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Assessment of endangered beach layia (Layia carnosa) on the Monterey Peninsula

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ASSESSMENT OF ENDANGERED BEACH LAYIA (Layia carnosa) ON THE MONTEREY PENINSULA

Layia carnosa (USFWS 1998)

A Capstone Project
Presented to the Faculty of Science and Environmental Policy
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Bachelor of Science

By

Michael E. Johns
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To the SEP faculty:

Over millions of years, the physical characteristics of California's coastline have been manipulated by fluctuations in natural processes such as erosion, sea level rise and fall, and shifts in climate. These variations in substrata and weather patterns have driven the evolution of a variety of plant species that thrive in coastal ecosystems, isolating them in some regions and opening up new niches in others. More recently, anthropogenic influences have rapidly altered the environment, threatening the future of many native species. This capstone project will focus on one such species found in Monterey County, beach layia (*Layia carnosa*).

The question of whether evolution is playing itself out in *L. carnosa* or rather humans are disrupting its progress is a large one, and requires multiple steps and a number of studies. Since no previous studies have been done on *L. carnosa* in Monterey County, an accurate population estimate is unknown. The purpose of this scientific inquiry capstone is to gain a baseline understanding of the population biology and timing of *L. carnosa*; as well as observe potential biological or environmental limiting factors. Knowing these parameters may increase our understanding about what influences the success or failure of this species.

During February and March of 2009, *L. carnosa* occurrences were located at two sites in Monterey County, Asilomar State Beach in Pacific Grove and Indian Village Dunes in Pebble Beach, with assistance from Joey Dorrell-Canepa and Lori Madison. Under a California Department of Fish and Game (CDFG) permit and a contract with the United States Fish and Wildlife Service (USFWS), occurrences were marked with flags and digitally mapped using GPS and ArcGIS. Individual plants were randomly selected and repeatedly visited to observe trends in growth and evaluate any disturbance or mortality. A final census at both sites and an estimation of density at Indian Village Dunes were conducted at the end of the study.

The USFWS lists *L. carnosa* as endangered on both the federal and state level. It is important to control human activities to prevent population extinctions. This capstone is immediately relevant to policy makers charged with managing this species, as well as private and commercial parties interested in developing land on or near existing *L. carnosa* populations. Public land use for recreation may also be affected by the results of this study. Most importantly, information gathered about the life history of *L. carnosa* may help direct and focus future research in order to better protect this endangered species.

Sincerely,

Michael Johns

Acknowledgments

I would like to particularly thank Joey Dorrell-Canepa for assisting with all aspects of this study, from indentifying plants to obtaining the necessary permits and permission to access study sites. The breakfast burritos made all the difference as well.

The following people have devoted their time to providing invaluable support, insight, and guidance during the many hours of this project; thank you:

- Mom & Dad
- Suzy Worcester
- Lori Madison
- Tram Nguyen
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Abstract

Coastal dunes are a unique and dynamic habitat, containing fauna that have adapted to life in harsh maritime conditions. While these species have managed to thrive in such a habitat, human influences may undermine their continued success. Beach layia (*Layia carnosa*), a small annual herb, is one example of a species which has become isolated by habitat loss from human expansion. Endemic to California, it exhibits a patchy distribution along the coast, and occurs in two dunes systems on the Monterey Peninsula, Asilomar State Beach and Indian Village Dunes. Previous estimates at these two sites indicate a small population size, less than 200 plants at Asilomar State Beach and unknown numbers at Indian Village Dunes. A complete census conducted at both sites in March 2009 revealed a total population of 1,973 plants. Density estimates at Indian Village Dunes showed less than one plant per square meter. Staggered germination timing was also discovered from late January to March, and most plants did not reach reproductive maturity until late March early April. Understanding basic population biology and timing, along with an accurate census, is essential for protection and management of this species.

1. Introduction

1.1 Coastal Dune Ecology

Coastal dune systems are among the most variable and dynamic of habitats in California, and encompass a variety of specialized vegetative communities (Sawyer & Keeler-Wolf 1995). Continually shifting substrate, relative lack of nutrients, and exposure to harsh maritime conditions have driven the evolution of species adapted to thrive in such a habitat. A number of ecological factors have been observed to influence coastal dune species, including; environmental variability, intraspecific density, interspecific competition, herbivory, mutualisms, pathogens, pollinators, and dispersal (Schemske *et al.* 1994).

1.1.1 Environmental Factors

Coastal regions, particularly in California, receive heavy winds throughout the year which can be both a positive and negative force for native dune plant species. On the central coast of California, wind originates predominately from the southeast during winter months from November through February, and from the northwest in the summer during the months of April through October (Dingler & Anima 2007). Wind events provide a means for seed dispersal and may create favorable conditions in sand composition for settlement and recruitment. Species found in mobile sand dunes compensate for burial by either increasing their stem length or by replacing buried photosynthetic leaves (Gilbert *et al.* 2008). Although native dune plants have adapted to deal with wind, prolonged or extreme burial and erosion events can inhibit the growth and survivorship of seedlings and juvenile plants (Gilbert *et al*. 2008; Franks & Peterson 2003; Maun 1998). Interestingly, increased wind may also facilitate the growth of invasive species again by opening new areas for recruitment (Lortie & Cushman 2007).

Low levels of nutrients in coastal dune systems may limit a plants ability to cope with burial episodes (Lortie & Cushman 2007; Gilbert *et al.* 2008). Wind not only affects the stability of dunes, it carries spray from breaking waves onto the dunes. The input of Na, Cl, and Ca from ocean spray and mist far exceeds the requirement of most plants; while N, P, and K, which are lacking in sea water, are often not found in high concentrations in dunes (Barbour 1978). It is the lack of these essential nutrients that may limit biomass and growth. Given that dune plants must expend extra energy to keep their leaves above the sand; they may either use nutrients efficiently or input little effort into tissue production (Gilbert *et al.* 2008).

1.1.2 Biological Factors

Dune plants compete for available bare sand necessary for germination, space for seedling growth, and ample sunlight for photosynthesis. The successive model of perennials presented by Franks (2003) shows how parent plants facilitate germination of cohorts, by limiting competition and providing suitable substratum for recruitment. This is not an option for annual species, leading to the tendency for more seeds than adults in annuals compared to perennials (Franks 2003). Increased vegetative cover of perennials reduces the potential for germination of annuals.

Herbivory may have a major effect on the survival of various plant populations, especially with species already faced with many other environmental threats. Herbivory may also drive selective pressures that lead to a reduction in population size and alteration of physiology (Maron & Kauffman 2006). A study by Warner and Cushman (2002) found that mammalian herbivory on perennial plants were species and stage dependent, affecting mainly juvenile plants.

1. 1.3 Anthropogenic Factors

Evolutionary time is immense compared to the sudden and dramatic changes brought about by human urbanization and development; which has fragmented coastal dune communities along California. The rapid reduction in available coastal dune habitat has isolated what were historically expansive populations of native plant species. This reduction in habitat increases mortality while reducing reproductive success, resulting in threats of local extirpation and extinction of several California endangered species, including among others; Menzie's wallflower (*Erysimum menziesii ssp. menziesii)*, Tidestrom's lupine *(Lupinus tidestromii)*, and beach layia (*Layia carnosa*) (Draft finding of the Monterey county 2003).

There are approximately 27 coastal dune systems in California, with some of the largest and most expansive systems found in the Monterey Bay region. Over half of the forty square miles of dune habitat in Monterey and Santa Cruz Counties have been altered and destroyed by urbanization, military and agricultural use, sand mining, and rapid erosion (CCC 1976). Along with these large scale population wide disturbances, small scale human presence in dune communities has a detrimental effect on individual plants. Trampling and erosion occurs with heavy foot traffic, and outdoor recreational vehicles (ORV) can create large scars in the landscape that accelerate wind driven erosion (CDFG 1999; Tibor 2001; USFWS 1998).

