain from the 2017 cohort, and exhibit similar trends. As in previous years, Macroplot 13 supported the largest number of plants with 73.5% of the total plants observed. Macroplot 10 was the next most populated macroplot, accounting for 10.4% of the total plants observed. Macroplot 19 (7.5%), Macroplot 15 (5.4%), Macroplot 16 (2.2%), Macroplot 6 (0.7%), and Macroplot 8 (0.2%) account for the rest of the plants. Figure 5 illustrates this spread of plants among the macroplots.

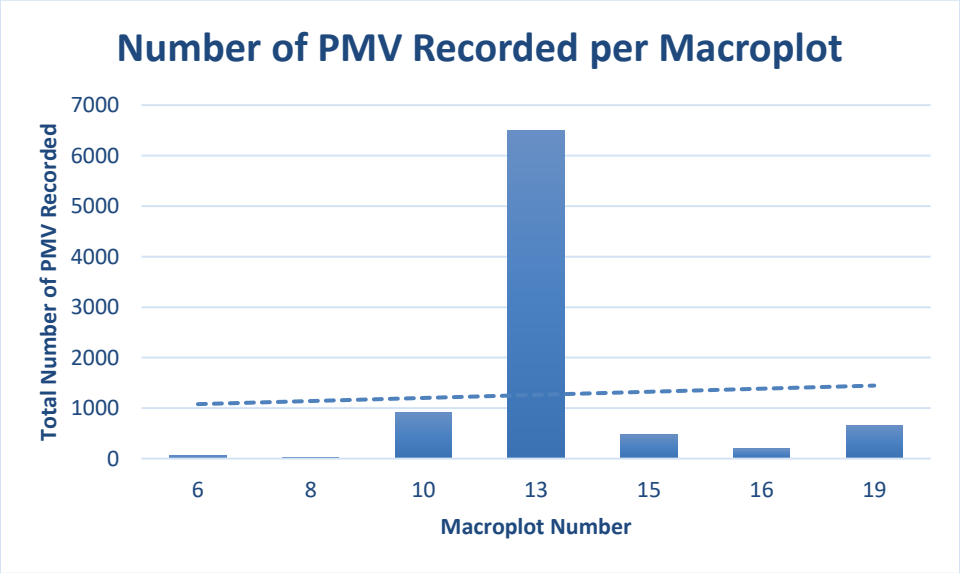

Figure 5. Total number of PMV recorded in 2018 by macroplot. Macroplots are shown in ascending numerical order which corresponds to their location in the Imperial Sand Dunes on a north-south axis with Macroplot 6 being the northern most plot and Macroplot 19 being the southernmost. The dotted line illustrates plant distribution trends on a north to south gradient.

The distribution of PMV individuals greater than 1 year old followed a similar pattern as the distribution of the total number of plants across the macroplots. Macroplot 13 supported most plants greater than 1 year old equaling 49% of the total. Macroplot 19 supported 21% which was more than the 12% in Macroplot 10. Macroplot 15 (9%), Macroplot 16 (5%), Macroplot 8 (2%), and Macroplot 6 (2%) account for the rest of the greater than 1-year old plants. Figure 6 illustrates this spread of these greater than 1-year old plants among the macroplots.

