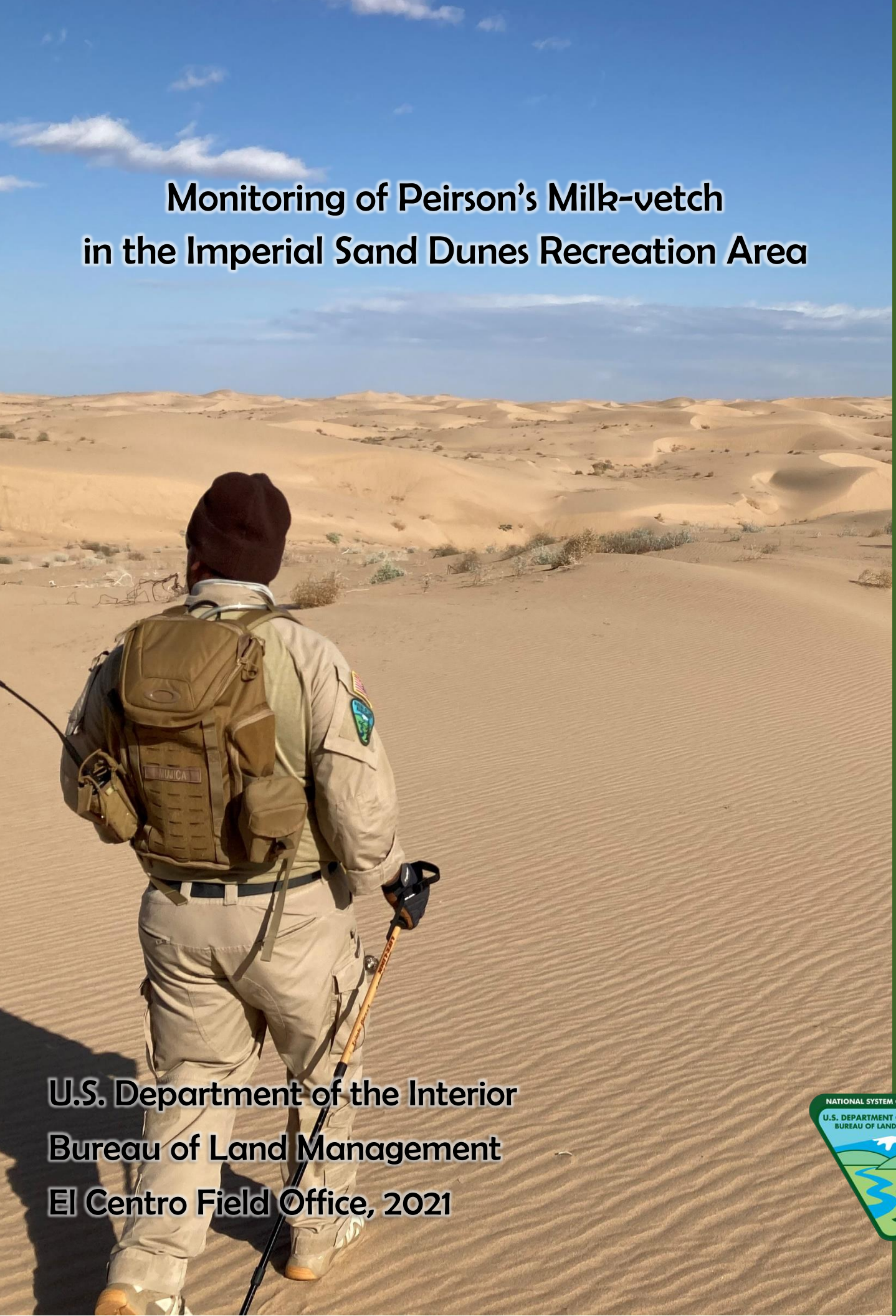
Monitoring of Peirson's Milk-vetch in the Imperial Sand Dunes Recreation Area



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Cover photo of BLM Park Ranger Michael Mujica surveying for Peirson's Milk-vetch, March 2021, Imperial Sand Dunes, CA.

Photo by Peter DeJongh, BLM.

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1. Preface

The author of this report is Peter DeJongh, Wildlife Biologist for the Bureau of Land Management (BLM), El Centro Field Office.

This report documents 2021 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 eighth year of annual monitoring of PMV by the El Centro BLM.

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), the 2018 is documented in Bruner (2018), the 2019 is documented in Vialpando (2019), and the 2020 is documented in DeJongh (2020).

The following individuals worked to accomplish the 2021 monitoring effort:

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2. Introduction

In March 2021, 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; 2021 is the eighth year of the surveys.