1.2 *Layia carnosa*

1.2.1 Description

Layia carnosa is a small prostrate annual herb that germinates in the winter and blooms between the months of March and July (Tibor 2001). It is in the family Asteraceae, which includes other sunflower-like species such as tidy tips (*Layia platyglossa*) and Jones's layia (*Layia jonesii*) (USFWS 1998; Tibor 2001). *Layia carnosa* has a variable morphology, growing unbranched to highly branched (Figure 1A), less than 16 centimeters tall, and obtaining a maximum rosette diameter of 4 decimeters (USFWS 1998). It contains fleshy, almost succulent lobed leaves and a somewhat stipitate or stalked glandular stem (Jepson 1925; Harris & Harris 1995). Flowers contain 25 to 32 modified calyxes also known as pappus-bristles with yellow discs and white rays approximately 4 centimeters in diameter (Figure 1B), containing ray-achenes analogous to a sunflower seed (Figure 1C)(USFWS 1998; Jepson 1925; Harris & Harris 1995).

Figure 1. Typical multi branched plant, displaying key identifying features (A). White rays of the flower with yellow pollen and black stomata (B). Example of fruits (C). Photos by Aaron Schusteff 2007

1.2.2 Life History

There is little research about specific ecological influences on *L. carnosa*; however, its presence in coastal dune ecosystems indicates that some of these influences may play a major role in its life history. Studies have indicated that there is little or no interspecific competition in *L. carnosa,* possibly relating to the timing of germination; emerging while most perennials are still dormant (Pickart & Sawyer 1998). It has also been suggested that the number of flowering heads on a single plant is dependent upon environmental conditions; moist locations yield large highly branched plants with over 100 flowering heads while dry conditions yield small erect plants with a single flowering head (USFWS 1998).

1.2.3 Habitat

Layia carnosa is restricted to coastal dune and coastal scrub habitats, characterized by a sandy composition (Tibor 2001). It has a narrow range of ideal habitat conditions, both biogeographical constraints such as the requirement of expansive coastal dune systems, as well as specific conditions within the dune system. Observations of *L. carnosa* suggest that the species requires sparsely vegetated to open sand for germination (USFWS 1998). A study by Basor (2002) on *L. carnosa* in Humboldt County found that seedling emergence increased with topographic position from ridges to troughs, with no emergence observed on ridges.

1.2.4 Distribution

Layia carnosa is endemic to coastal California and is not well studied in its distribution. This study will refer to the US Fish and Wildlife Service (USFWS) and its description of five major occurrences along the California coast (USFWS 1998). These occurrences are located, from south to north, in Northern Santa Barbara County, Monterey Peninsula in Monterey County, Point Reyes in Marin County, and two dune systems in Humboldt County (CDFG 1999; USFWS 1998) (Figure 2). Some sources suggest that *L. carnosa* has been extirpated in Santa Barbara County (Sacramento Fish & Wildlife Office 2009). Surveys in 1998 estimated a total of 300,000 individual plants within all known occurrences in California (USFWS 1998). There are most likely small occurrences that have yet to be found, including sites within Monterey County.

Geographic Extant of *L. carnosa*

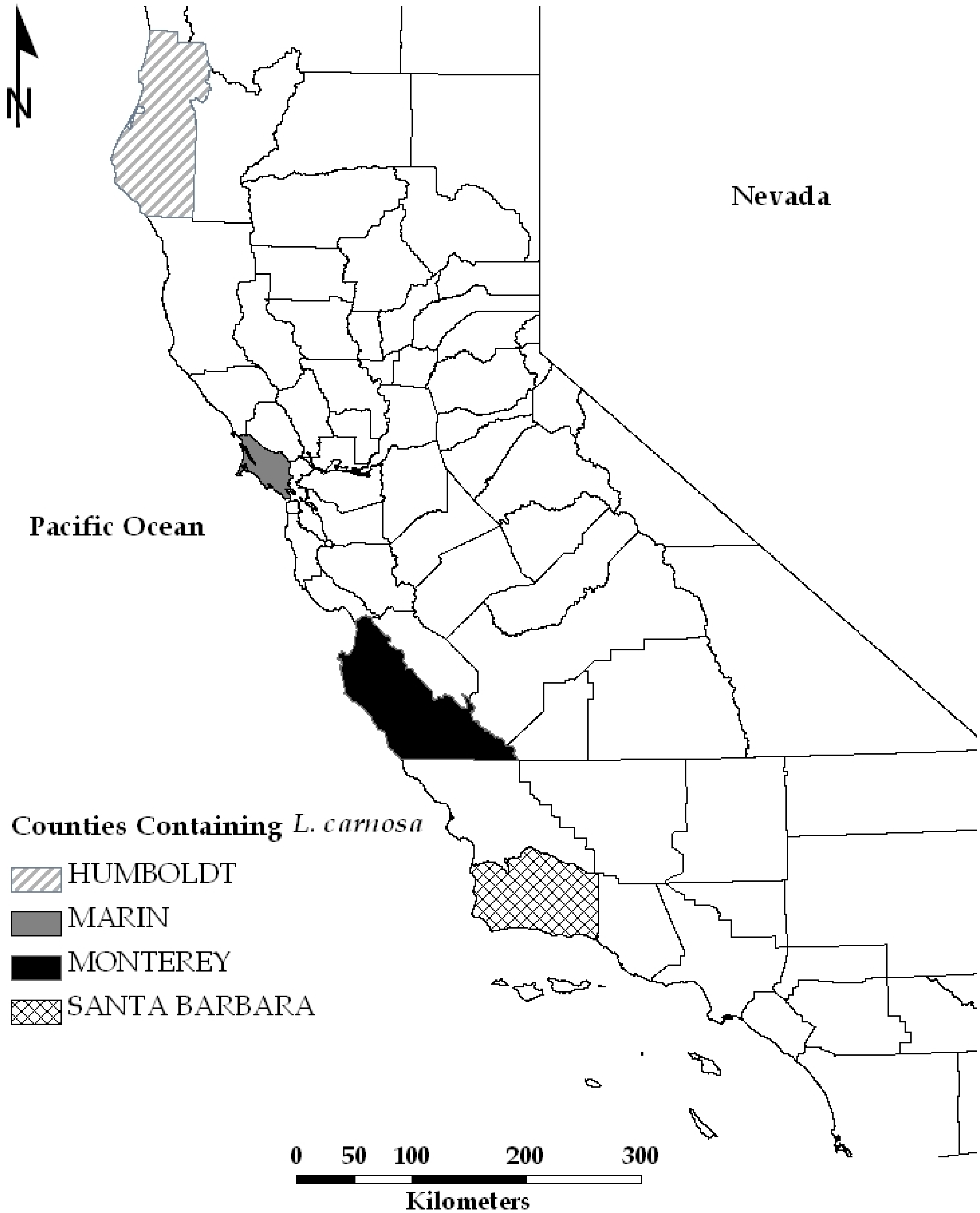


Figure 2. Map of California Counties with highlighted counties containing *L. carnosa* occurrences. Note that *L. carnosa* does not occur uniformly throughout highlighted counties both rather are isolated in micro-habitats within major coastal dune systems.

There is a significant gradient in annual precipitation between the northern and southern extant of *L. carnosa*. Dunes located in northern California receive a greater volume of annual rainfall over a longer time span than dunes in central and southern California (Figure 3). Fox *et al.* (2006) observed a strong linear relationship between the amount of precipitation and both germination rate and seedling survival of *Gilia tenuiflora arenaria,* a species often seen in association with *L. carnosa*. According to a study by Eschevaria (1993), however, there appears to be no linear relationship between rainfall and density of *L. carnosa* (Pickart & Sawyer 1998).

Vigor and population size varies annually and among occurrences. Studies in Humboldt County have shown *L. carnosa* existing in large numbers, while occurrences in Monterey and Santa Barbara Counties are much lower in abundance (CCC 2001). Pickart and Sawyer (1998) measured a possible decline from 14.2 to 2.2 individuals per square meter over a five year period in Humboldt, and it is speculated that the species has been declining since 1989 (CDFG 1999). Development and human use has resulted in a 25% loss in occurrence of *L. carnosa* due to a reduction in available habitat (Tibor 2001; USFWS 1998; Pickart & Sawyer 1998). Five occurrences have been lost in San Francisco, Monterey, and Humboldt Counties (USFWS 1998). One occurrence in Humboldt was extirpated in the 1960's during the construction of Highway 101 coupled with the introduction of non-native plants (USFWS 1998). Due to these reasons, *L. carnosa* was added to the state endangered species list in 1990, and was federally listed in 1992 (Department of Fish and Game 2009; Federal Register 2002).