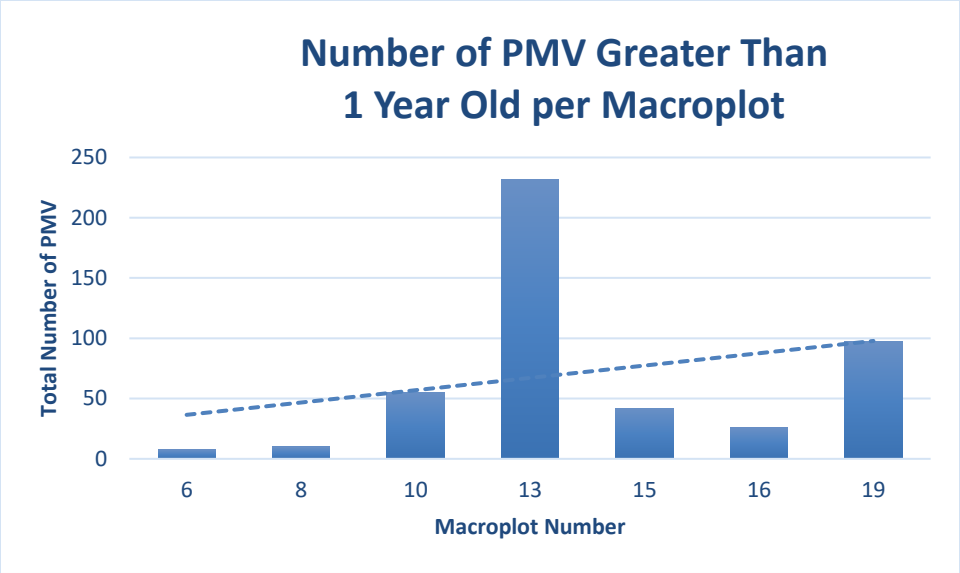

Figure 6. Total number of PMV plants greater than 1 year old recorded in 2018 by macroplot. The total number of PMV by macroplot. Macroplots are shown in ascending numerical order which corresponds to their location in the Imperial Sand Dunes on a north-south axis with Macroplot 6 being the northern most plot and Macroplot 19 being the southernmost. The dotted line illustrates plant distribution trends on a north to south gradient.

Based on the 2005 dune wide sampling effort (Willoughby 2005), there is a north-south gradient in terms of number of plants present, with the southern part of the Imperial Sand Dunes system supporting more plants than the northern portion. This is expressed in the 2018 monitoring data to a degree. Figures 5 and 6 show a slight trend towards more plants in the southernmost plots, which partially accounts for lower overall plant population numbers in the more northern macroplots even though habitat suitability, as discussed earlier, and OHV impacts to PMV are also likely factors that affect overall trends (see section 5.4 Impacts to PMV). Macroplot 13 is the exception to this trend being more in a central location of the Imperial Sand Dunes and consistently having large PMV populations each monitoring year.

5.2 Stage-class Composition

Overall, the monitoring effort in 2018 found the PMV populations to be mostly mature plants greater than 1 year old. This is significantly different than the results of past monitoring years in which mature plants were the minority; this demonstrates the species response to a lack of (or changes from typical) precipitation.

The 2017-2018 growing season represented the lowest precipitation total recorded since the RAWS began collecting site specific data for the Imperial Sand Dunes in 2001 (Table 4). This low precipitation level during the growing season followed what was an above average precipitation level in the 2016-2017 growing season that had produced some 18,715 seedlings within the monitored macroplots. While the 2017-2018 growing season had below average

precipitation levels, a large rain event in September 2017 (Figure 4) is believed to have provided enough moisture for plants present in 2017 to persist into 2018.

From 2014-2017 an average of 18.25 PMV greater than 1 year old had been recorded each year during the annual monitoring effort. Monitoring in 2018 located 470 PMV greater than a year old, significantly more than average. Observers noted that many of these plants were covered in seed pods having already flowered and gone to seed by the time the annual monitoring was conducted. BLM employees working in the Imperial Sand Dunes had incidentally noted multiple PMV in flower with developing seed pods as early in the year as January 5, 2018 (Picture 1). These may have resulted from rains in August and September of 2017 that helped plants from the 2016-2017 growing season to over-summer into the 2017-2018 growing season.

Picture 1. A greater than 1-year old PMV plant in flower with developing seed pods in the North Algodones Dunes Wilderness on January 5, 2018. Photo by Camden Bruner, BLM.

During the 2018 monitoring, a huge amount of dead mature PMV were classified as Non-OHV Damage. These plants were larger than the size of typical seedlings from early in the 2018 growing season and had developed woody stems. It is likely they were present during the 2017 monitoring effort and had survived through most of the winter, dying with the below average precipitation levels sometime in late 2017 or early 2018.

