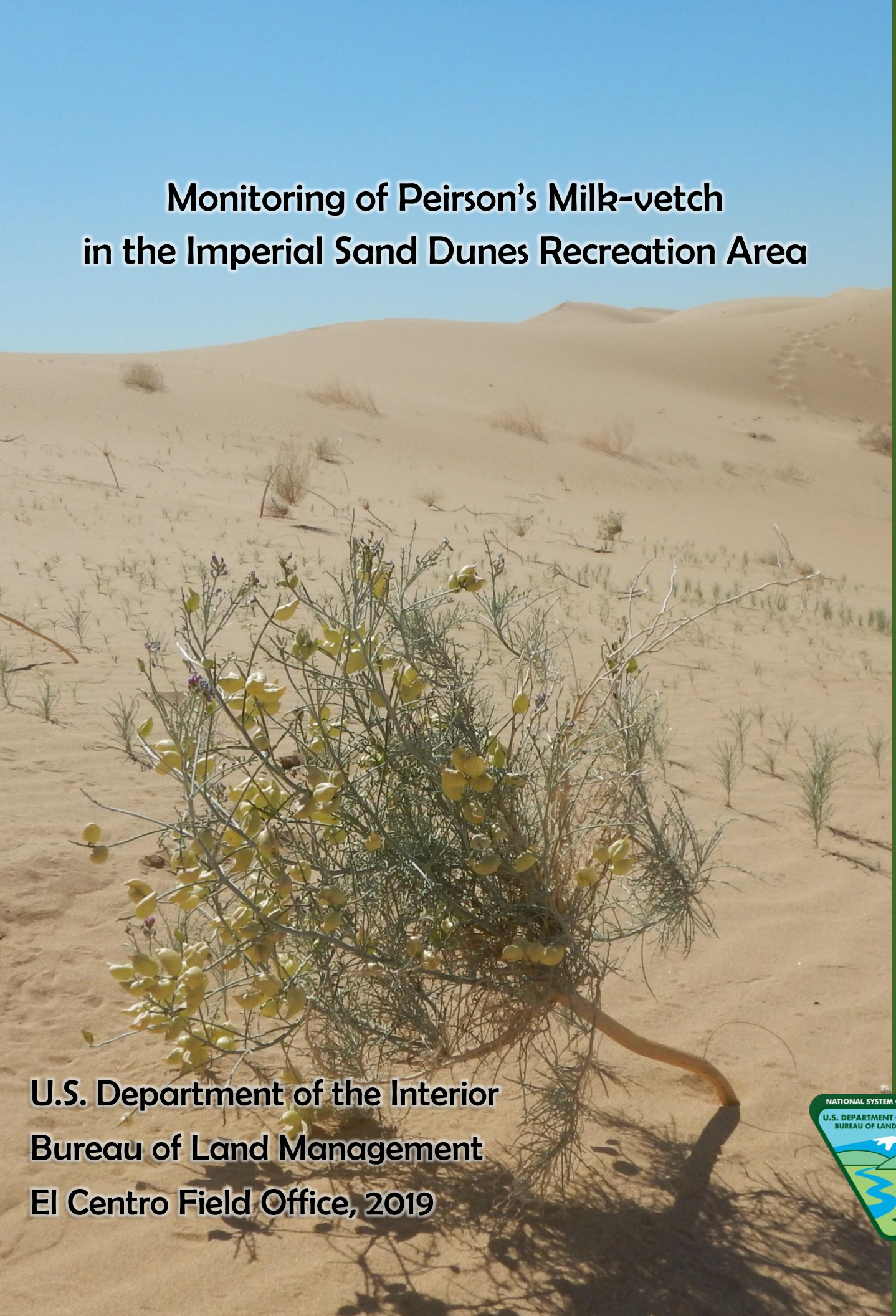
Monitoring of Peirson's Milk-vetch in the Imperial Sand Dunes Recreation Area



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Cover photo of a Peirson’s Milk-vetch flower.

Photo by Calvin Vialpando, BLM.

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1. Preface

The author of this report is Calvin Vialpando, Wildlife Biologist for the Bureau of Land Management (BLM), El Centro Field Office (2019). 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 2019 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 sixth 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), the 2017 monitoring is documented in Willoughby (2017b) and the 2018 is documented in Bruner (2018).

The following individuals worked to accomplish the 2019 monitoring effort:

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2. Introduction

In March 2019, 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; these plots are 6, 8, 10, 13, 15, 16, and plot 19 is generally done as a practice plot. 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; 2019 being the sixth year of the surveys.