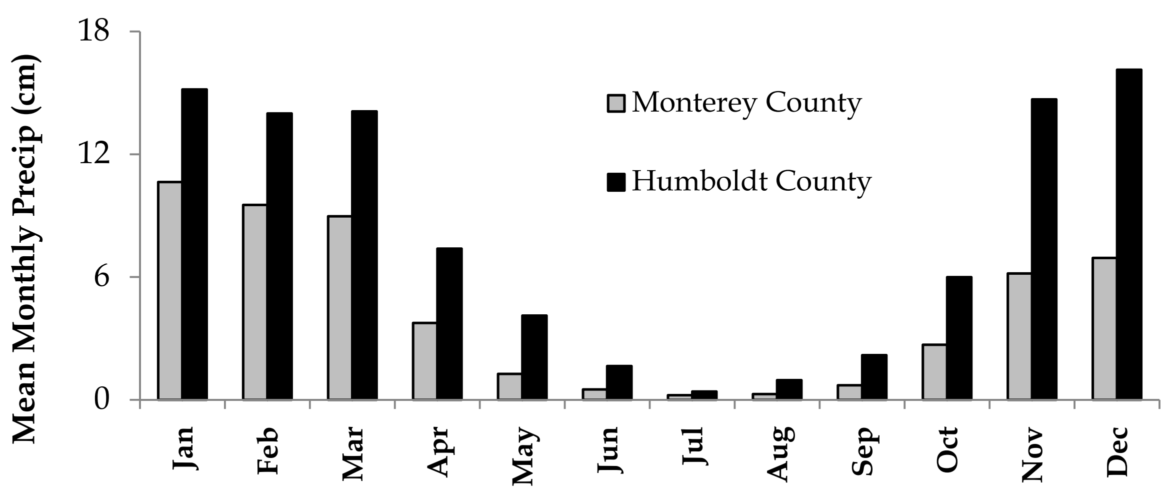


Figure 3. Average monthly precipitation (cm) for Monterey and Humboldt Counties.

1.3 *Layia carnosa* in Monterey County

There exist at least two main occurrences of *L. carnosa* in Monterey County, Asilomar State Beach and Indian Village Dunes, both located on the Monterey Peninsula. The last official count suggested less than 100 plants on the Monterey Peninsula (CDFG 1999). Surveys conducted again in 2000 by Lorrie Madison of *L. carnosa* at Asilomar State Beach depicted a patchy distribution of five small occurrences or polygons, ranging from less than 10 to 179 individuals per polygon, for a total of approximately 340 plants. There is no literature on the current number of individuals at Indian Village Dunes and for this study it was assumed the numbers were comparable to Asilomar State Beach. Suitable habitat has been found in several other locations on the Monterey Peninsula including Carmel dunes; however, they have not been officially surveyed (City of Carmel-by-the-Sea 2002).

1.3.1 Management

Coastal dunes are considered Environmentally Sensitive Habitat Areas (ESHA); due to the delicate nature of their morphology and of the species which occupy them, and are considered vulnerable to degradation (Draft findings of the Monterey County 2003). Monterey County does not allow excess recreational use of lands containing rare or endangered species; and broadly applies this same restriction to dune habitats (USFWS 1998). Any development or recreational use of land labeled as ESHA is highly regulated, and depending on local conditions, is strictly forbidden (CCC 2001; CCC 2005, BLM 2002). Asilomar State Beach and Indian Village Dunes contain several other endangered species along with *L. carnosa*; including *E. menziesii ssp. menziesii* and *L. tidestromii*; thus, California State Parks and USFWS monitor and regulate the use of both sites.

The introduction of invasive species has been shown to have a detrimental effect on endemic dune plant species (Pickart & Sawyer 1998). European beachgrass (*Ammophilia arenarea*), for example, was first introduced in San Francisco in the 1800's, and has since spread along coastal California (Lamson-Scribner 1895). Much effort has been put into managing the encroachment of non-native species along the coast of California (Pickart & Sawyer 1998; CDFG 1999; Tibor 2001; USFWS 1998). *Ammophilia arenarea* and ice plant (*Carpobrotus. edulis*) are persistent in their establishment and reduce available space for germination of annuals like *L. carnosa* (Sawyer & Keller-Wolf 1995; Pickart 1997; Thomson 2005). A study by Pickart (1997) concluded that seven acres of *A. arenaria* existed on the Monterey Peninsula; however, it is not known if *A. arenaria* or any other invasive are currently impacting *L. carnosa* populations in Monterey County.

1.4 Project Parameters

1.4.1 Purpose

This study will focus on providing a better understanding of the distribution and status of *L. carnosa* in Monterey County. Given the lack of knowledge in population biology and life history information, this study will also attempt to describe the species local growth habits and ecology. Most importantly, it is essential to closely monitor plants with low population numbers to insure long term survival, and to avoid repeating historical extirpations in Monterey County. According the USFWS, *L. carnosa* will be considered for delisting when all major occurrences reach a sustained population size of over 5,000 individuals per occurrence (USFWS 1998).

1.4.2 Goals

- *Census L. carnosa at Indian Village Dunes and Asilomar State Beach*

A current census for both sites will act as a baseline to track population dynamics over time. The conclusions made may ultimately lead to possible de-listing of the species and will guide further research, management, and protection.

- *Estimate the density of L. carnosa at Indian Village Dunes*

To estimate density, quadrats in the shape of elongated rectangles will be randomly distributed throughout macroplots containing high aggregations of *L. carnosa*. The macroplots will be positioned based on polygons established in the field. A density estimate will aid future studies interested in estimating populations of *L. carnosa* that may be too large to conduct a complete census.

- *Characterize the growth of L. carnosa at Indian Village Dunes*

It has been observed that *L. carnosa* exhibits a variable growth within individual populations and across populations throughout California. This will be examined by measuring growth parameters on a regular basis during key developmental stages of *L. carnosa*. Measurements will include physical and reproductive growth and timing taken from a random sample of plants. Knowing the timing of germination and reproductive state may provide insight into environmental tolerance and response, and will aid in the timing of future studies.

- *Document pertinent qualitative observations at Indian Village Dunes*

Observations like noticeable deer or human tracks, sand movement or erosion by wind, competition with invasive or native plants, or any visible damage to the plant will be noted during the most active period of vegetative growth. These simple observations should aid future management plans aimed at protecting *L. carnosa* at Indian Village Dunes and other locations.

2. Methods

2.1 Site Descriptions

2.1.1 Indian Village Dunes

Indian Village Dunes is located adjacent to the 17 Mile Drive in Pebble Beach, and is bounded by Bird Rock Road to the north and The Dunes Road to the south (Figure 4). The site is further isolated by a golf green on the north side, a Monterey Pine forest on the east side, residential development on the south side, and the ocean to the west. The land is privately owned and managed by the Pebble Beach Company. A recreational boardwalk runs east and west through the site alongside a small annual creek. An old cottage sits on top of the hill to the east along the tree line and serves as a good landmark for site recognition. A complete list of native species observed on site can be found in APPENDIX II, invasive species include small amounts of *C. edulis* within the property, ripgut brome (*Bromus diandrus*) along the perimeter of the property, and *Senecio sp.* all throughout the dune system.

2.1.2 Asilomar State Beach

Asilomar State Beach is located between Sunset Drive and Asilomar Avenue in Pacific Grove, near the boundary of Pebble Beach (Figure 4). Similar to Indian Village Dunes, the site is isolated by development and has a recreational boardwalk. Little time was spent at this site, and a complete list of species was not created; however, many of the species found at Indian Village Dunes occur at Asilomar State Beach, including the three invasive species mentioned.