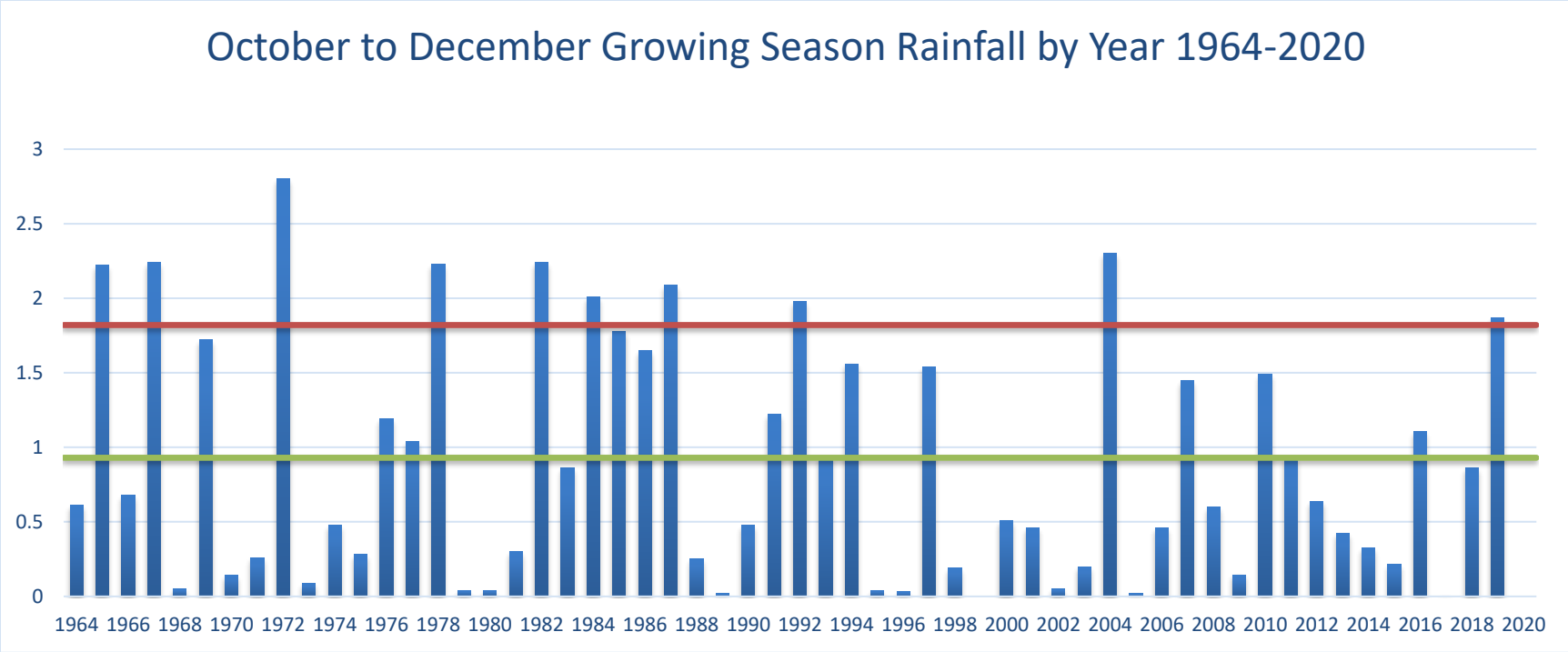

Figure 1. Total October-December growing season precipitation from 1964-2020 in the Imperial Sand Dunes. Precipitation values for growing seasons from 1964 to 2000 are the averages of seven Western Regional Climate Center (WRCC) weather stations in the vicinity of the Imperial Sand Dunes. The values for growing seasons 2001 to 2020 are the averages of the precipitation recorded by the Cahuilla and Buttercup Remote Area Weather Stations (RAWS) in the Imperial Sand Dunes (these stations were installed in November 2000). The value for the 2019 growing season is the average of the precipitation recorded using NOAA 4-inch manual rain gauges at the Cahuilla and Buttercup RAWS stations. 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 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 represent 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.

[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.

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. 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 are 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 specialist with the Carlsbad Field Office of the U.S. 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 stored in each GPS unit corresponding to the beginning and end of each 25m x 25m cell. Figure 3 shows the numbering system used in 2021.

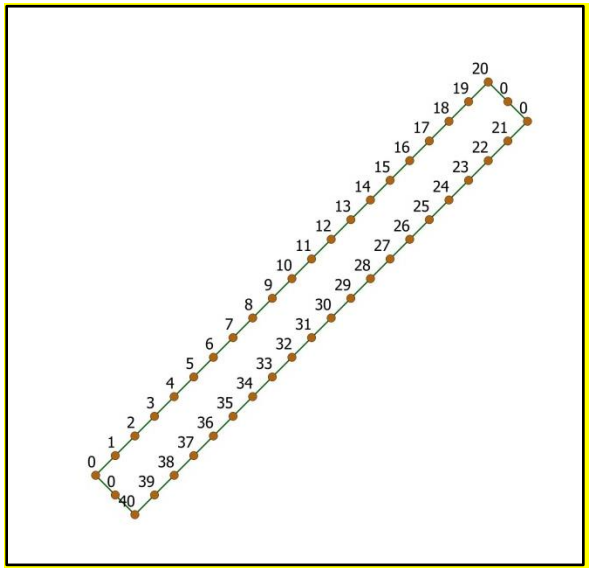

Figure 3. Waypoint numbering system used in 2021 for monitoring each macroplot. The waypoints numbered 0 are for navigation purposes only and have no data recorded for them.

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 2017-2021

The system used to collect data was modified for the 2017-2021 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 2017-2021 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 for the 2001-2020 growing seasons 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.

In 2019, BLM staff collecting the RAWS data observed that the precipitation recorded from the RAWS was inconsistent with manual NOAA 4-inch rain gauges that had been established at both stations. After extensive review and discussion of the RAWS and manual rain gauge data, the BLM and the USFWS agreed that the manual rain gauge data was reliable, and that the PMV monitoring threshold for all 19 macroplots had been exceeded (Crawford). Maintenance was completed on both RAWS stations in the spring of 2020 to ensure accurate data collection in future years.

4. Results

4.1 Precipitation

From October-December 2020 no rain was recorded at the Butter Ranger Station or the Cahuilla Ranger Station RAWS rain gauges. This lack of precipitation predicted a slow growing season for the PMV and necessitated the reduced sampling effort of 6 macroplots.