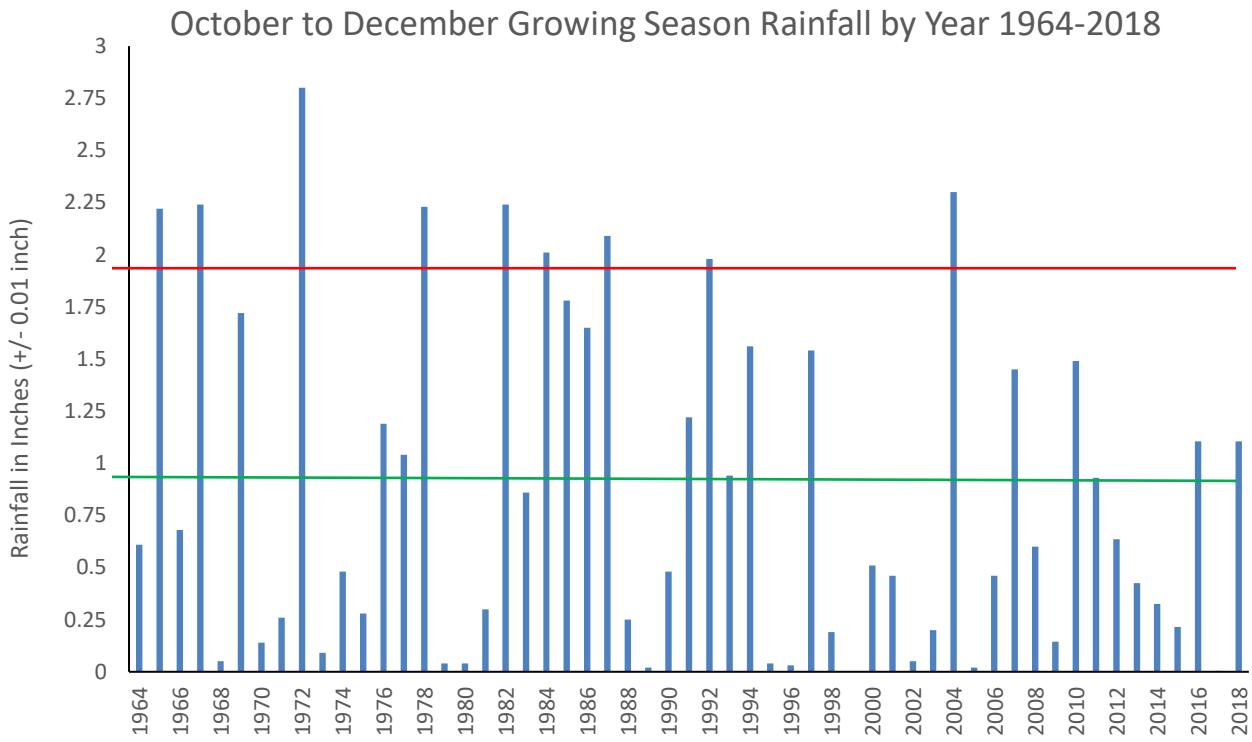

Figure 1. Total October-December growing season precipitation from 1964-2018 in the Imperial Sand Dunes. Precipitation values for growing seasons from 1964 to 2000 are the averages of seven Western Regional Climate Center (WRCC) weather stations in the vicinity of the Imperial Sand Dunes. The values for growing seasons 2001 to 2018 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 by 500m in size and are oriented southwest to northeast. The macroplots are divided into forty 25m by 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 the westernmost sampling areas (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 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.

[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.

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, (now retired) GIS expert with the Carlsbad Field Office of the Fish and Wildlife Service, 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 PMV specific variables, the number of OHV tracks was recorded, as well as any additional special status plants present in the cell. These 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 2019.

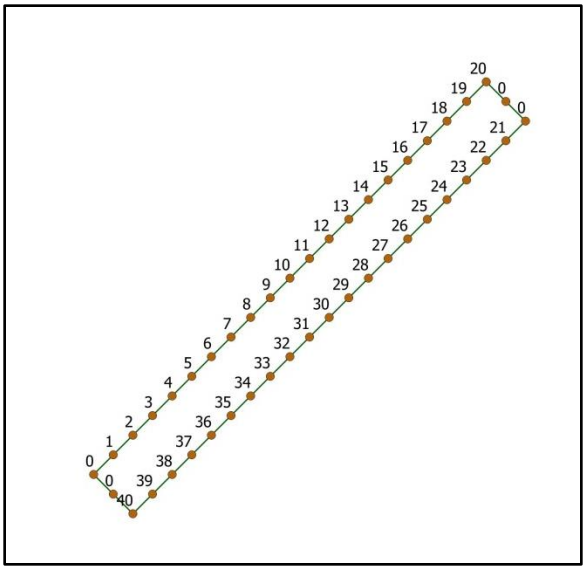

Figure 3. Waypoint numbering system used in 2019 for monitoring each macroplot. The waypoints numbered 0 are for navigation purposes only and have no data recorded for them.

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 2017-2019

The system used to collect data was modified for the 2017-2019 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 2017-2019 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 2018 1.03 inches of precipitation were recorded at the Buttercup Ranger Station RAWS and 1.06 inches of precipitation were recorded at the Cahuilla Ranger Station RAWS. This averages to 1.05 inches of precipitation for the Imperial Sand Dunes, remaining 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 2017-2019*. Because Macroplot 19 was surveyed according to protocol, the results are included in this report.