Only 38 total plants were located with flowers during the 2018 monitoring effort; the average number of flowering plants located during the 2014-2017 monitoring efforts is 68. This is likely a reflection of plants blooming before the 2018 monitoring effort in response to rain as previously discussed. Contrast this to the monitoring results of 2005 when 75% of the plants were flowering. The 2004-2005 growing season experienced rainfall that was both much higher than average and well distributed throughout both the early and late halves of the growing season accounting for the number of plants in bloom.

Only 7 seedlings were observed during the 2018 monitoring; all were in Macroplots 6 and 8. This is very different from previous monitoring years. Almost all (99%) of the plants counted in 2017 were seedlings and young, non-flowering plants. The stage-class distribution of plants in 2017 is like that observed in the previous three years of monitoring, with almost all of the plants observed being in the seedling and non-flowering category.

5.3 Survivorship and Recruitment

The 2018 monitoring effort documented high survivorship rates of plants present from 2017 to spring 2018. This cohort of mature plants that survived the summer likely is contributing large numbers of seeds into the seed bank.

Porter et al. (2005) and Phillips and Kennedy (2005) noted that PMV possesses two different strategies for seed production. Plants that flower early in the growing season have time to flower and set seed during the same season. Porter et al. states there is approximately 90 days between germination and flowering. Plants that germinate later in the growing season do not flower in that growing season. Rather, they depend upon surviving through the summer to flower and produce seeds in the subsequent growing season. The former strategy appears to produce the largest quantity of seed simply because the numbers of same-season flowering plants are much higher (Phillips and Kennedy 2005 and 2006; Willoughby 2005 and 2006), but the latter strategy certainly also works to put seeds into the seed bank. Although one year old and older plants are normally far fewer, they produce much more seed per plant than same-season flowering plants (Porter et al. 2005, Phillips and Kennedy 2005).

The 2018 monitoring occurred with abnormal precipitation given an exceptionally large rain event in September 2017 and below average 2017-2018 growing season precipitation. This precipitation pattern did not seem to favor PMV seedlings. Likely few to no PMV seedlings germinated, flowered, and set seed at all during the spring 2018 season. However, this precipitation pattern did seem to support survivorship of plants present in 2017 to spring 2018. Given that 1-year old and older plants produce much more seed per plant than same-season flowering plants (Porter et al. 2005, Phillips and Kennedy 2005), the large number of older plants present in 2018 likely means significant contributions to the seed bank occurred despite a lack of same-season flowering plants.

Survivorship of PMV from one year to the next has been difficult to calculate. With the loss of 3 macroplots worth of data in 2016, it is hard to estimate survivorship of plants from 2015 to 2016 or from 2016-2017. However, with 7 macroplots worth of data in 2017 and another 7 macroplots surveyed in 2018, we can estimate the percentage of plants present in 2017 that survived to 2018. By dividing the number of PMV greater than 1 year old located in 2018 by the total number of PMV found alive in 2017, we have a rough percentage of the number of plants that survived the summer. With this methodology we can estimate that roughly 2.5% of PMV survived from spring 2017 to spring 2018. Note that if the dead mature plants counted in 2018 represented a cohort of plants that had germinated in the 2016-2017 growing season then the > 1 year old plants surviving into at least part of the 2017-2018 growing season is much larger and the survival rate much higher.

Calculating survivorship for previous monitoring years shows that 0.043% of plants survived from 2014-2015, 1.026% of plants survived from 2015-2016, and that 0.048% survived from 2016-2017. Note that as described above the 2015-2016 and 2016-2017 survivorship estimates

are based on only three macroplots. Yet again, although the numbers in the > 1-year old plants category represent the plants still living at the time of monitoring, the number of plants that germinated in the 2016-2017 growing season was probably much greater given the large number of dead, mature plants counted. Likely most, if not all, of these plants would have also been recorded as > 1-year old plants if they had still been living; therefore, the survivorship rate would have been much higher as well.