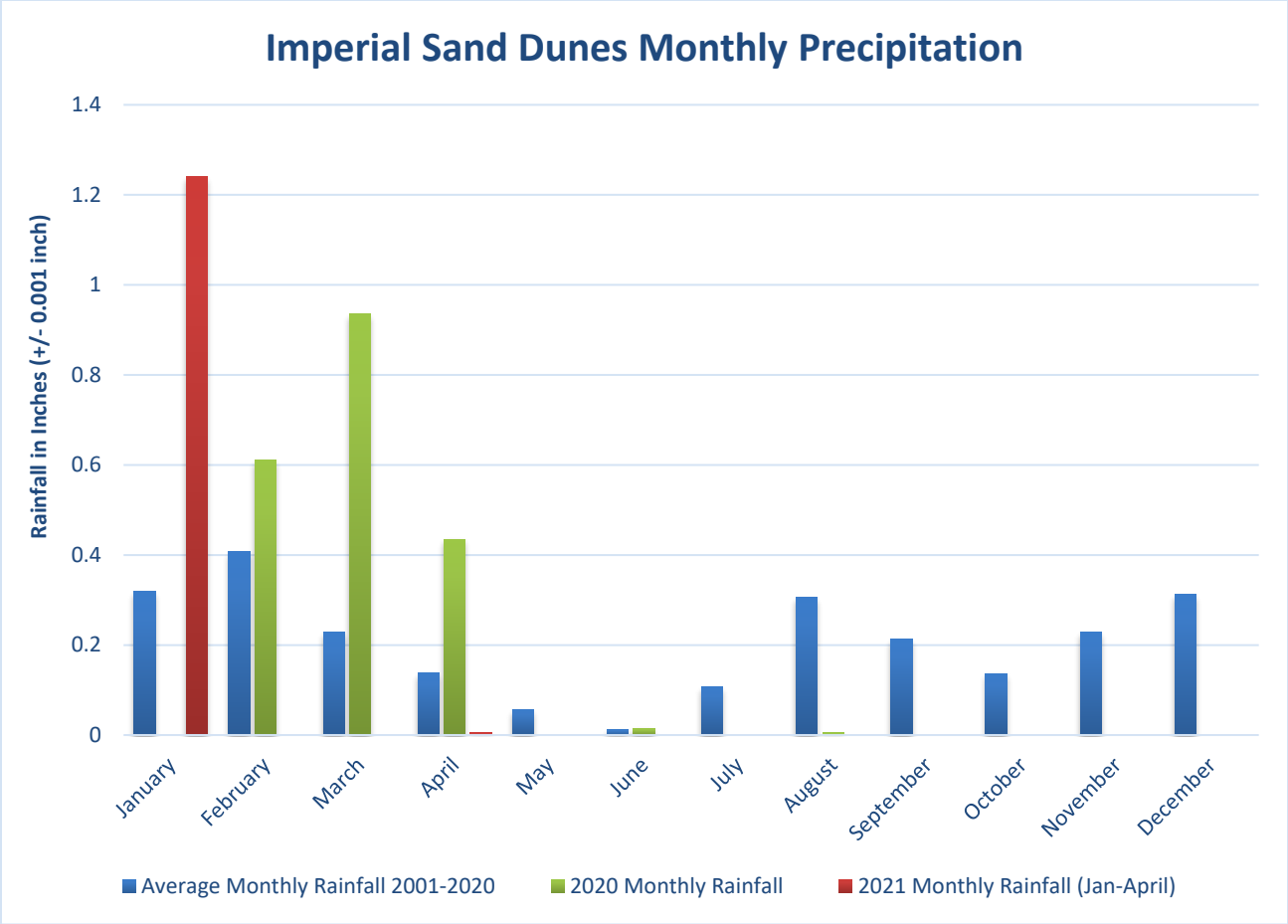

Figure 4. Average monthly rainfall for the Imperial Sand Dunes. Most of these data were recorded by the RAWS from 2001-2020; however, manual rain gauge data was used for October-December 2019. In 2020, October-December average rainfall was 0 for the Imperial Sand Dunes, averaging station totals for those three months. From January to March 2021, the Cahuilla and Buttercup RAWS stations (averaged) recorded a total of 1.24 inches of precipitation, resulting in a total of 1.24 inches of precipitation for the 2020-2021 growing season.

Table 4. Growing season precipitation recorded mostly by the RAWS from 2001-2020; however, manual rain gauge data was used for October-December 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
2019-2020	1.87	1.545	3.415
2020-2021	0	1.24	1.24

4.2 Monitoring Effort

One training plot and six macroplots were monitored from March 22-25, 2021, as shown in Table 5. Six observers participated each day of the PMV surveys. Two macroplots were surveyed each day, except for March 22, on which only the training plot was monitored.

Weather conditions ranged from very mild to windy during the 2021 monitoring effort. Wind made observation more difficult due to fast blowing sand, and care was taken to not double count PMV individuals whose sand markings had blown away. Rain was spotted in the dunes but never occurred over the monitoring area. Temperatures generally ranged between 25-32 degrees Celsius.

Table 5. Monitoring dates and observers in 2021.

Macroplot Surveyed	Date Surveyed	Observers
19 (training plot)	3/22/2021	Alexia Williams, Asdrubal Estrada, Jeff Sahagun, Madeleine Giordano, Michael Mujica, Peter DeJongh
15, 16	3/23/2021	Alexia Williams, Asdrubal Estrada, Jeff Sahagun, Madeleine Giordano, Michael Mujica, Peter DeJongh
10, 13	3/24/2021	Asdrubal Estrada, Madeleine Giordano, Michael Mujica, Peter DeJongh, Tristan Riddell
6, 8	3/25/2021	Alexia Williams, Asdrubal Estrada, Jeff Sahagun, Madeleine Giordano, Michael Mujica, Peter DeJongh

4.3 Peirson's Milk-vetch

A total of 1,261 plants were counted during the 2021 surveys (Table 6). Of the total number, 1,160 seedlings were counted along with 101 flowering plants. A total of 175 plants that were over a year old were observed. Consistent with previous years, PMV were most abundant in macroplot 13, which exhibited 54.9% of the total number of plants recorded during the survey. Macroplot 8 had the fewest plants counted during the survey (4 individuals). PMV occupied 65 of 280 microplots (23.2%). No plants were observed with OHV damage or non-OHV damage.

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 2021.

Macroplot	Date Monitored	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	3/25/2021	124	0	124	7	0	0	63	6	18
8	3/25/2021	4	0	4	0	0	0	11	3	2
10	3/24/2021	308	1	309	22	0	0	0	9	0
13	3/24/2021	622	70	692	95	0	0	0	18	0
15	3/23/2021	35	18	53	31	0	0	0	6	0
16	3/23/2021	16	1	17	1	0	0	0	8	0
19	3/22/2021	51	11	62	19	0	0	0	15	0

4.4 OHV Impacts and Tracks

Of the 280 microplots monitored, 20 had OHV tracks present. In total, 74 OHV tracks were recorded within the 7 macroplots. OHV tracks were not evenly distributed across the plots; Macroplot 6 had 63 vehicle tracks, constituting 85.1% of the total tracks. Unlike 2020, all the tracks recorded in 2021 were documented within the plots located in areas open to OHV use. While the lack of OHV impacts to PMV in open areas may be a result of decreased production due to lack of rainfall, it is encouraging that no OHV trespass was documented.

4.5 Non-OHV Impacts

No plants were observed with non-OHV damage. It is worth noting that PMV numbers were noticeably reduced, likely due to lack of rainfall.

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 may not be suitable for PMV occurrence given the current microhabitat and dune topography. In 2021, of the 40 cells within each of the 7 monitored macroplots, an average of 9 cells were occupied with PMV (Table 7). This is lower than past years of monitoring and could demonstrate how sand movement within the dunes alters habitat suitability year after year, often resulting in unsuitable habitat for PMV within areas of previous PMV abundance. However, it is more likely that the reduced presence of PMV within each macroplot is a result of the low rainfall experienced during the 2020 October – December growing season.