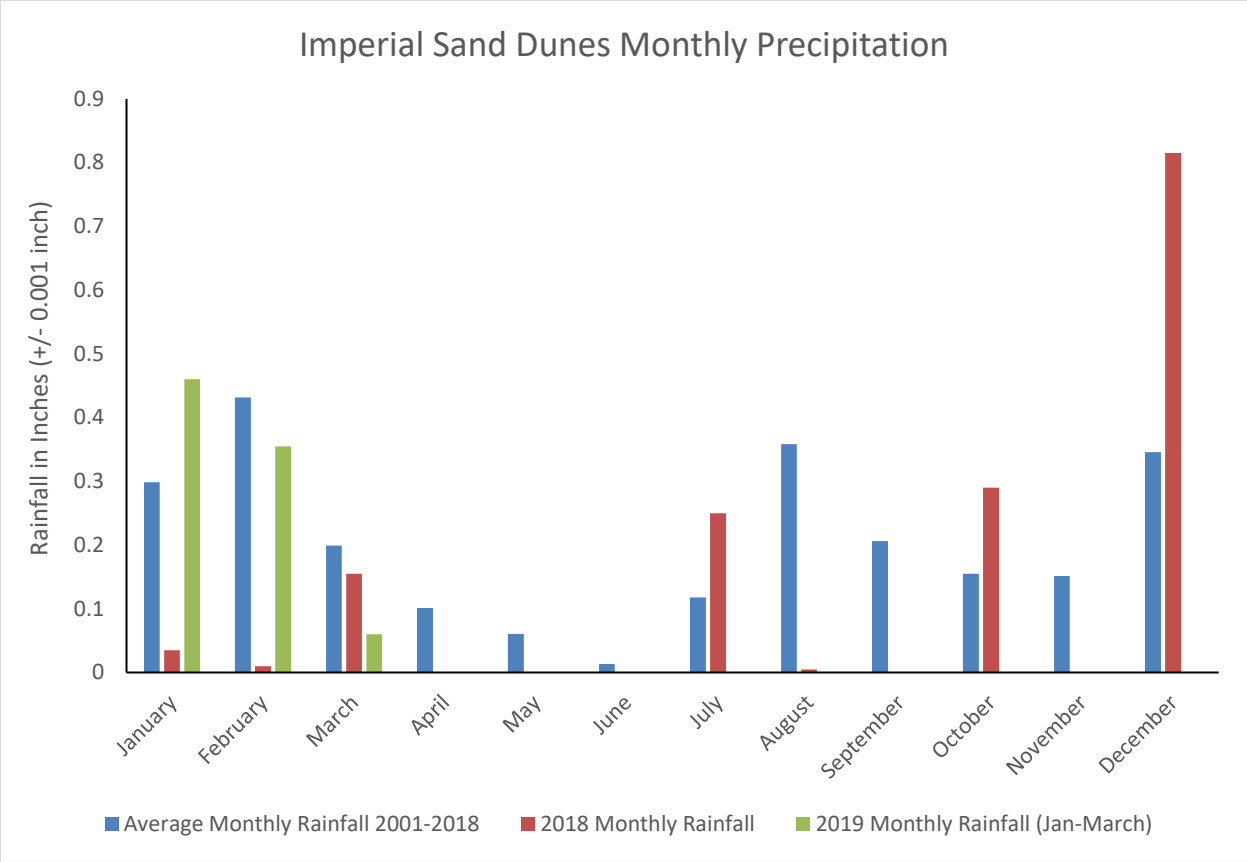

Figure 4. Average monthly rainfall for the Imperial Sand Dunes recorded by the RAWS from 2001-2019. In 2018, October-December average rainfall was 1.11 for the Imperial Sand Dunes. From January to March 2019, a total of 0.875 inches of precipitation was recorded giving a total of 1.98 inches of precipitation for the 2018-2019 growing season.

Table 4. Growing season precipitation recorded mostly by the RAWS from 2001-2019. 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 18 and 21, 2019, as shown in Table 5. Between 6-9 observers participated each day of the PMV surveys. Macroplot 19 was the training plot and was the only macroplot surveyed that day. The rest of the survey, two macroplots were surveyed per day.

Weather conditions were generally mild during the 2019 monitoring effort (Table 6). Winds were present most days but did not affect visibility. Temperatures generally ranged between 25-32 degrees Celsius.

Table 5. Monitoring dates and observers in 2019.

Macroplot	Date Monitored	Observers
19	3/18/2019	Calvin Vialapndo, Jeff Sahagun, Mary Crawford, Daniel Baca, Jacob Sotelo, Michael Mujica, David Clemmer, and Asdrubal Estrada
10 & 13	3/19/2019	Calvin Vialapndo, Tony McKinney, Mary Crawford, Jacob Sotelo, Michael Mujica, David Clemmer, and Asdrubal Estrada
15 & 16	3/20/2019	Calvin Vialapndo, Tony McKinney, Mary Crawford, Jacob Sotelo, Michael Mujica, and Asdrubal Estrada
6 & 8	3/21/2019	Calvin Vialapndo, Jeff Sahagun, Jacob Sotelo, Michael Mujica, David Clemmer and Asdrubal Estrada

4.3 Peirson's Milk-vetch

A total of 13,463 plants were counted during the 2019 surveys (Table 6). Of the total number, 12,855 seedlings were counted along with 608 flowering plants. A total of 22 plants that were over a year old were observed. PMV were most abundant in macroplot 13 consisting of 57.6% of the total number of plants recorded during the survey. One microplot in macroplot 13 had 2,469 individual plants. Macroplot 8 had the fewest plants counted during the survey (170 individuals). PMV occupied 156 of 280 microplots (55.7%) (Table 6). Few plants were recorded as having non-OHV damage (26 individuals).

Table 6. 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 2019. 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	Number of OHV Tracks	Number of Cells Occupied by PMV	Number of Cells w/ OHV Tracks
6	493	2	495	0	0	0	0	8	0
8	169	1	170	0	0	0	8	23	6
10	2788	407	3195	6	6	12	5	20	5
13	7628	131	7759	15	0	4	0	33	0
15	584	12	596	0	3	0	25	28	10
16	228	2	230	0	0	0	0	18	0
19	965	53	1018	1	2	10	45	26	11
Total	**12855**	**608**	**13463**	**22**	**11**	**26**	**83**	**156**	**32**

4.4 OHV Impacts and Tracks

Of the 280 microplots monitored, 32 had OHV tracks present. In total, 83 OHV tracks were recorded within the 7 macroplots. OHV tracks were not evenly distributed across the plots; Macroplot 19 had 45 vehicle tracks (54.2%) of the total tracks. Other macroplots in the PMV closure areas 6, 13, and 16 did not have any OHV tracks, whereas macroplots 10 and 15 did. Two macroplots (6 and 8) reside in OHV open areas. Only macroplot 6 had OHV tracks present (8 total tracks).

In total, 11 plants (all seedlings) had OHV damage. Macroplot 10 alone had 6 plants that were damaged from OHV use. These plants had obvious broken stems and signs of crushing. The macroplots (6 and 8) open for OHV use did not have any OHV damaged plants, but the sites overall had low numbers of plants.