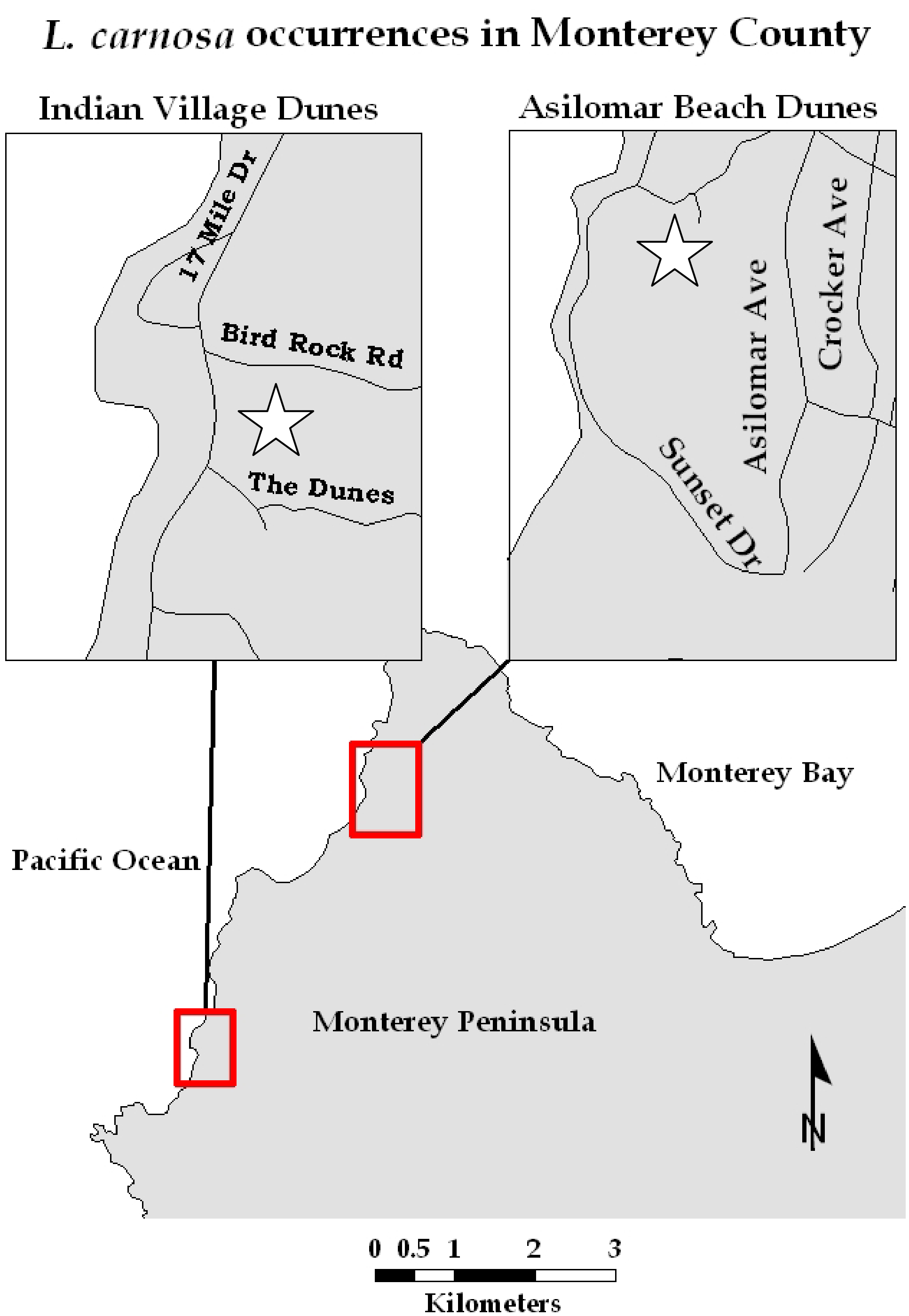


Figure 4. Map of the two study sites on the Monterey Peninsula containing *L. carnosa*; Asilomar State Beach and Indian Village Dunes. Specific locations of sites are denoted by a white star.

2.2 Complete Census

Layia carnosa germinates in predictable patches annually, with some migration, and previous occurrences of *L. carnosa* at Asilomar State Beach had been mapped by Lori Madison in 2000. These areas were relocated and marked with colored flags once germination was noticed. Polygons were established as the plants continued to germinate. Search efforts were focused in these known locations, and new occurrences were also marked. For Indian Village Dunes, previous occurrences were unknown. The entire property was thoroughly searched, particularly in areas of bare to sparsely vegetated sand, and emergence marked using colored flags.

Polygons were assigned names at Asilomar State Beach based on the protocol of previous years. At Indian Village Dunes, polygons were assigned names based on their associated ridge lines; north (NR), east (ER), south (SR), west (WR), or middle (MR) (Figure 5). Polygons were mapped using a Trimble GPS unit and projected in ArcGIS for reference in the field.

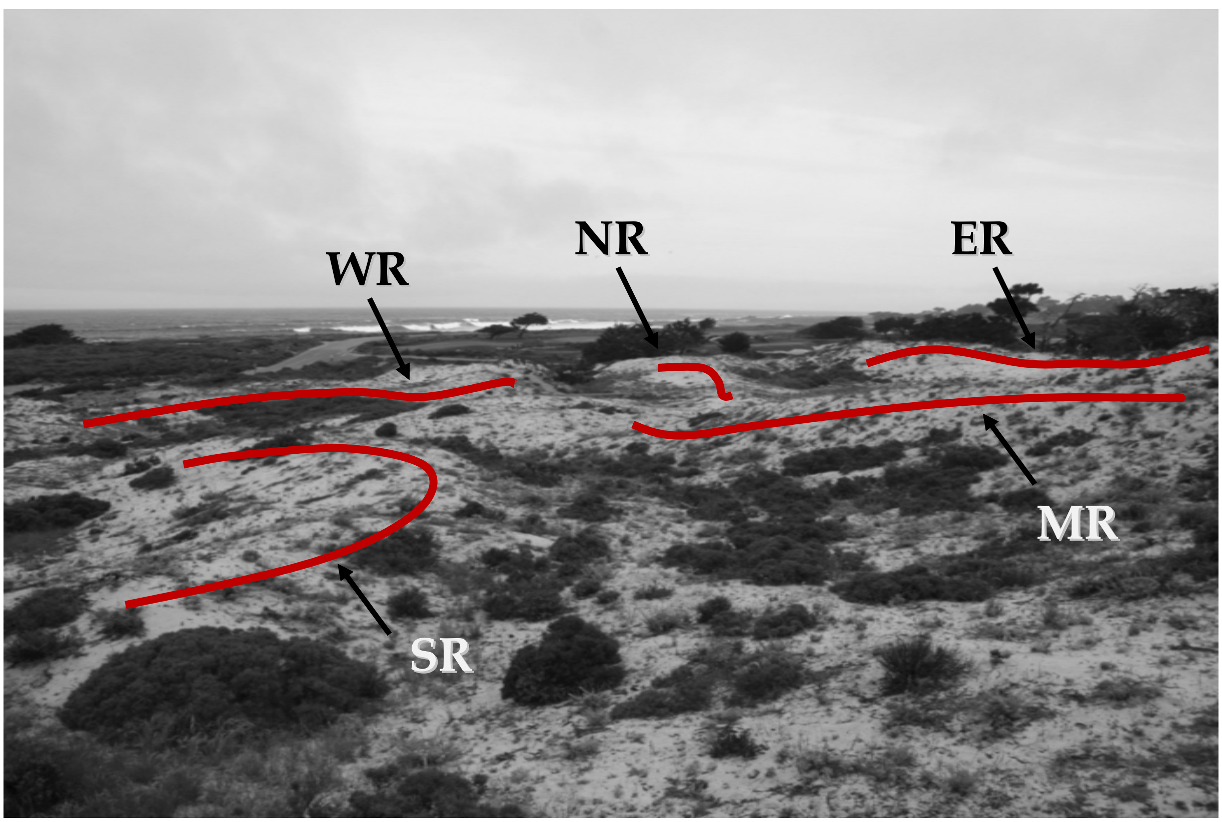


Figure 5. Photograph of Indian Village Dunes, with major ridge lines in red and associated names; south ridge (SR), west ridge (WR), north ridge (NR), east ridge (ER), middle ridge (MR).

A complete count of individual plants was made for each polygon at both sites in late March, when many of the plants had reached reproductive maturity. A circle was drawn in the sand around each plant to avoid recounting. All size classes greater than 10 mm were counted.