5.4 Impacts to Peirson's Milk-vetch

During the 2018 monitoring, three primary impacts to PMV were documented. The first was the impact of recent atypical precipitation patterns in the area. The other two observed impacts were OHV use within the dunes and Border Patrol's trespass inside the southernmost PMV critical habitat closure area.

Atypical precipitation was the primary impact to PMV survivorship observed during the 2018 monitoring effort as evidenced by the huge amount of dead, mature plants, all of which were classified as Non-OHV Damage. These are likely plants that were present in 2017 and did not receive the precipitation needed to survive until spring 2018. As discussed in section 5.3, *Survivorship and Recruitment*, it has been difficult to calculate survivorship from past monitoring years. A long-term average PMV survival rate from one year to the next is not known, though it is believed to be low with most of the plants exhibiting an annual, rather than perennial, lifecycle due to low precipitation. With the large number of PMV seedlings found in 2017, high mortality rates were expected and subsequently documented during the 2018 monitoring period. Behaving as an annual appears to be the species natural response to fluctuating precipitation levels over past years with a boom year in 2017 and a bust year in 2018 in terms of seedling germination, even though 2018 was an exceptional year for PMV surviving to be greater than 1 year old. The past two monitoring years have helped to document PMVs response to fluctuating precipitation levels, indicating how strongly the species is influenced by changes in the quantity and seasonality of rain events. Drought conditions or other climatic variables likely dramatically impact the species.

A total of 50 PMV plants damaged by OHV were recorded during the 2018 monitoring effort. These plants all had broken stems and other evidence of being crushed, consistent with having been run over by a tire. This is a significant increase in PMV impacts by OHV activity compared to previous monitoring years (Figure 7).

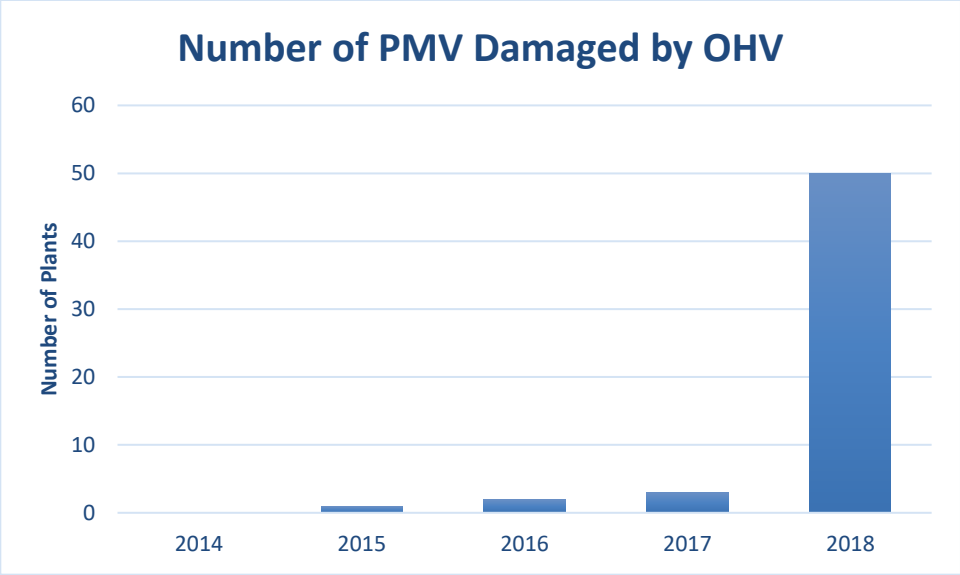

Figure 7. Number of PMV damaged by OHVs by monitoring year.

The number of OHV tracks recorded in the macroplots during 2018 appears to be generally consistent with previous monitoring years (Figure 8).