4.5 Non-OHV Impacts

A total of 26 plants were counted as having non-OHV damage. Macroplot 19 had the most plants damaged by non-OHV with a total of 10. Plants may have been damaged by observers accidentally stepping on them, or from insect herbivory. Macroplot 19 was used for the training plot for the observers; the subsequent surveys had few plants damaged by accidental stepping on.

Insect damage was also noted in the 2019 surveys. An actual number was not quantified due to the limited expertise of the observers in identifying insect damaged plants. Some plants, predominately mature individuals in flower or seed, did exhibit notable numbers of aphids. Aphids appeared less frequently on seedlings than on mature plants, potentially indicating a herbivorous preference for older plants.

5. Discussion

5.1 Distribution and Abundance

Suitable habitat for PMV within the Imperial Sand Dunes only exists 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°-15° angle and in dune bowls where there is less sand movement and more consistency in dune topography. Dune slip faces and dune crests are often not suitable for the species, as these areas change rapidly with the wind and experience continual sand movements, some of which can dramatically alter PMV habitat.

While the macroplots used for monitoring were selected based on the presence of PMV, during any given monitoring year a large percentage of each macroplot will not be suitable habitat for PMV given the current microhabitat dune topography present there. In 2019, of the 40 microplots within each macroplot, an average of 21.43 of the microplots were occupied with PMV (Table 7). This is consistent with past years of monitoring and demonstrates how many of the microplots likely are not suitable habitat for the species during any given monitoring year due to sand movement within the dunes. It is important to note that habitat suitability is influenced by precipitation as well, and areas of previously unsuitable habitat could exhibit PMV recruitment in years of high precipitation.

In Macroplot 13, PMV occupied 33 microplots, which is well above the average for 2019. Similarly, Macroplot 13 supported an average of 235 PMV per occupied microplot, considerably higher than the 2019 average of 86. This suggests, among other factors, that during 2019 Macroplot 13 had a higher percentage of suitable habitat for PMV than the other plots. Macroplots 6 and 16 were found to be well below the average number of occupied microplots and the average number PMV per occupied microplot. This is likely influenced by the amount of suitable habitat present in these plots, though many other factors may contribute to these numbers. Figure 5 illustrates the distribution of recorded PMV individuals between macroplots.

Macroplot Number	Number of Ocuupied	Average Number of PMV per Ocuupied Microplot
6	8	62
8	23	7
10	20	160
13	33	235
15	28	21
16	12	13
19	26	39
Average	21.43	86

Table 7. Average number of microplots occupied with PMV by macroplot as well as the average number of PMV per occupied microplot.

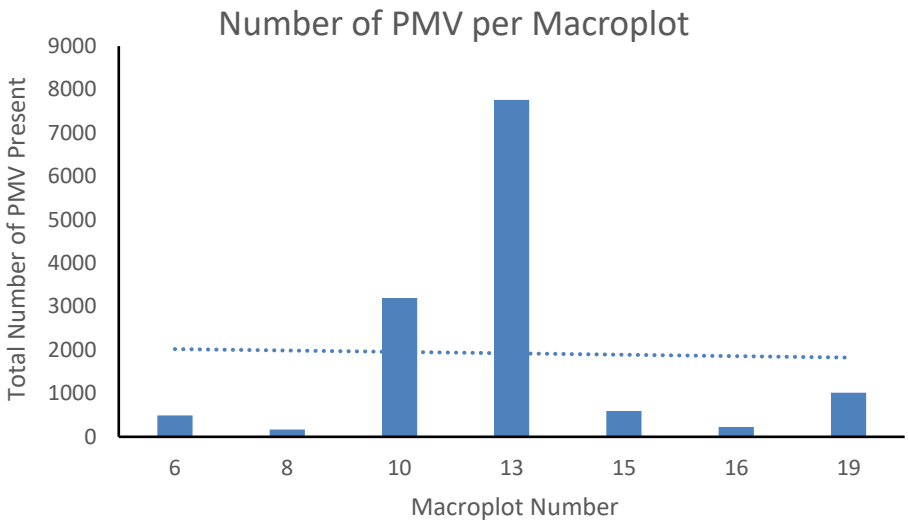

Figure 5. Total number of PMV recorded in 2019 by macroplot. Macroplots are shown in ascending numerical order which corresponds to their location in the Imperial Sand Dunes on a north-south axis with Macroplot 6 being the northern most plot and Macroplot 19 being the southernmost. The dotted line illustrates plant distribution trends on a north to south gradient.

There were 22 PMV that were older than one year old. 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 the majority of plants greater than 1 year old with 68.2% of the total. Macroplot 10 supported 27.3% and Macroplot 19 had 4.5%; the remaining plots had none. Figure 6 illustrates this spread of these greater than 1-year old plants among the macroplots.