2.3 Density Estimation

Density estimations were limited to Indian Village Dunes, and were taken within the three major polygons of the south, middle, and east ridges. A baseline was established parallel to a polygon edge that was most easily accessible without damaging the dune area, which would allow for the maximum number of quadrats, and which would best represent the polygon in its entirety. The length of the baseline corresponded with the length of the polygon. Randomly placed along the baseline were 1mx15m quadrats, with the 15m length running perpendicular to the baseline (Figure 6). Similar quadrat dimensions were used in a capstone study of *E. menziesii* by Phillips and Vogel (2007) and are recommended by Elzinga *et al.* (2000). Plants greater than 10mm (unless positively identified) were counted to estimate the mean number of plants per quadrat and the density for the sampled polygons.

$$D = x_q / A_q$$
$$P = D * A_p$$

D= Density
P= Population estimate
x_q= mean number of plants per quadrat
A_q= quadrat area
A_p= polygon area

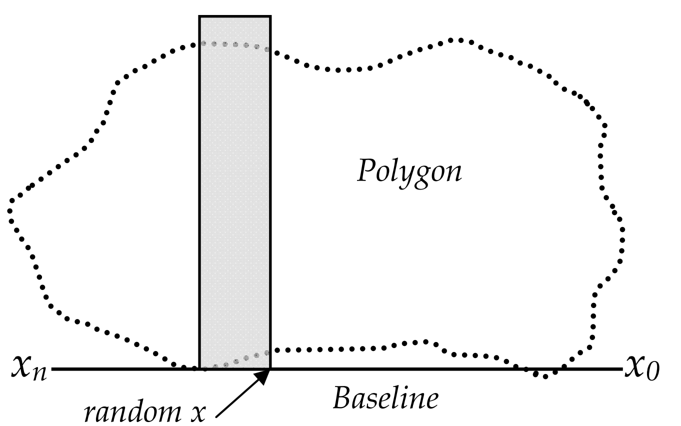


Figure 6. Example of a hypothetical polygon of *L. carnosa* marked by a dotted line. Shaded box indicates a 1mx15m quadrat placed left of a random position (x). Solid line indicates the baseline from starting point (x_0) to ending point (x_n).

2.4 Monitoring Growth

Several parameters of individual plants were measured on a weekly basis during March 2009 at Indian Village Dunes. At the beginning of March, flattened wooden sticks painted bright colors and labeled by a number were positioned six centimeters away from all size classes of individual *L. carnosa* plants, totaling 1000 indentified plants. Fifty-five random samples were chosen and labeled with a colored flag marked with an identifying number. Each plant was measured and observed once a week from March 9th to March 30th.

Measurements of these 55 random plants included rosette diameter, height, number of buds, and number of flowers. The longest distance between two opposing points through the middle of the plant was measured as the rosette diameter. The height of each plant was recorded in increments of 5mm, from the base of the plant to the tallest point either of a leaf, bud, or flowering head. Plants that had fallen over were measured from what would have been the tallest point had it been standing erect. Height was recorded as a class (Table 1). Buds were distinguished and counted based on stems, in other words one bud per stem. When a bud opened and revealed pollen it was recorded as a flowering head. Buds that were almost flowering heads but had not opened were counted as a bud.

Table 1. Size class breakdown of height measurements based on ranges of 5mm.

Height (mm)	<5	5	10	15	20	25	30	35	40	45	50	>50
Class	1	2	3	4	5	6	7	8	9	10	11	12

2.5 Qualitative Observations

Many hours were spent in the field observing the plants as they grew from cotyledons to reproductive maturity. This provided an opportunity to note specific biological, physical, and environmental parameters potentially acting on *L. carnosa*. Photographs were taken when applicable. The observations noted were not random, and were not systematically collected. Thus, inferences cannot be made uniformly to the entire population. The information, however, may still be useful.

3. Results

3.1 Indian Village Dunes

3.1.1 Complete Census Results

A complete census revealed a final count of 1,783 individual plants within all polygons, with ER2, MR1, and SR2 containing more than 100 plants per polygon (Table 2). GIS computed a combined area of 2,294 square meters for all polygons, with an overall density of 0.77 plants per square meter (Table 2). In total, ten isolated occurrences were found within the property of Indian Village Dunes; two associated with south ridge, four with west ridge, two with east ridge, one with north ridge, and one with middle ridge (Figure 7).

Table 2. Census results for Indian Village Dunes. Area of polygons derived from ArcGIS.

Indian Village Dunes Complete Census			
Polygon	*Area (m^2)*	*Count*	*Density (#/m^2)*
NR1	160	57	0.36
ER1	10	5	0.50
ER2	1180	1183	1.00
MR1	282	338	1.20
SR1	1	1	1.00
SR2	341	124	0.36
WR1	58	7	0.12
WR2	202	54	0.27
WR3	23	10	0.43
WR4	37	4	0.11
Total	2294	1783	0.77

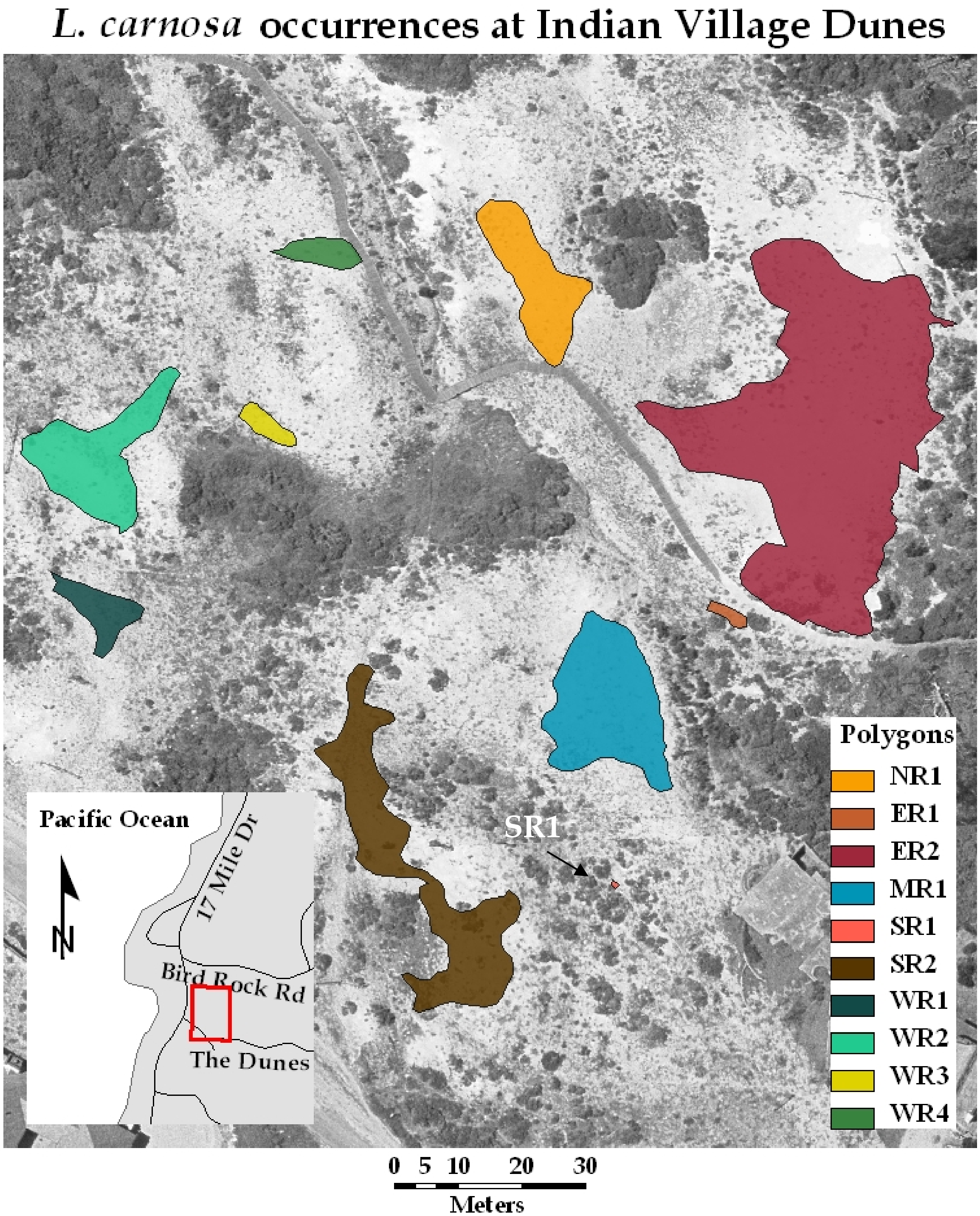


Figure 7. Map of Indian Village Dunes with *L. carnosa* boundaries represented as colored polygons. Note polygon SR1 which does not show well at this scale.