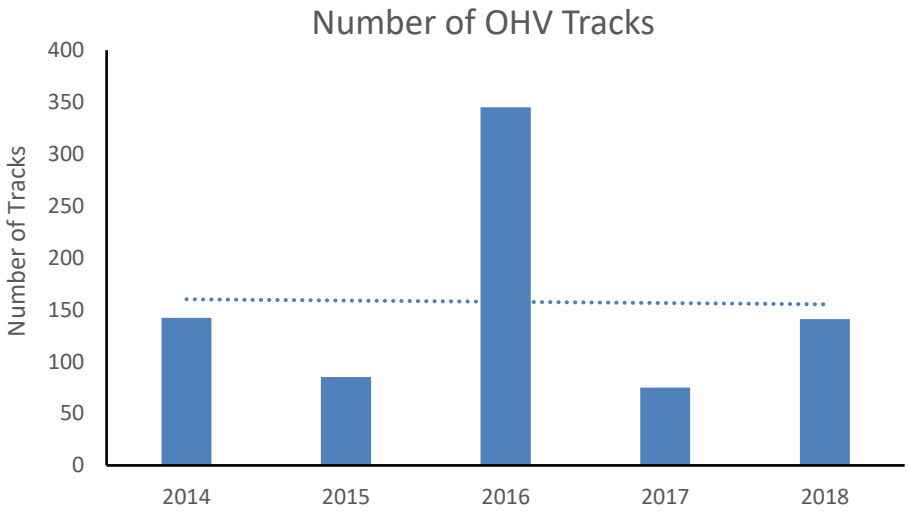

Figure 8. Number of OHV tracks recorded by monitoring year.

As discussed in section 5.3, *Survivorship and Recruitment*, the number of PMV persisting in the macroplots from spring 2017 to spring 2018 were unparalleled in previous monitoring years. The increase in the number of PMV impacted by OHVs likely reflects the larger than average number of PMV that germinated in 2017 and the longer than average duration those plants persisted on the landscape. Simply put, there were more plants present for a longer period likely leading to more plants located during monitoring being impacted by OHV use. Those impacts were spread

out across the macroplots with 5 of the 7 macroplots sampled having OHV-damaged plants present. These results show that there continues to be OHV trespass within critical habitat closure areas that impact PMV.

Macroplot 19 is in the southernmost PMV critical habitat closure (Map 2). This closed section of critical habitat is approximately 218 acres and runs parallel to the international border between the United States and Mexico. 86 vehicle tracks, or 60% of the total tracks recorded across all 7 macroplots, were observed in Macroplot 19. Overall, these tracks appear to be from truck tires, not sand tires or dirt bike tires typically associated with OHV use. The tracks were not spread out across the landscape nor were they contouring with the dune topography in a manner typical with recreational driving. Instead the tracks primarily formed a sand road heading through a dune pass towards the border. A Border Patrol truck was observed driving through Macroplot 19 during annual monitoring and for the second year in a row a Border Patrol ground sensor was present in the macroplot. Despite these observations, no vehicle damage to PMV were recorded in Macroplot 19. However, based on the number of tracks present and the observed use of the area, it is likely Border Patrol activities in the southern critical habitat closure have an impact on PMV to some degree.

5.5 Presence of Other Special Status Species

As noted in section 4.6, *Other Special Status Species*, five additional species of conservation concern were observed during the annual PMV monitoring effort (Table 8). This was the first time other special status species data were recorded within macroplots. This monitoring effort was not designed to specifically collect data on these species and the macroplot locations were not identified based on factors influencing the presence of these species like they were for PMV. However, collection of these data may prove useful in the future when looking at long term trends within the macroplots. With only one year of data from 5 of the 7 macroplots monitored, reliable conclusions cannot be drawn. It is recommended that future monitoring efforts collect data on special status species for evaluation of species trends within the dunes.

Of note, Macroplot 13 had very high number of Wiggins' croton (*Croton wigginsii*), Algodones dunes sunflower (*Helianthus niveus* ssp. *tephrodes*), Colorado Desert fringe-toed lizard (*Uma notata*), and sand food (*Pholisma sonorae*) compared to the other macroplots. This is the same trend observed with PMV numbers over the past 5 monitoring years and suggests that Macroplot 13 is highly suitable habitat for multiple species of conservation concern. This macroplot appears to be an ideal location for studying microhabitat characteristics influencing habitat suitability for these species.