Consistent with previous years, macroplot 13 exhibited the highest number of occupied cells with 18, well above 2021 average occupancy (Table 7). Macroplot 13's average number of PMV per occupied cell was similarly above average with 38. This suggests, among other factors, that during the 2021 growing season macroplot 13 contained a higher percentage of suitable habitat for PMV than the other plots. Macroplots 8, 16, and 19 exhibited well below the average number PMV per occupied cell. 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.

Table 7. A summary of the number of cells occupied with PMV by macroplot as well as the average number of PMV per occupied cell. Averages are rounded to the nearest whole number.

Macroplot	Number of Cells Occupied by PMV	Average Number of PMV per Occupied Cell
6	6	21
8	3	1
10	9	34
13	18	38
15	6	9
16	8	2
19	15	4

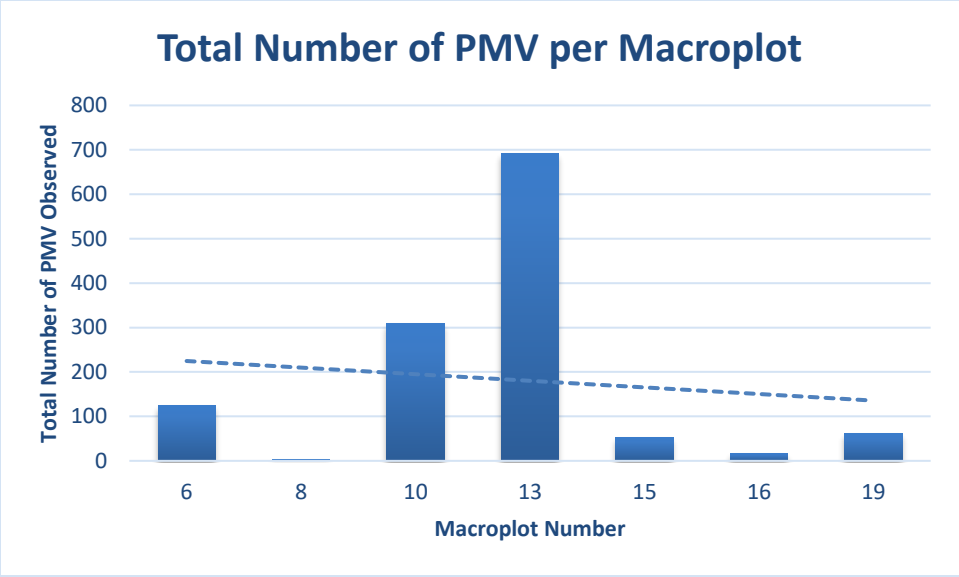

Figure 5. Total number of PMV recorded in 2021 by macroplot. Macroplots are shown in ascending numerical order which corresponds to their location in the Imperial Sand Dunes on a north-south axis with macroplot 6 being the northernmost plot and macroplot 19 being the southernmost. The dotted line illustrates plant distribution trends on a north to south gradient.

There were 175 PMV that were older than one year. The distribution of PMV individuals greater than 1 year old roughly resembled the distribution of the total number of plants across the macroplots, except for macroplot 15, within which 58.5% of the total plants were greater than 1 year old (31 of 53 plants). Macroplot 13 supported the most plants greater than 1 year old with 95 individuals, but this only made up 13.7% of the total (Figure 6). Due to the drastic differences in the total numbers of PMV present in each macroplot, the raw abundance of PMV individuals older than 1 year by macroplot is not a representative metric of PMV survivability within each plot. PMV survivability is more effectively determined by comparing the percentages of PMV individuals older than one year relative to the total number of PMV individuals recorded in each plot the previous year (Figure 7). Using this metric, survivability is highest in macroplots 6, 15, and 19. These plots represent areas spread throughout the entire dune complex and do not illustrate any trend. Factors that may influence PMV survivability are dune movement and disturbance, reduced resource competition between PMV individuals, and differences in microclimate and weather conditions.

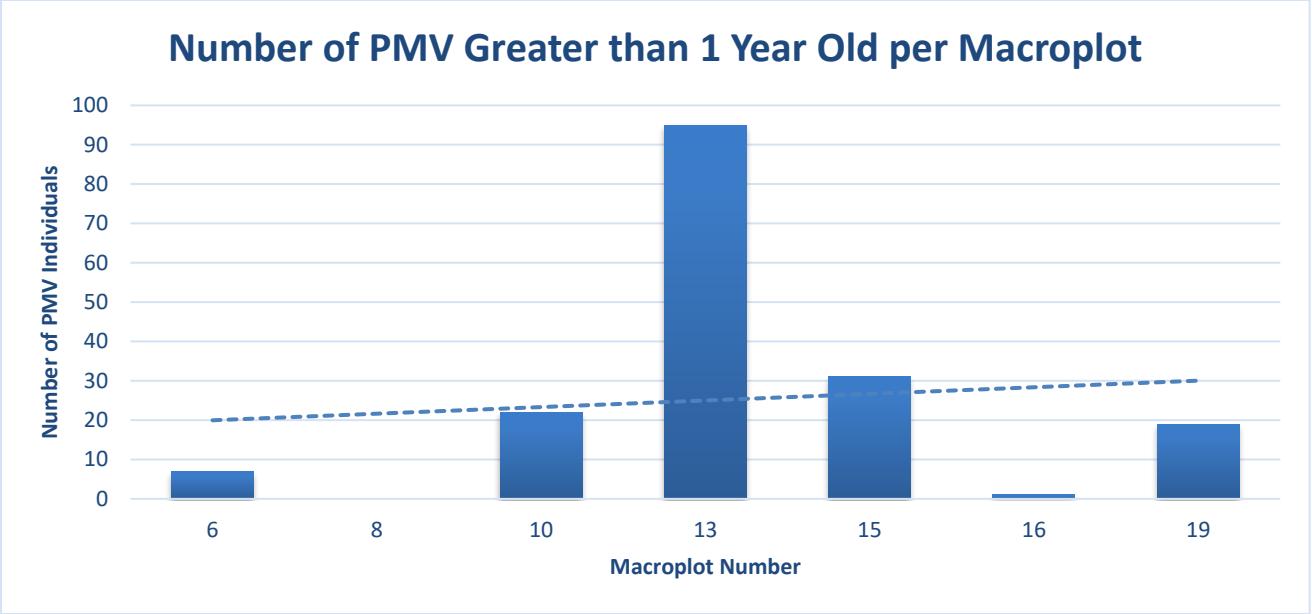

Figure 6. Total number of PMV plants greater than 1 year old recorded in 2021 by macroplot. Macroplots are shown in ascending numerical order which corresponds to their location in the Imperial Sand Dunes on a north-south axis with macroplot 6 being the northernmost plot and macroplot 19 being the southernmost. The dotted line illustrates plant distribution trends on a north to south gradient.