3.1.2 Density Estimate Results

In total, twenty one quadrats were sampled between three polygons that contained the highest counts of *L. carnosa*; ER2 with five quadrats, MR1 with ten quadrats, and SR2 with six quadrats (Table 3). There were on average 16.3±13.8 plants per quadrat, for an overall density estimate of 1.08 plants per square meter (Table 3). The remaining polygons were not sampled using quadrats due to a low plant count as well as time constraints.

Table 3. Density estimate results for Indian Village dunes. Quad area is 1mx15m.

Polygon	*n*	*Area (m^2)*	*Mean (#/Quad)*	*Density (#/m^2)*
ER2	5	1180	31.8±14.6	2.12
MR1	10	282	13.9±8.7	0.93
SR2	6	341	3.3±3.4	0.22
Total	21	1804	16.3±13.8	1.08

3.1.3 Growth measurements

Of the 55 randomly chosen plants, 9% died mainly by uprooting and desiccation, 26% produced a flowering head, and 50% produced at least one bud by the fourth week (Figure 8). A slight decrease per week in mean rosette diameter was measured; from 27.1±11.9 mm during the first week to 24.0±15.5 mm on the fourth week (Figure 9A). The height class increased each week, from 2.7±1.1 in the first week to 3.9±2.2 (Figure 9B), although stems tended to lay flush with the sand as the height increased. Significant numbers of buds were not noticed until week three (Figure 8) with a mean of 0.5±1.3 buds per plant increasing to a mean of 1.1±1.5 buds per plant in the fourth week (Figure 9C). The majority of the sample plants did not produce a full flowering head until week four, with an average of 0.3±0.5 flowering heads per plant (Figure 9D).

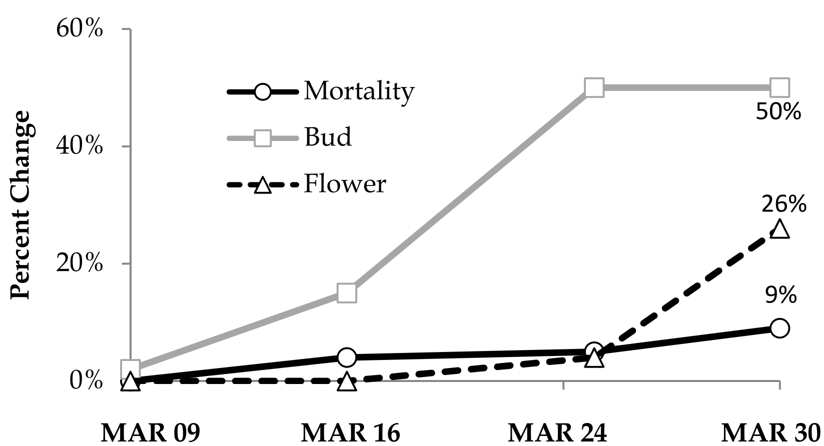


Figure 8. Weekly change in percentage of plants containing at least one bud or one flowering head, along with the weekly rate of mortality.

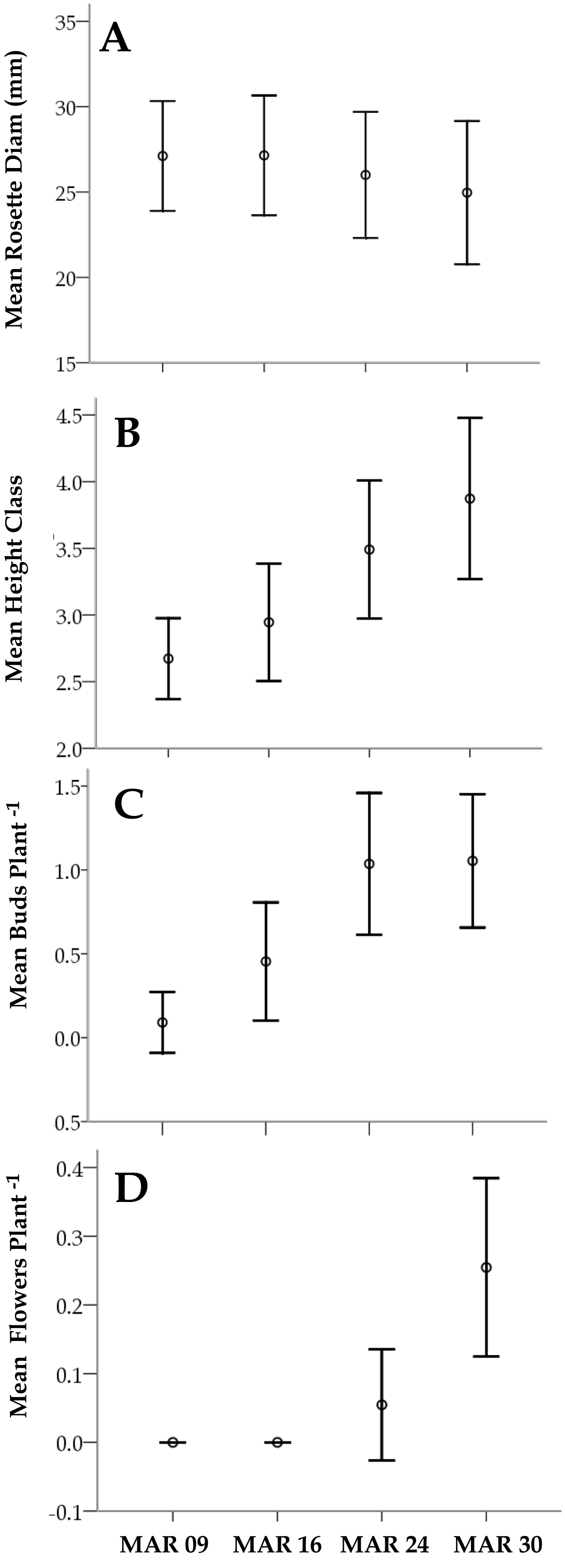


Figure 9. Mean weekly values of four different measurements of 55 sampled plants at Indian Village Dunes from March 09 to March 30, with associated 95% confidence intervals. Measurements; rosette diameter (A), height class based on Table 1 (B), number of buds per plant (C), number of flowering heads per plant (D).

3.1.4 Observations

Layia carnosa exhibited a clumped distribution, and occurred in a range of micro conditions. It was not found in high numbers within dense areas of mock heather *(Ericameria ericoides)* and coyote brush (*Baccharis pilularis)*; although a few occurrences were noted, such as polygons ER1 and SR1 (Figure 7). It was mainly seen in open and sparsely vegetated sand, in association with popcorn flower *(Cryptantha leiocarpa)*, sagewort *(Artemisia pycnocephala)*, invasive senecio *(Senecio sp.)*, endangered Tidestrom's lupine *(Lupinus tidestromii)* and Menzie's wallflower *(Erysimum menziesii)*. Sand composition where *L. carnosa* was found ranged from coarse consolidated grains to loose fine grains, with the majority of the plants in sand with a fine grain size. Finally, germination continued to occur throughout the entire month of March during the sampling period; and small 5-10 mm plants existed simultaneously with large 50-100 mm plants.

In terms of ecological factors, no specific herbivory by large ungulates were noticed; however, deer tracks had uprooted a few plants. In some cases, *L. carnosa* emerged adjacent to *Senecio sp*., *C. leiocarpa*, and native and invasive grasses, which did not seem to have an adverse affect on its growth. *Ammophila arenaria* was not observed at either Indian Village Dunes or Asilomar State Beach. Human foot prints were heavy on middle ridge (MR1). Wind scours uprooted plants in exposed areas of the dune. A species of box elder beetle pictured in APPENDIX I (Plate I) was seen on a single occasion with its proboscis submerged into the flowering head of *L. carnosa*, followed by what appeared to be a cleaning of antennae and cephalic appendages. A camera was not present during this observation.

3.2 Asilomar State Beach

3.2.1 Complete Census Results

The largest polygon identified as number 400 had 136 plants. The total population for Asilomar State Beach numbered 190 individual plants. Overall density for the site was 1.25 plants per square meter (Table 4). In total, seven isolated polygons were discovered at Asilomar State Beach, with two major polygons containing more than 30 plants each (Figure 10).