6. Literature Cited

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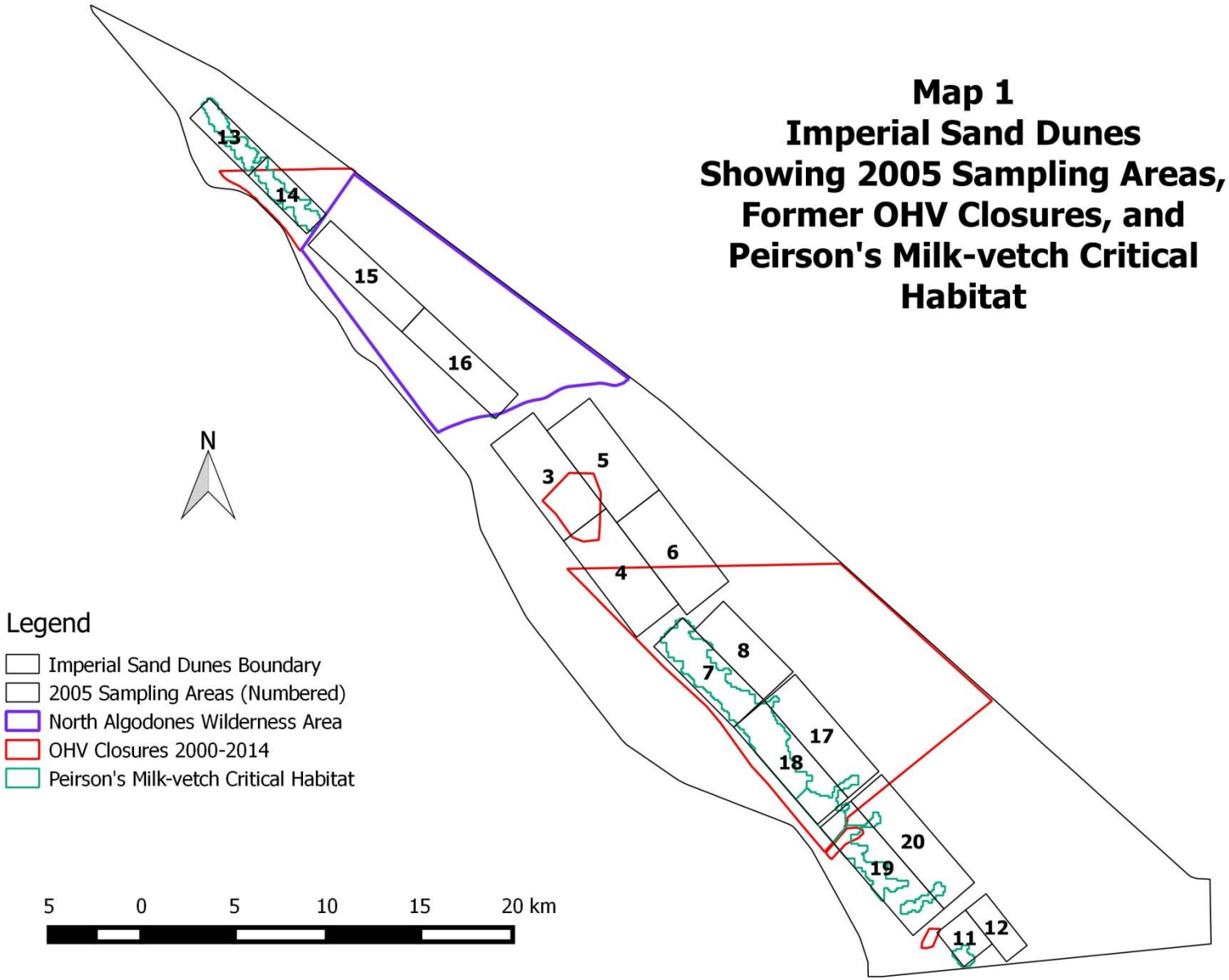
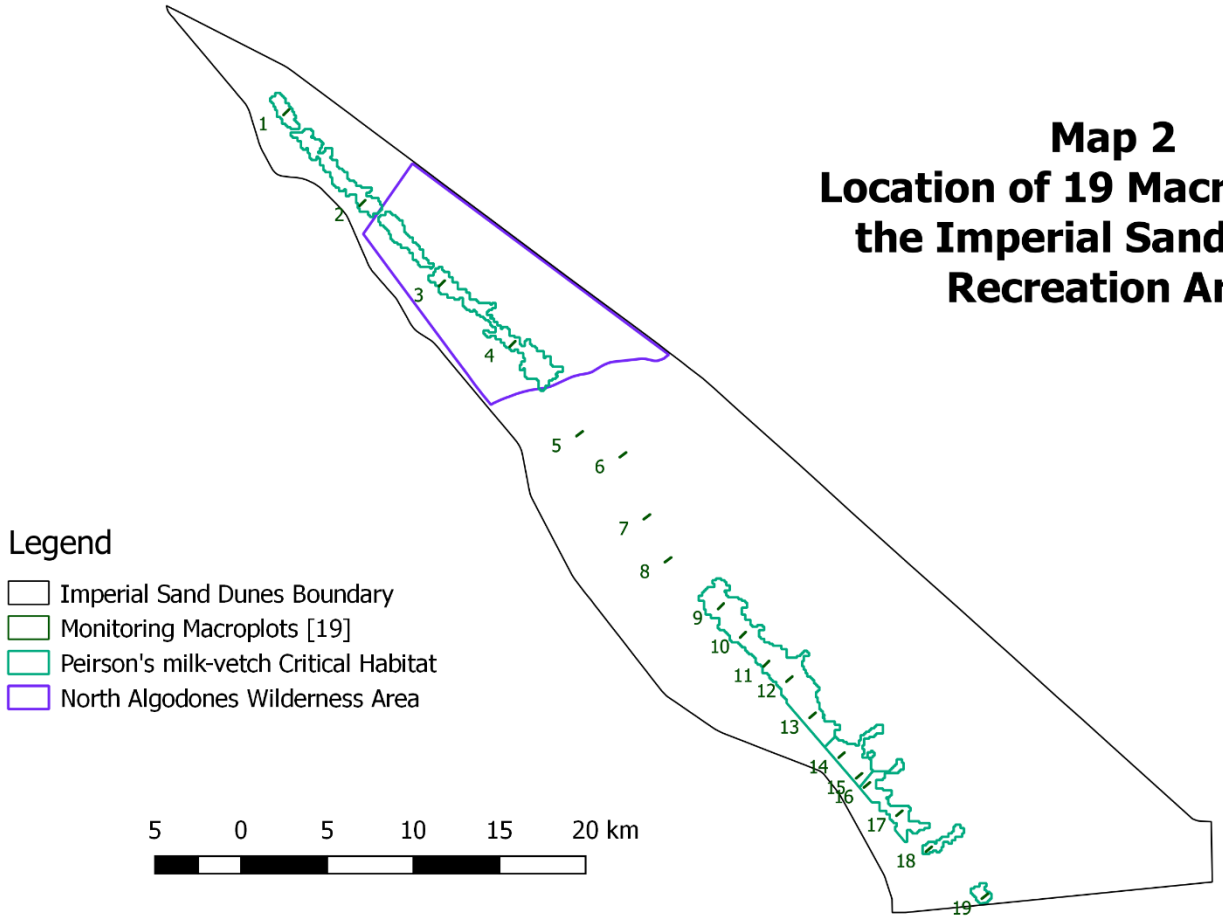