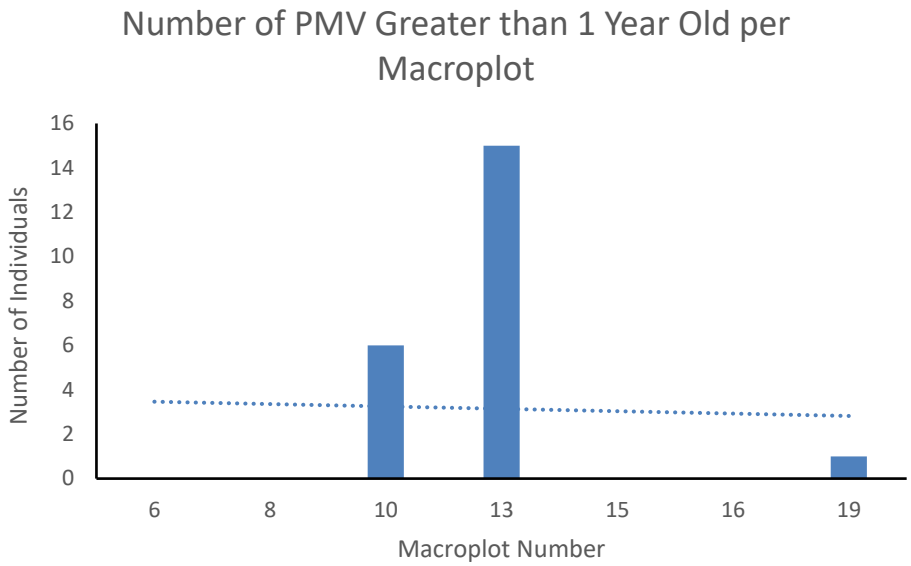

Figure 6. Total number of PMV plants greater than 1 year old recorded in 2018 by macroplot. The total number of PMV by macroplot. Macroplots are shown in ascending numerical order which corresponds to their location in the Imperial Sand Dunes on a north-south axis with Macroplot 6 being the northern 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. The 2019 monitoring data (Figures 5 and 6) do not support this hypothesis. The trend line shows a slight negative trend from north to south, however, this is likely due to the high counts in macroplots 10 and 13 which are more centrally located compared to the rest. These two plots historically have the highest number of individual PMV and PMV greater than 1 year old.

5.2 Stage-class Composition

The monitoring efforts in 2019 for that the PMV populations comprised mostly of seedlings. With the exception of the 2018 monitoring efforts, these results were consistent with previous years. These results are likely due to the amount of precipitation received during the growing season.

The 2018-2019 growing season recorded a total of 1.98 inches of precipitation from October to March. This growing season follows the 2017-2018 growing season which was the lowest precipitation total recorded since the RAWS began collecting site specific data for the Imperial Sand Dunes in 2001 (Table 4). The rainfall recorded for October to December 2018 was enough to cause seeds to germinate with January to March precipitation maintaining further growth and flowering of PMV.

The 2019 monitoring efforts recorded numerous PMV in flower, many of which were less than one year old. This was the highest number (608) of flowering plants observed since these surveys began in 2014 (2017 surveys recorded the second highest amount with 109 flowering). This high number of flowering individuals were likely due to the wet growing season. There was ample rainfall early on followed by continuous precipitation events to allow for young PMV to go into flower. It's important to note that plants germinating in response to December rain may not have had time to flower before the mid-March monitoring effort. Therefore, it is likely that more plants flowered in early to mid-April and were not recorded during monitoring.

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 yielded a high number of PMV greater than a year old (413 individuals). The number of PMV greater than a year old observed during the 2019 surveys numbers returned closer to the 2014-2017 averages with 22 recorded. It is possible that most of these plants are from the 2017 cohort (i.e., they survived into their 3rd year), since 2018 exhibited low seedling recruitment and low numbers of flowering plants. It was noted that many of the mature plants observed in 2019 had a high number of seed pods. Some of the seed pods appeared to have dispersed some of their seeds around the time of the surveys.

5.3 Survivorship and Recruitment

The winter rains were adequate enough to cause a lot of the seeds produced from last season's seed bank to germinate during the growing season. Seedlings accounted for 95% of the overall plants. Additionally, there were a lot of plants that were flowering that did not appear greater than one year suggesting those plants germinated earlier in the growing season.

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).

Survivorship from last season was low. Only 22 plants were documented on being over a year old with most occurring in Macroplot 13, which had 15 mature plants. Since the start of these surveys in 2014, the average number of mature plants or plants over one year old is 85. In 2018, there were an exceptionally high number of mature plants documented (413) thus skewing the average. With the 2018 numbers omitted, the average mature plants is substantially lower at 19 mature plants per year making the 2019 numbers just slightly above the average. Many of the

mature plants already had seed pods with some pods that already had opened suggesting they flowered earlier in the year.

5.4 Impacts to Peirson's Milk-vetch

The limited distribution and habitat requirements of PMV make them vulnerable to any impact present within their range. Potential impacts include but are not limited to climate and weather conditions, anthropogenic disturbances, resource competition within the vegetation community, and insect infestations and herbivory. Under the right circumstances, any one of these factors can detrimentally impact PMV populations.

Surveys since 2014 have illustrated that PMV recruitment and mortality can vary considerably from year to year due to several factors that can both positively and negatively impact the species. Climate and weather are likely the largest contributing factor to PMV population fluctuation. In 2018, high PMV mortality was observed following notably low rainfall during the first half of the growing season (Bruner 2018). Conversely, high rainfall in the 2019 growing season yielded increased seedling recruitment and allowed for several PMV to flower and produce seeds. These data illustrate how sensitive PMV populations are to climatic changes, which are common in the dynamic and often hostile dune environment. Recruitment and survivorship become especially important when environmental stressors persist for more than one season. For example, severe drought can greatly impact this species, particularly if drought persists for consecutive years.

The Imperial Sand Dunes are a popular OHV recreation use area. Two macroplots that were monitored in 2019 are located in open OHV use areas with the remaining in areas closed to OHV use. On average, 145 OHV tracks have been recorded since 2014 within the macroplots measured during that time period. Macroplots 6 and 8, collectively, which are open for OHV use, account for on average of 40 of the total OHV tracks recorded per season. Since Macroplot 19 has been used as a training plot for observers (2017-2019) and data included in the monitoring efforts, Macroplot 19 on average records 60 OHV tracks per survey. OHV use still occurs within closure areas (Macroplot 19). In 2019, 75 OHV tracks were recorded within the closure area or 90% of all tracks recorded. If Macroplot 19 data is omitted, there were 30 tracks recorded in the closure area (macroplots 10, 13, 15 and 16) with 25 of those tracks within macroplot 15. Macroplot 19 is subject to more OHV activity due to the close proximity to the border wall, which is patrolled by the Border Patrol.