Table 4. Census results for Asilomar State Beach. Area of polygons derived in ArcGIS.

Asilomar State Beach Complete Census			
Polygon	*Area (m^2)*	*Count*	*Density (#/m^2)*
400	64	136	2.13
402	75	40	0.53
403	1	2	2.00
404	9	9	1.00
405	1	1	1.00
406	1	1	1.00
999	1	1	1.00
Total	152	190	1.25

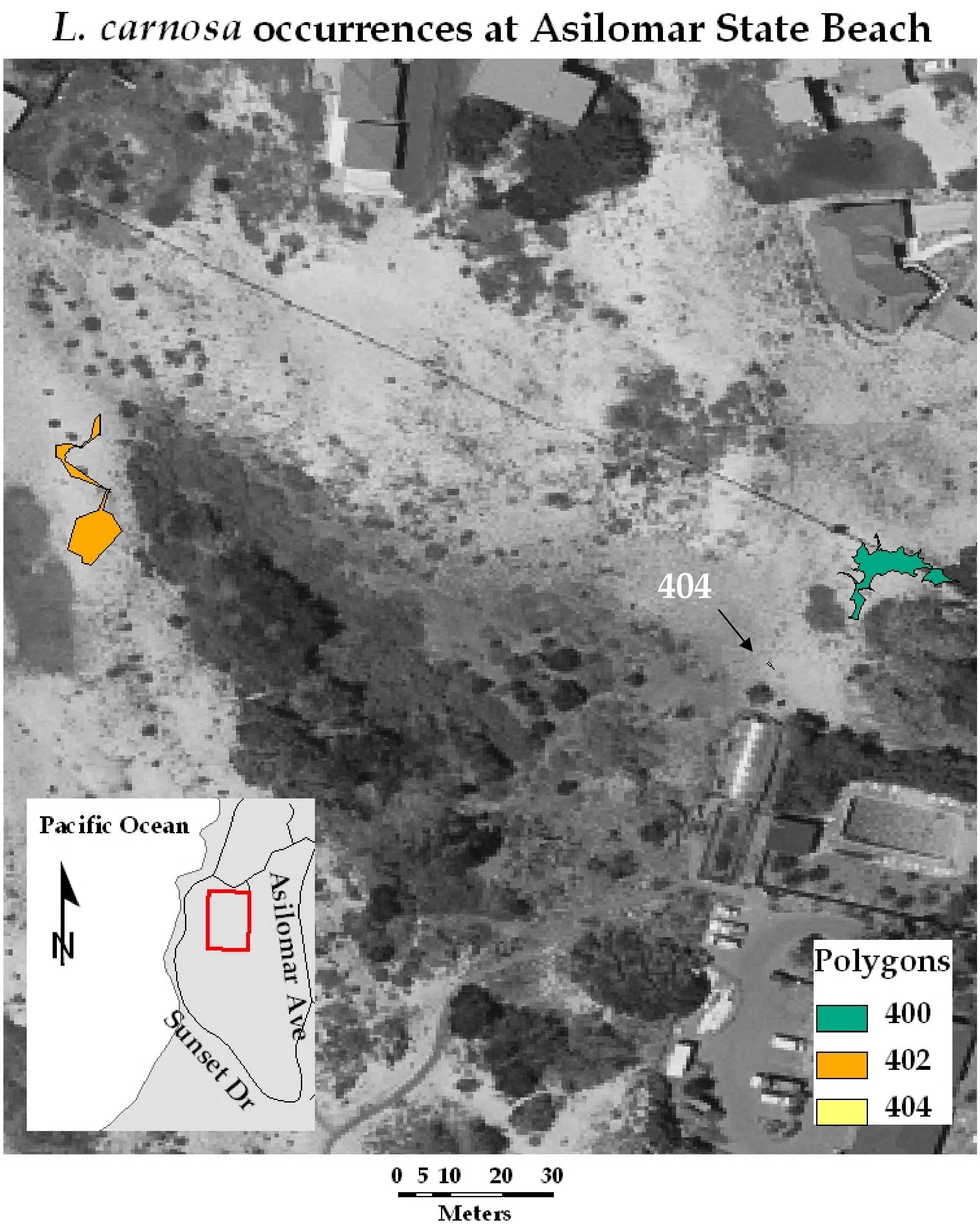


Figure 10. Map of Asilomar State Beach with *L. carnosa* boundaries represented as colored polygons. Note polygon 404 which does not show well at this scale. Polygons 403, 405, 406, and 999 have been omitted from this map due to scaling, refer to Table 4.

4. Discussion

4.1 Status within Monterey County

Shemske *et al.* (1994) suggests three steps necessary for proper management of rare and endangered plant species; the first step is acquiring accurate demographic information such as a census. A total census of 1,973 plants is a much higher number than was previously expected going into this study. It is difficult to say whether this census of Asilomar State Beach and Indian Village dunes is representative of the total number of *L. carnosa* in Monterey County; given there may be other occurrences that have yet to be counted. Regardless of that fact, it is still only half of what the USFWS deems as a sustainable population size. Since previous population counts were unknown for Indian Village Dunes and limited at Asilomar State Beach, it is unknown whether these two populations are increasing, decreasing, or remaining stable. Annual censuses during the month of March of polygons for both sites would take at least five to six hours per site. This would not include surveying the entire property for new occurrences, which would take another five to six hours per site. These surveys would help in understanding the general trend of these populations, with this study as the baseline for future counts.

The disparity in total plants between the two sites may be the result of many factors not addressed in this study, possibly differences in nutrient availability, community composition, historical human interference and restoration efforts, or other forms of natural variation. Again, due to a lack in previous data of population sizes at Asilomar State Beach and Indian Village Dunes, the pattern of fluctuations at the two sites is unknown.

Density estimates are another form of demographic information used in this study. Density estimates were highly variable between ER2, MR1, and SR2; and contained a high level of error. More quadrats would have reduced sampling error, which would have increased the power of the estimate. The 1m x 15m sized quadrat was easy to sample and quick to set up in the field. It was difficult to judge whether plants were within or outside quadrats, especially since dunes are typically topographically complex. Determining a protocol for accepting or rejecting edge effects would have made sampling more efficient, and is recommended by Elzinga *et al*. (2001). Wind also increased difficulty since it made the transect tape unstable. When planning future studies one should allow for at least several days of unfavorable sampling conditions. Complete census techniques are time consuming, and not appropriate for expansive populations. Plants may have been unnoticed during the counting process, thus lowering the actual number of plants. For these reasons, obtaining an accurate density estimate is essential for future studies and for monitoring this species.

4.2 Variation in Growth

The second step recommended by Schemske *et al.* (1994) is to gage which life history stage has the greatest influence over population growth, such as seedling survival compared to reproductive success. In order to understand this parameter, one most first know the life history of the species. As expected, *L. carnosa* initially put effort into growing large basal leaves for photosynthesis during early stages in its development. Once the plants began to produce flowering bodies, basal leaves diminished in size. This pattern is presented in Figures 8A & B, where mean rosette diameter shrinks as mean number of buds and flowering heads increase. Some plants grew tall instead of wide, and although it is not shown in the data, tall plants tended to produce one to three flowering heads while wide short plants produced multiple flowering heads. These tall plants most likely were putting energy into growing above the shifting sand, and had minimal energy to spare for reproduction. It would be interesting to test the relationship between the degree of loose or compact sand and plant height in *L. carnosa.*

The monitoring period ended before all of the sample plants reached reproductive maturity; only 50% of the sample had a flowering head by the fourth week. This resulted in a lower estimation of the number of flowering heads per plant. Extending the sampling period into late April or even early May would have better represented reproductive timing and may have led to a higher estimation of flowering heads per plant. Knowing the average number of flowering heads per plant is important for predicting the longevity of populations of *L. carnosa* since it provides a means for estimating the number of seeds in the seed bank, and subsequently how many plants may emerge the following year.

As mentioned in the introduction, the higher amount of mean monthly precipitation of northern compared to southern California counties containing *L. carnosa* occurrences may contribute to larger plants and a larger population size. Coupled with precipitation, moisture retention based on sand composition may also govern the growth of this species. *Layia carnosa* did appear more diminutive in size at Asilomar State Beach compared to Indian Village Dunes, which could be a result of differences in sand composition and water retention. These parameters again were not tested in this study, but may prove to be significant between both sites along with across geographic regions if explored in future studies.