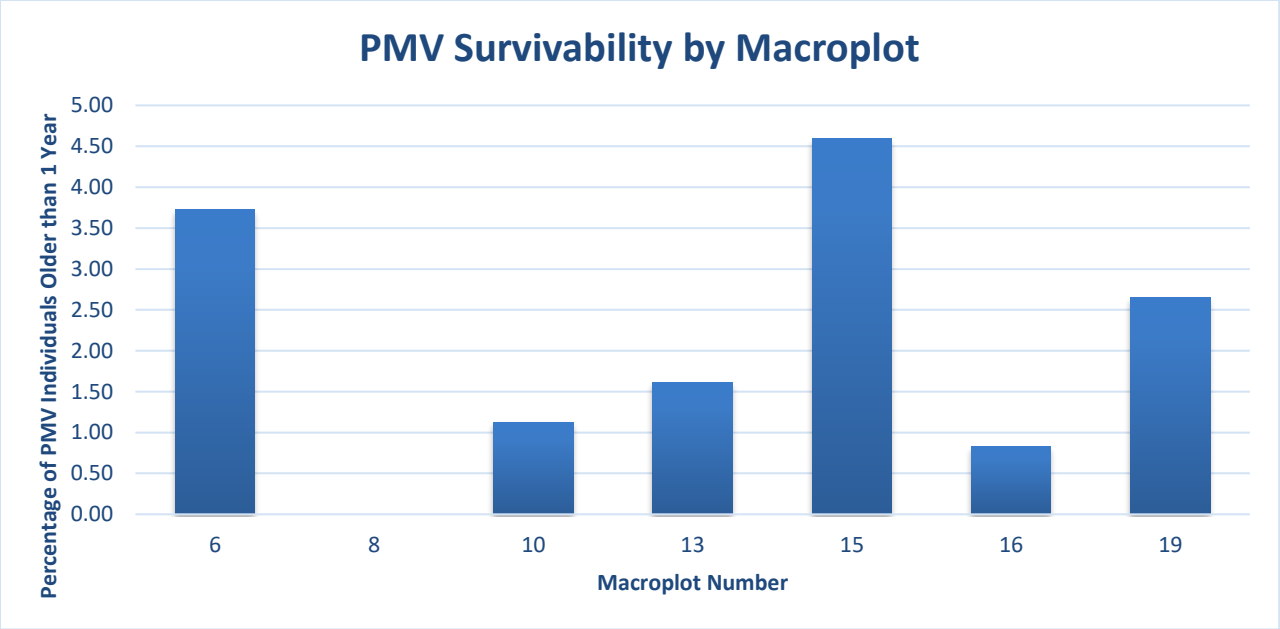

Figure 7. 2021 PMV survivability displayed using percentages of PMV individuals older than 1 year relative to the total number of PMV individuals in each macroplot in 2020. Macroplots are shown in ascending numerical order which corresponds to their location in the Imperial Sand Dunes on a north-south axis with macroplot 6 being the northernmost plot and macroplot 19 being the southernmost.

The 2005 dune wide sampling effort (Willoughby 2005) suggested that 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 2021 monitoring data do not support this hypothesis (Figures 5 and 6). The highest PMV counts are in macroplots 13 and 10, which are centrally located within the dunes. This is consistent with previous years' data, as macroplot 13 historically exhibits the highest number of individual PMV and PMV greater than 1 year old.

5.2 Stage-class Composition

The 2021 monitoring efforts recorded mostly seedlings, which accounted for 92.0% of the total PMV plants observed this season. Apart from the 2018 monitoring efforts, these results are consistent with previous years. PMV germination in any given year is dependent on rainfall, which, given the absent precipitation recorded during the growing season, is likely a large contributing factor to

2021's relatively low seedling production compared to previous years. While seedling germination occurs because of October through December rainfall, January to March precipitation generally helps to maintain further plant growth and support flowering of PMV.

The 2021 monitoring efforts recorded 101 PMV in flower, the majority of which were greater than a year old. Except for plot 15, all the macroplots exhibited lower levels of flowering plants than the 2020 season. This reduction of flowering individuals was likely due to the dry growing season. There was little to no rainfall early on followed by sporadic, low volume precipitation events, which provided difficult conditions for young PMV to go into flower. Differences in distribution of flowering PMV individuals could be due to dune movements, climatic and weather conditions, or resource competition within the vegetative community. It is also important to note that this year's monitoring effort ended in March, while PMV often continue to flower into early to mid-April. This could influence the reduced number of flowering individuals recorded. Some rainfall was recorded during the January – March season and could enable young PMV individuals to flower later in the season.

5.3 Survivorship and Recruitment

Compared to previous years, there was notably reduced recruitment in 2021, with 1,160 seedlings accounting for 92.0% of the overall plants. Additionally, none of the 101 flowering individuals observed appeared to be less than 1 year old. This year's reduced recruitment is unsurprising, given the lack of precipitation this 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 in 2021 was relatively high, with 175 surviving plants over a year old, substantially more than the 59 individuals observed in 2020. Many of these mature plants had seed pods, some of which had opened; this suggests they flowered earlier in the year. High levels of precipitation in 2020 likely contributed to the increased survivability of this cohort, even despite the dry

conditions leading into 2021. PMV mortality was likely a result of many different factors including climate and weather conditions, resource competition within the vegetative community, and movement and alteration of dune habitat.

5.4 Impacts to Peirson's Milk-vetch

The limited distribution and habitat requirements of PMV makes this species vulnerable to any impacts 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 and 2021, high PMV mortality and low recruitment were observed following notably low rainfall during the first half of the growing season (Bruner 2018). Conversely, high rainfall in the 2019 and 2020 growing seasons 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 of the macroplots monitored in 2021 are located within open OHV use areas (plots 6 and 8), while the remaining macroplots are in areas closed to OHV use. Since 2014, the total number of OHV tracks recorded during the monitoring season has fluctuated between 75 and 345. Macroplots 6 and 8 contain a historical average of approximately 40 total OHV tracks recorded per season; 2021 observations were slightly above this average, exhibiting 74 observations in the open plots (Figure 8). There were no OHV tracks observed in macroplots closed to OHV use.