Macroplot 19 is located in the southernmost PMV critical habitat closure (Map 2). This closed section of critical habitat totals approximately 218 acres and runs parallel to the international border between the United States and Mexico. There were 45 vehicle tracks recorded across this plot. Overall, these tracks appear to be from truck tires, not the 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. Border

Patrol was not observed in the closure area, but in years past they have been seen within this closure area. There were two OHV damaged PMV recorded in this macroplot. However, based on the number of tracks present and observed use of the area, it is likely Border Patrol activities in the southern critical habitat closure does impact PMV to some degree.

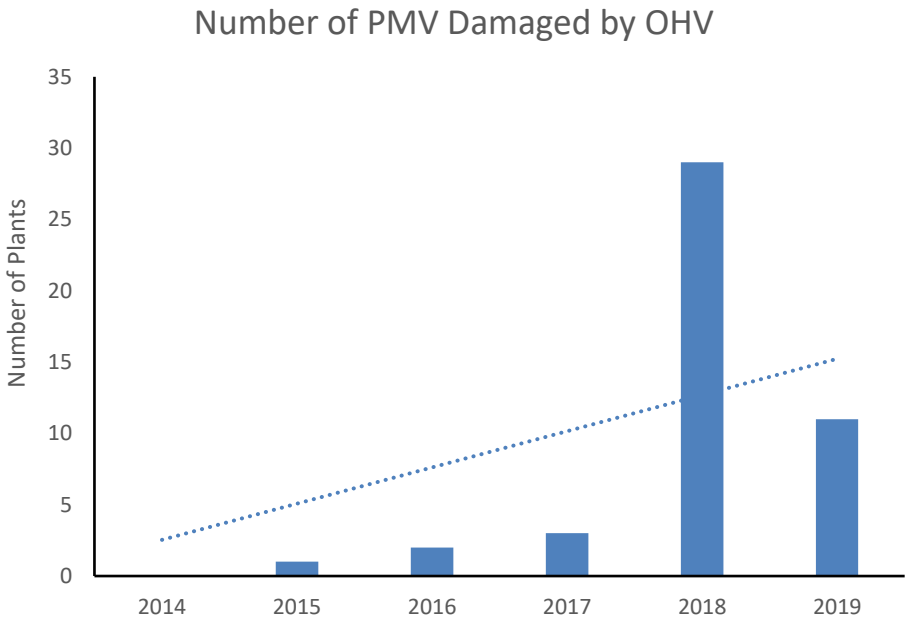

Figure 7. Number of PMV damaged by OHVs by monitoring year.

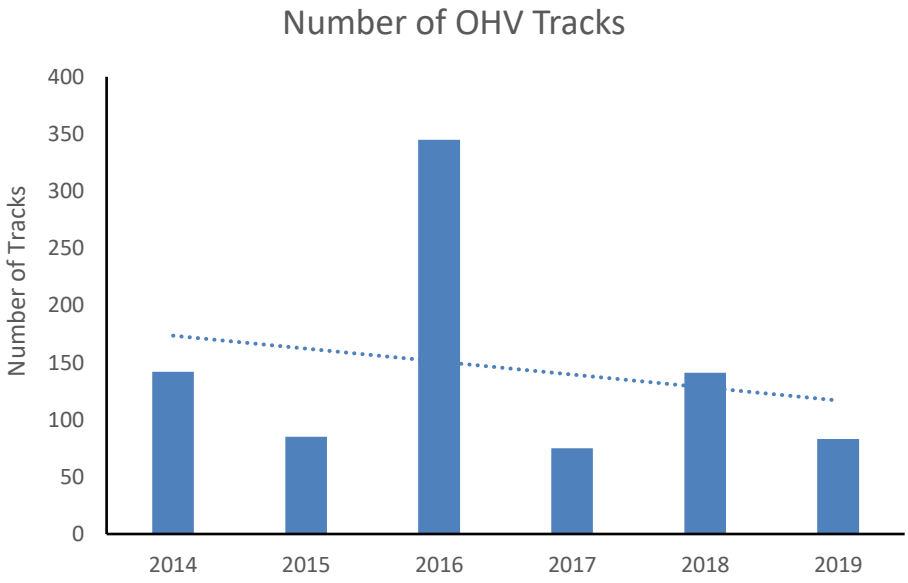

Figure 8. Number of OHV tracks recorded by monitoring year.

There is the potential for other impacts to detrimentally affect PMV populations (e.g., trampling). During the survey, a few PMV were stepped on by observers; this was most common during training activities. However, foot trampling is not likely to notably impact PMV populations due to the limited accessibility of the closure areas within the dunes. Additionally, aphids were present on some of the PMV suggesting there may be a risk of disease and herbivory. Aphids appeared to be attracted to mature plants more so than seedlings. It is not known to what extent PMV is affected by insects; further study is needed to fully understand their impact.