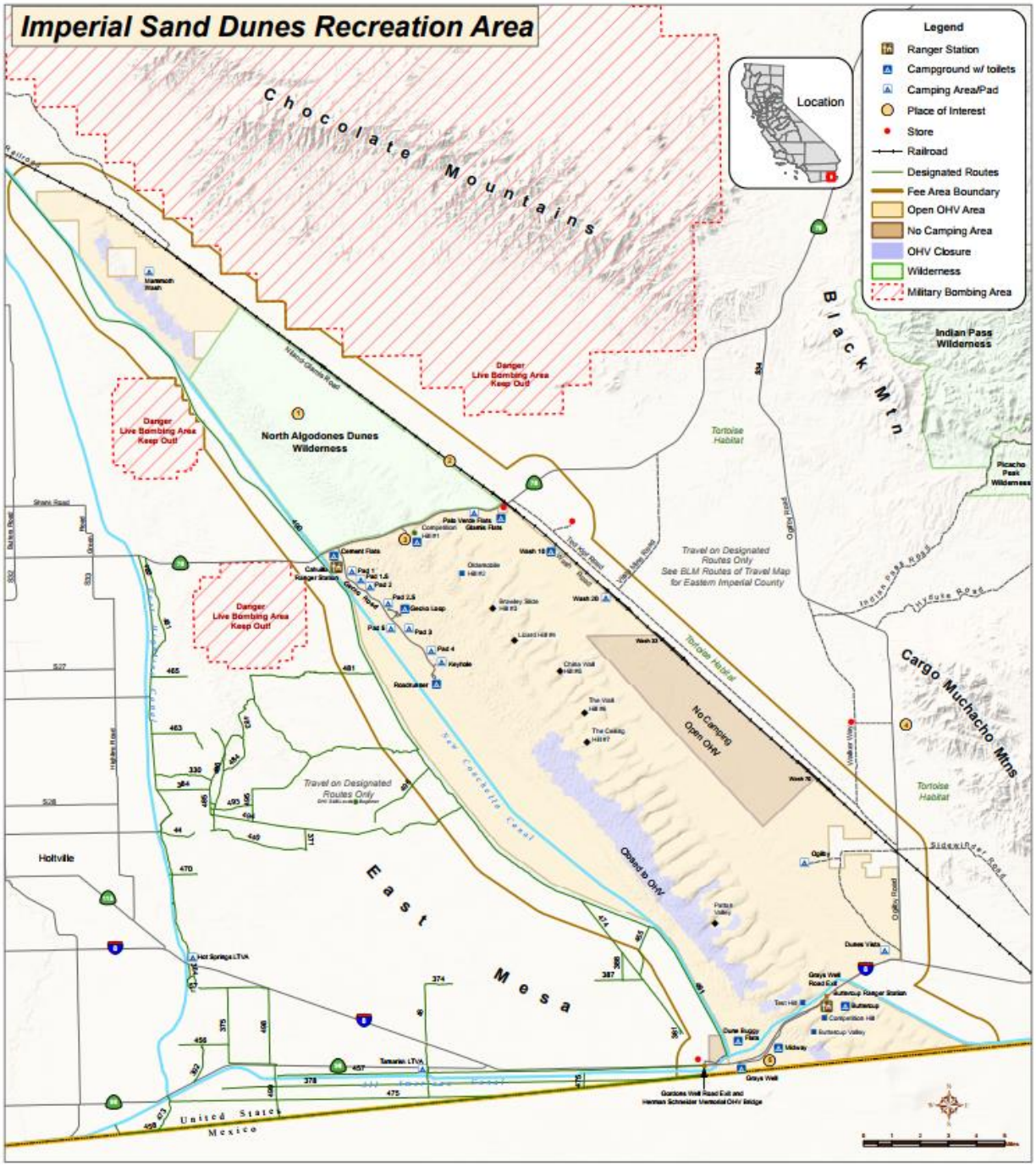
Map 1
Imperial Sand Dunes Showing 2005 Sampling Areas, Former OHV Closures, and Peirson's Milk-vetch Critical Habitat



Map 2
Location of 19 Macroplots in the Imperial Sand Dunes Recreation Area



Map 3

Location of Visitor Facilities Including Buttercup and Cahuilla Ranger Stations in the Imperial Sand Dunes Recreation Area