These data contrast with previous years' observations. In 2019, 75 OHV tracks were recorded within the closure areas (90% of all tracks recorded). In 2020, a somewhat reduced percentage of trespass OHV use was recorded, with 62.3% of all tracks observed within closure areas (Figure 8). While no OHV trespass was recorded in 2021, tracks do disappear quickly with wind in the dunes, so it is unlikely, based on historical data, that no OHV trespass occurred. It is important to note that outside of direct damage to plants, OHV use can impact plant populations through increased erosion; the indirect nature of these impacts make them difficult to quantify. Further information is needed to adequately assess these potential impacts.

Macroplot 19 is in the southernmost PMV critical habitat closure area (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. In 2021, no OHV tracks were observed in macroplot 19. This is a departure from previous years, where high numbers of tracks found in macroplot 19 were hypothesized to be a result of frequent Border Patrol activities in the area. Border Patrol was not observed during the 2021 PMV surveys, but they have been within this closure area in the past. BLM often coordinates with Border Patrol and has communicated the presence of PMV critical habitat in this area. It is possible that the decreased incidence of tracks within macroplot 19 over the past couple years is a result of this communication.

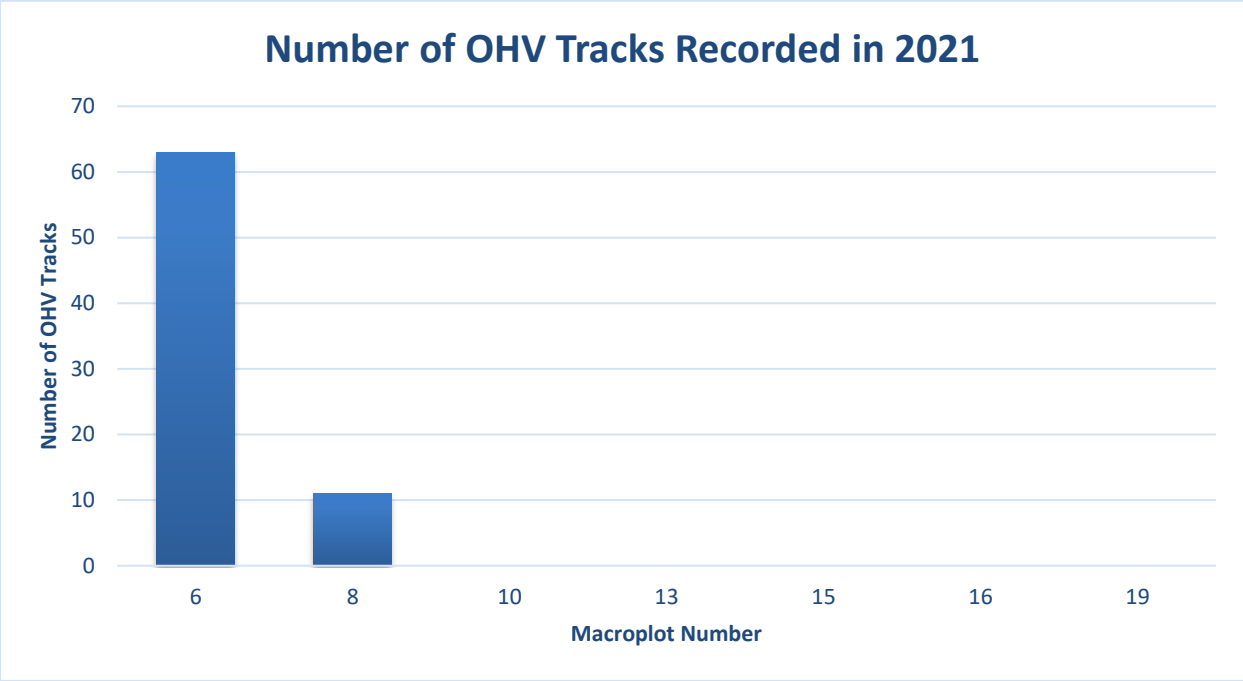

Figure 8. Number of OHV tracks recorded by macroplot in 2021.

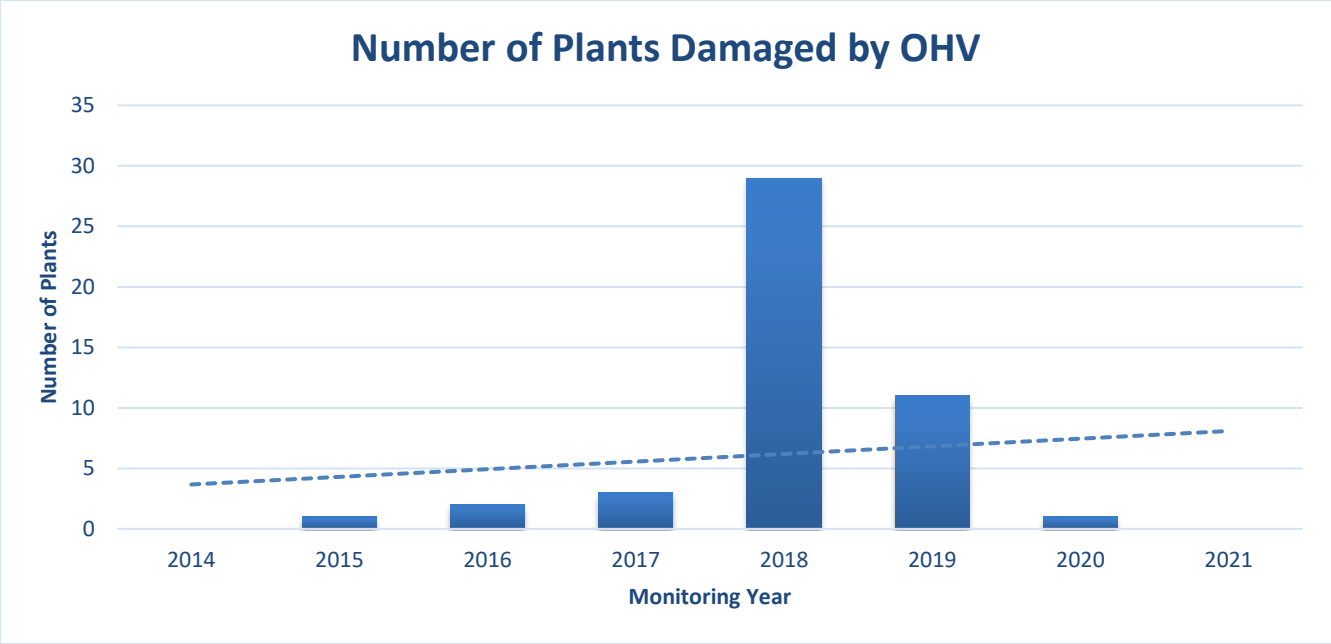

Figure 9. Number of PMV damaged by OHVs by monitoring year. Note that these totals include the additional 13 macroplots monitored in 2020.