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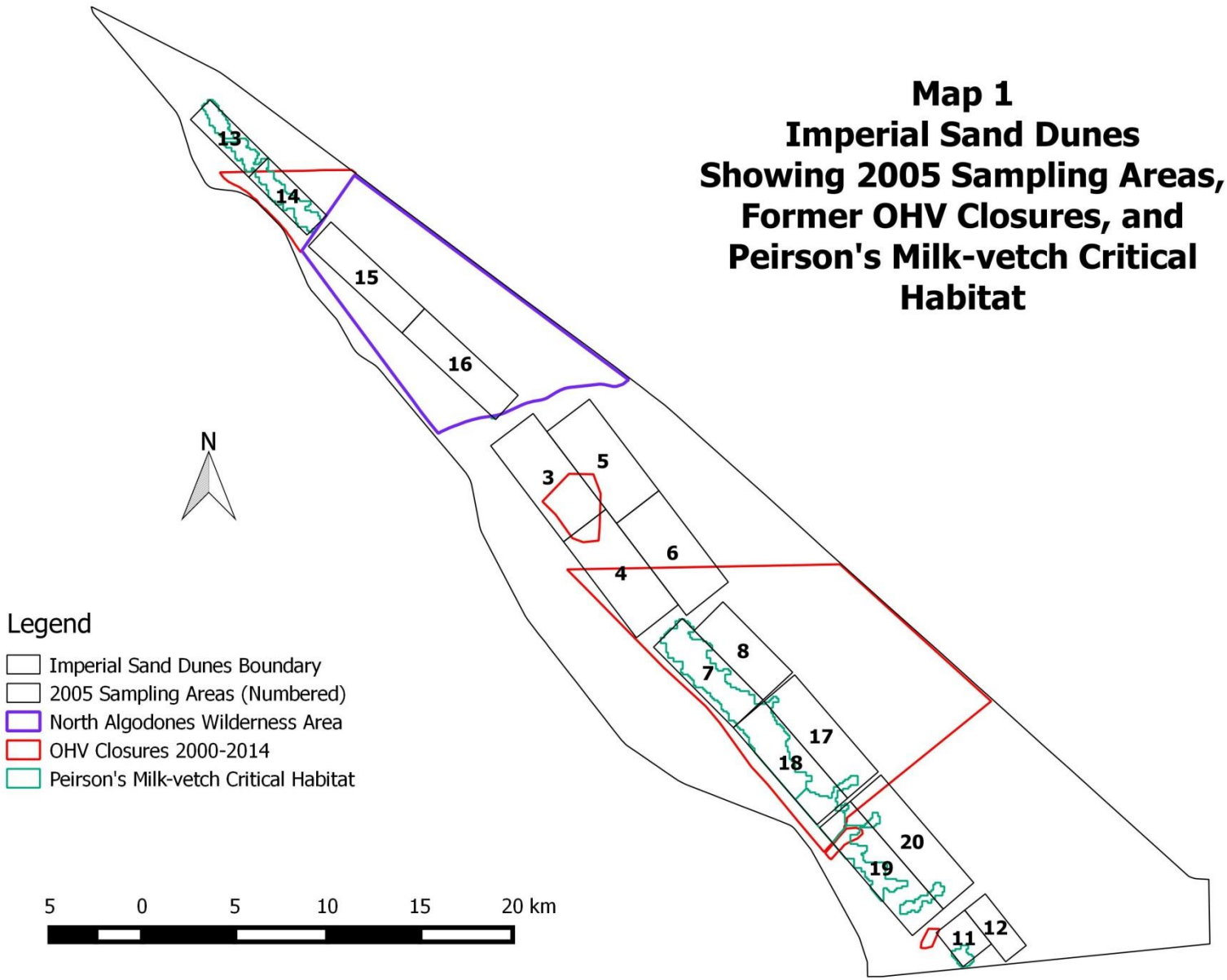
Map 1
Imperial Sand Dunes
Showing 2005 Sampling Areas,
Former OHV Closures, and
Peirson's Milk-vetch Critical
Habitat
N
Legend
Imperial Sand Dunes Boundary
2005 Sampling Areas (Numbered)
North Algodones Wilderness Area
OHV Closures 2000-2014
Peirson's Milk-vetch Critical Habitat