There is the potential for other impacts to detrimentally affect PMV populations (e.g., trampling). During previous years surveys, PMV have been 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 have been observed on PMV in previous years, 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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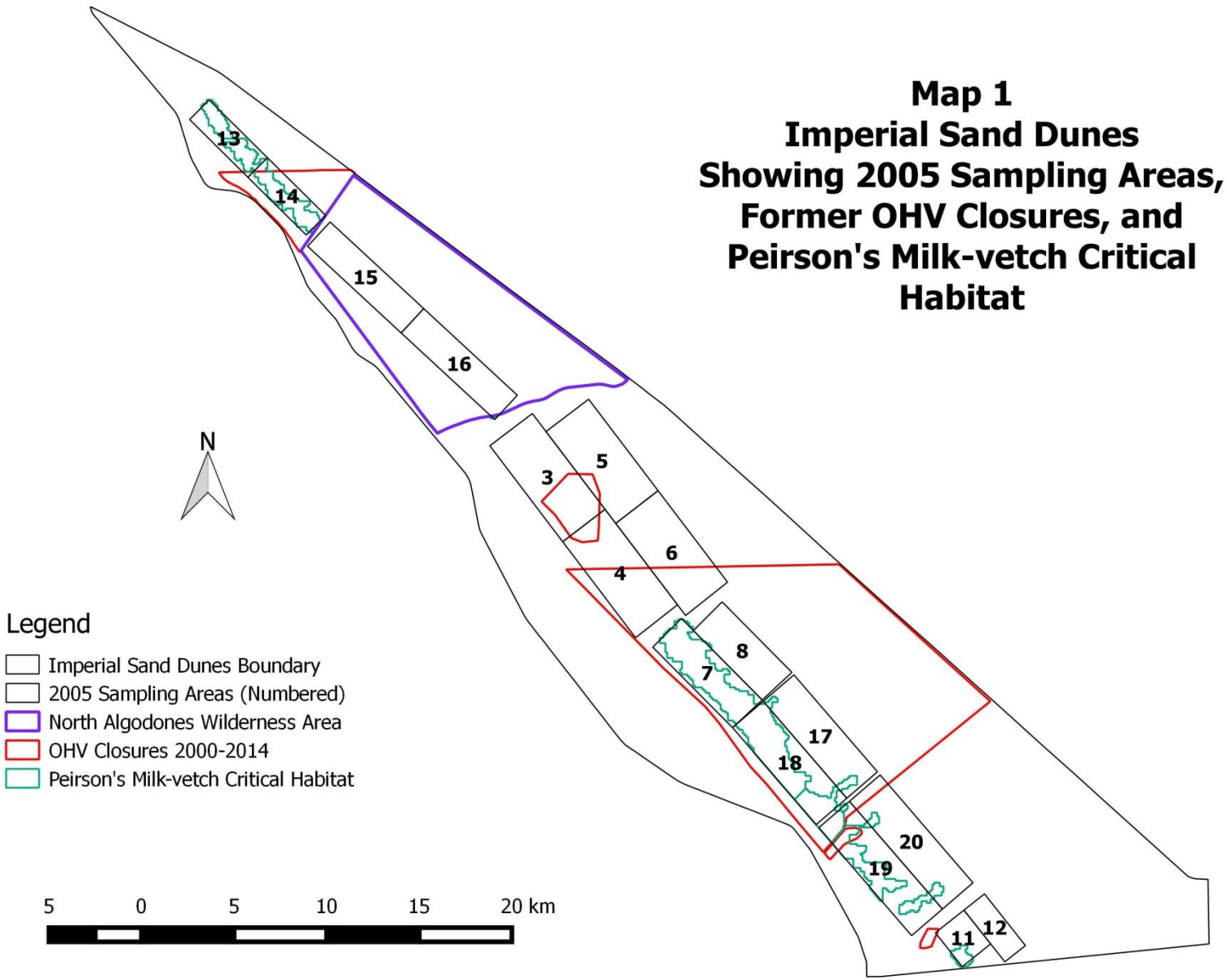
Map 1
Imperial Sand Dunes
Showing 2005 Sampling Areas,
Former OHV Closures, and
Peirson's Milk-vetch Critical
Habitat
N
Legend
Imperial Sand Dunes Boundary
2005 Sampling Areas (Numbered)
North Algodones Wilderness Area
OHV Closures 2000-2014
Peirson's Milk-vetch Critical Habitat
5 0 5 10 15 20 km
13
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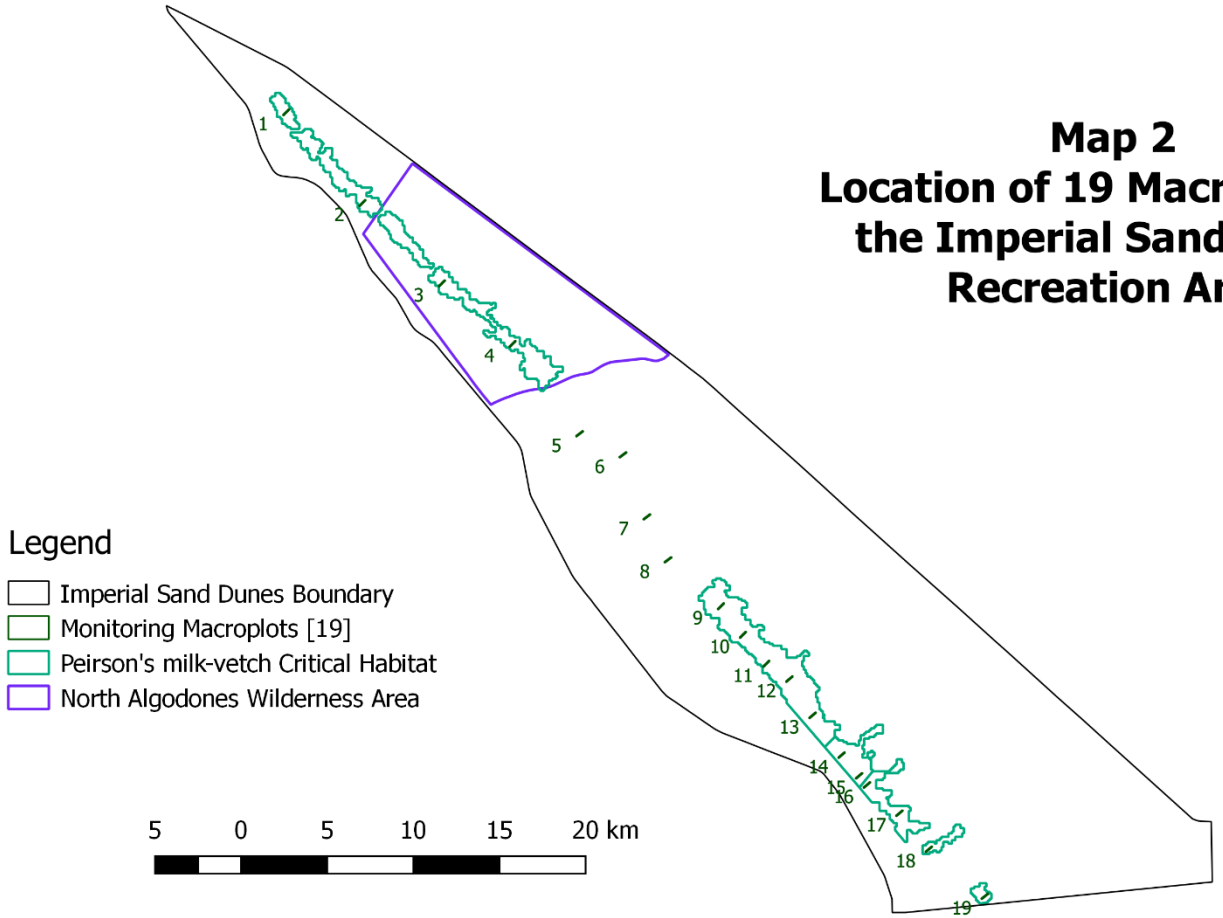
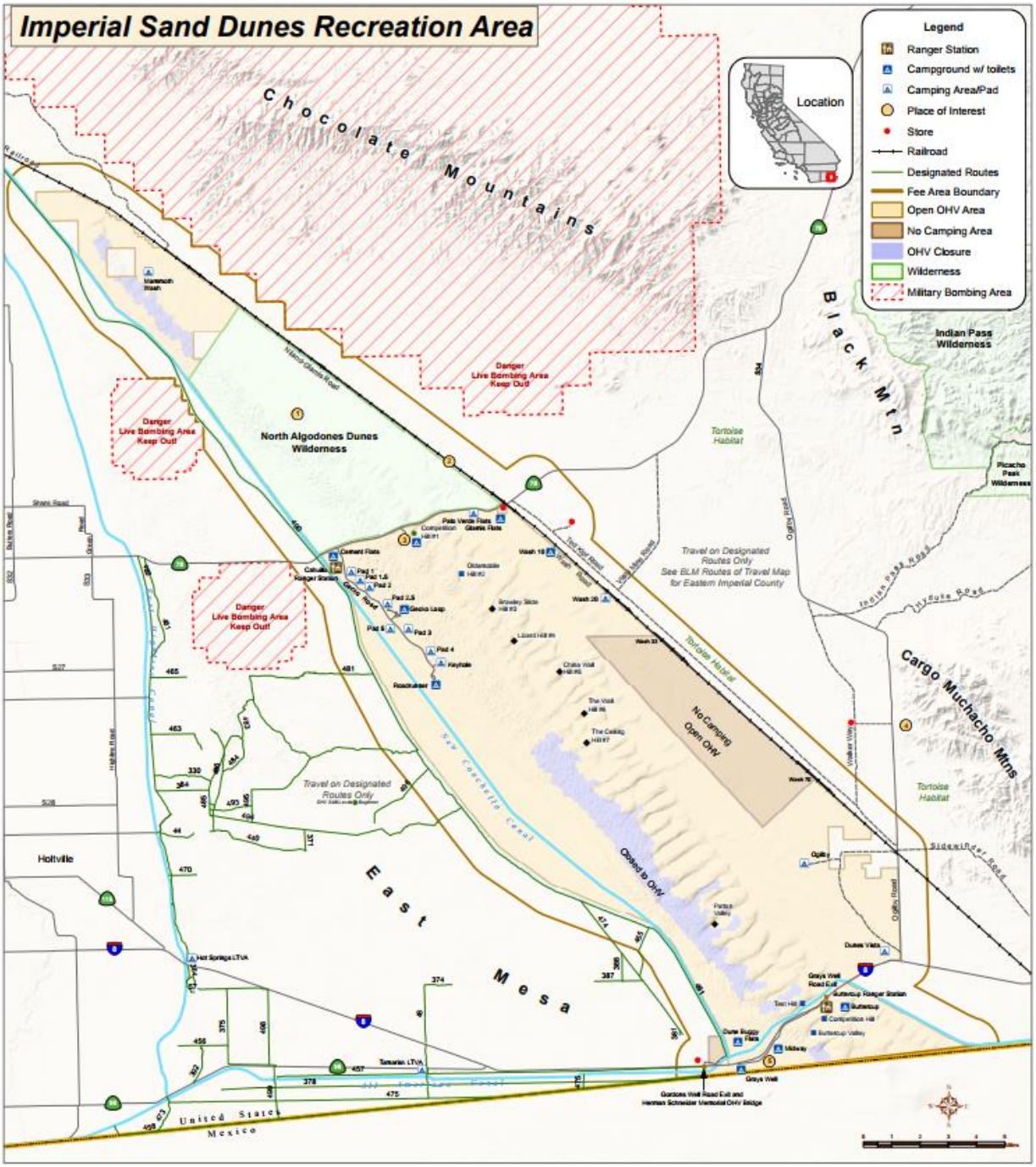
Map 2
Location of 19 Macroplots in the Imperial Sand Dunes Recreation Area



Map 3



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