5 0 5 10 15 20 km
13
14
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16
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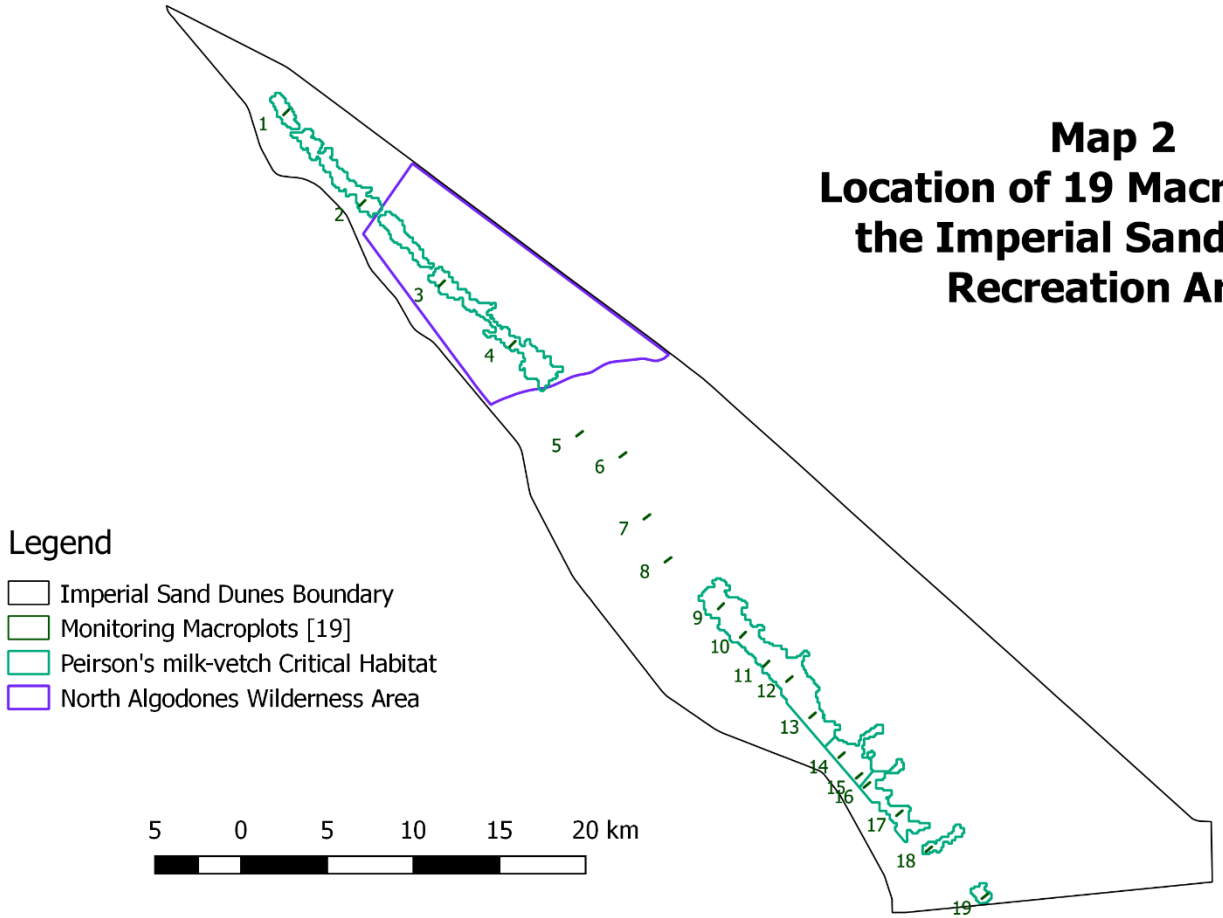
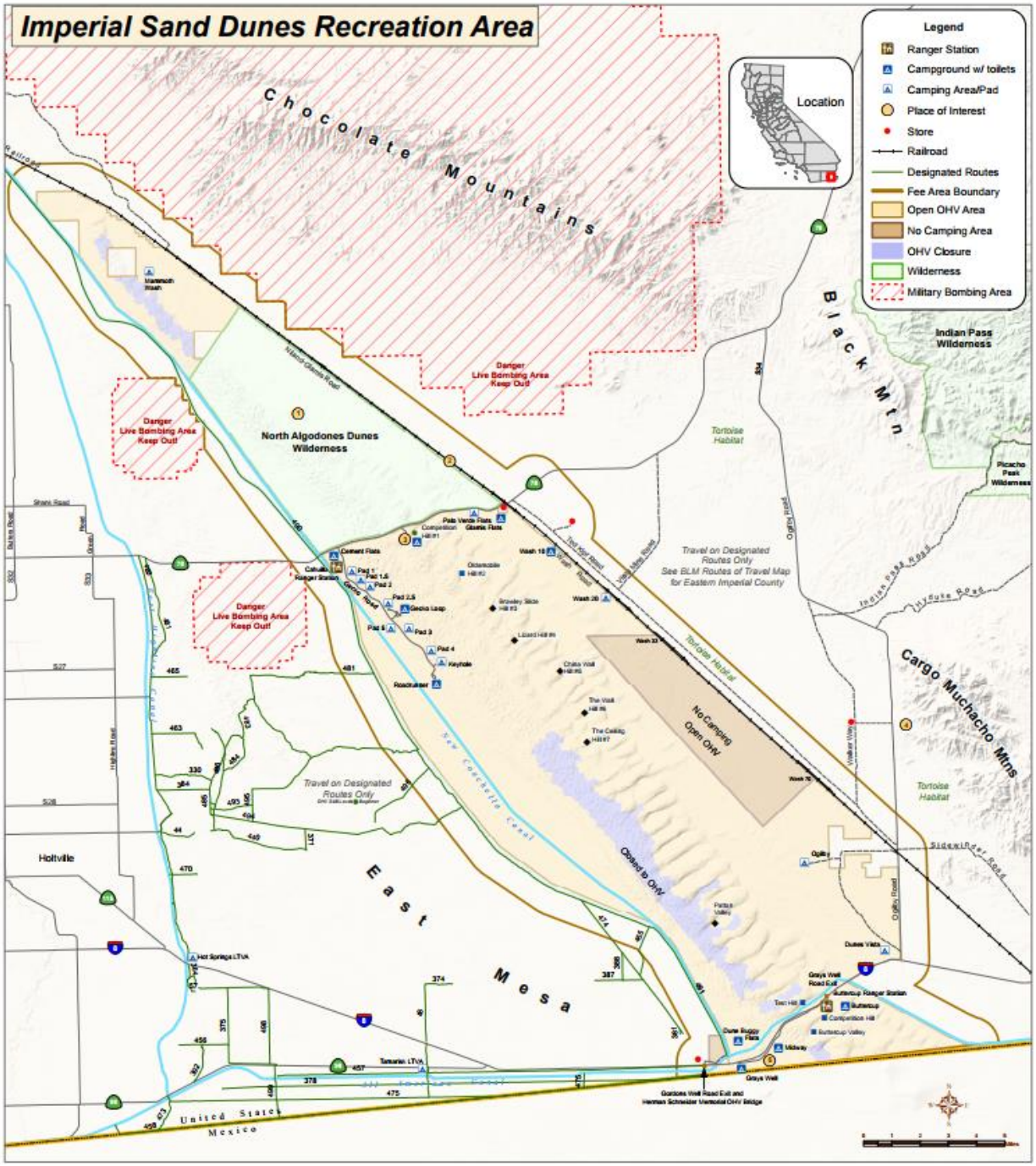
Map 2
Location of 19 Macroplots in the Imperial Sand Dunes Recreation Area



Map 3

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