Finally, the third step to proper recovery and management is to understand the biology of the species, such as allele diversity and variation among and within populations (*Schemske et al.* 1994). This is a complex question that could be addressed by future studies, possibly in a greenhouse. Based on the relatively low numbers of *L. carnosa* observed at both sites, particularly at Asilomar State Beach, growing them in a greenhouse may be needed for transplanting. Seeds could be gathered at Indian Village Dunes and transplanted at Asilomar State Beach. This could potentially increase the genetic diversity and help improve tolerance of *L. carnosa* to environmental variation.

4.3 Management at Indian Village Dunes

Although detectable human use in the form of footprints and disturbed sand was minimal at the Indian Village Dunes site, it still has the potential to negatively impact a small population of plants like *L. carnosa*. The boardwalk is useful for keeping people from roaming through the dunes, but does not alone convey the importance of staying on the boardwalk to pedestrians. Interpretive signs along the boardwalk would help keep people from roaming off trail, by explaining the delicate nature of the ecosystem and the importance for preserving biodiversity. Asilomar State Beach has interpretive signs for *E. menziesii ssp menziesii* and other species along its boardwalk; however, Indian Village Dunes has none. Adding these at Indian Village Dunes could limit trampling by human use while educating the public about local endangered species, and may be a good capstone project for future CSUMB students or other organizations.

The two invasive species *A. arenarea* and *C. edulis* have been problematic for endangered dune plants species throughout California but do not appear to be a major concern at Indian Village Dunes or Asilomar State Beach (Bossard *et al*. 2000). Only small patches of *C. edulis* were discovered and were physically removed. *Ammophilia arenarea* was not found at either site. Lori Madison expressed a concern that *Senecio sp*. may compete with *L. carnosa* for germination (personal communication 2009), and was observed in high numbers at both sites. Continued monitoring of invasive species at Indian Village Dunes and Asilomar State Beach is required to keep *C. edulis* cover low, and to determine if in fact *Senecio sp.* is limiting the success of *L. carnosa*.

4.4 Conclusions

As with most endeavors in science, this study has raised more questions than answers. There is much to learn about the intricate details of this small annual herb, providing enough funding remains to allow researchers into the field. Human activities have limited the space for *L. carnosa* populations, but disturbances currently seem minimal. A lack in observable limiting factors of *L. carnosa* at Indian Village Dunes and Asilomar State Beach suggests that variations in small scale conditions are at work. Nutrient composition, substrate texture, and availability of water most likely contribute to the noticeable difference in size between plants of different populations. Public awareness of the importance in preserving species diversity in complex ecosystems like coastal dunes may play a vital role in insuring *L. carnosa* remains undisturbed by human recreational use. Further research is also largely important to closely monitor these and other populations throughout its extant in California.

5. Literature Cited

Barbour M. 1978. Salt spray as a microenvironmental factor in the distribution of beach plants at Point Reyes, California. Oecologia (Berl.) 32: 213-224.

Basor B. 2002. Emergence, survival, and fecundity of the endangered annual *Layia carnosa* (Asteraceae). Humboldt State University/USFWS. Unpublished document.

[BLM] Bureau of Land Managment. 2002. Environmental assessment for the south spit interim management plan. Arcata Field Office. 1695 Heindon Road. Arcata, CA 95521.

Bossard C, Randall J, Hoshovsky M. 2000. Invasive plants of California's wildlands. California: University of California Press.

[CCC] California Coastal Commission. 1976. California coastal act. Public resource code: 30100 et seq.

[CCC] California Coastal Commission. 2001. Staff Report. City of Eureka and Bureau of Land Management (BLM). Application no.: 1-00-047. (November 21).

[CCC] California Coastal Commission. 2005. Staff Report. Humboldt bay harbor, recreation, and conservation district. Application no.: 1-05-039. (August 15).

[CDFG] California Department of Fish and Game. 1999. Species account.

City of Carmel-by-the-sea. Local coastal program: coastal land use plan. Submitted to the California Coastal Commission. Resolution no: 2002-128. (November 12, 2002).

Department of Fish and Game. 2009. State and federally listed endangered, threatened, or rare plants of California. California Natural Diversity Database. (January 2009).

Dingler J, Anima R. 2007. Investigation of wind and water levels for Giacomini Wetland restoration Project, Point Reyes National Seashore. US Geological Survey/US Department of Interior. Open-file report: 2007-1151.

Dorrell-Canepa J. Biologist. Native Solutions. Personal communication.
3470 San Juan Canyon Road
San Juan Bautista, CA 95045
(831) 915-7873

Draft findings of the Monterey County LCP periodic review. 2003. Chapter 3: Environmentally sensitive habitat areas. (December).

Elzinga C, Salzer D, Willoughby J, Bibbs J. 2001. Monitoring plant and animal populations. Malden, MA: Blackwell Science, Inc.

Escheverria S. 1993. 1993 monitoring report on *Layia carnosa* (Compositae) on the Lanphere-Christensen Dunes Preserve: a correlation analysis on rainfall indices and mean population densities and notes on the comparative effectiveness of monitoring designs used for this element. Unpublished document. The Nature Conservancy. Arcata, CA.

Federal Register. 2002. Endangered and threatened wildlife: six plants and Myrtle's silverspot butterfly from coastal dunes in northern and central California determined to be endangered. Fish and Wildlife Service. 57 (120): 27848-27859.

Fox L, Steele H, Holl K, Fusari M. 2006. Contrasting demographies and persistence of rare annual plants in highly variable environments. Plant Ecology. 183:157-170.

Frank S. 2003. Facilitation in multiple life-history stages: evidence for nucleated succession in coastal dunes. Plant Ecology. 168:1-11.

Franks S, Peterson S. 2003. Burial disturbance leads to facilitation among coastal dune plants. Plant Ecology. 168: 13-21.

Gilbert M, Pammentar N, Ripley B. 2008. The growth responses of coastal dune species are determined by nutrient limitation and sand burial. Oecologia. 156: 169-178.

Harris J, Harris M. 1995. Plant identification terminology: an illustrated glossary. Spring Lake Publishing: Spring Lake, UT.

Jepson W. 1925. A manual of the flowering plants of California. University of California, Publishers of Botanical Books. 961-1170.

Lamson-Scribner F. 1895. Grasses as soil and soil bridges. U.S. Department of Agriculture. U.S. Government Printing Office: Washington, D.C. 421-436.

Lorrie Madison. State Parks Environmental Scientist. Personal Communication.
State of California Department of Parks and Recreation: Asilomar Sector.
804 Croker Avenue
Pacific Grove, CA 93950

Lortie C, Cushman H. 2007. Effects of a directional abiotic gradient on plant community dynamics and invasion in a costal dune system. Journal of Ecology. 95: 468-481.

Maron J, Kauffman M. 2006. Habitat specific impacts of multiple consumers on plant population dynamics. Ecology. 87(1): 113-124.

Maun M. 1998. Adaptations of plants to burial in coastal sand dunes. Canadian Journal of Botany. 76: 713-738.

Phillips S, Vogel H. 2007. Monitoring populations of the endangered wallflower *Erysimum menziesii* in the Monterey dunes. Capstone Thesis. California State University Monterey Bay.

Pickart A. 1997. Control of European Beachgrass (*Ammophila arenaria*) on the West Coast of the United States. California Exotic Pest Plant Council.

Pickart A, Sawyer J. 1998. Ecology and restoration of Northern California coastal dunes. Sacramento, CA: California Native Plant Society.

Sacramento Fish and Wildlife Office. 2009. Species account: beach layia (*Layia carnosa*). Endangered Species Division: USFWS. Available from: http://www.fws.gov/sacramento/es/plant_spp_accts/beach_layia.htm

Sawyer J, Keeler-Wolf T. 1995. A manual of California vegetation. Sacramento, CA: California Native Plant Society.

Schemske D, Husband B, Ruckleshaus M, Goodwillie C, Parker I, Bishop J. 1994. Evaluating approaches to the conservation of rare and endangered plants. Ecology. 74(3): 584-606.

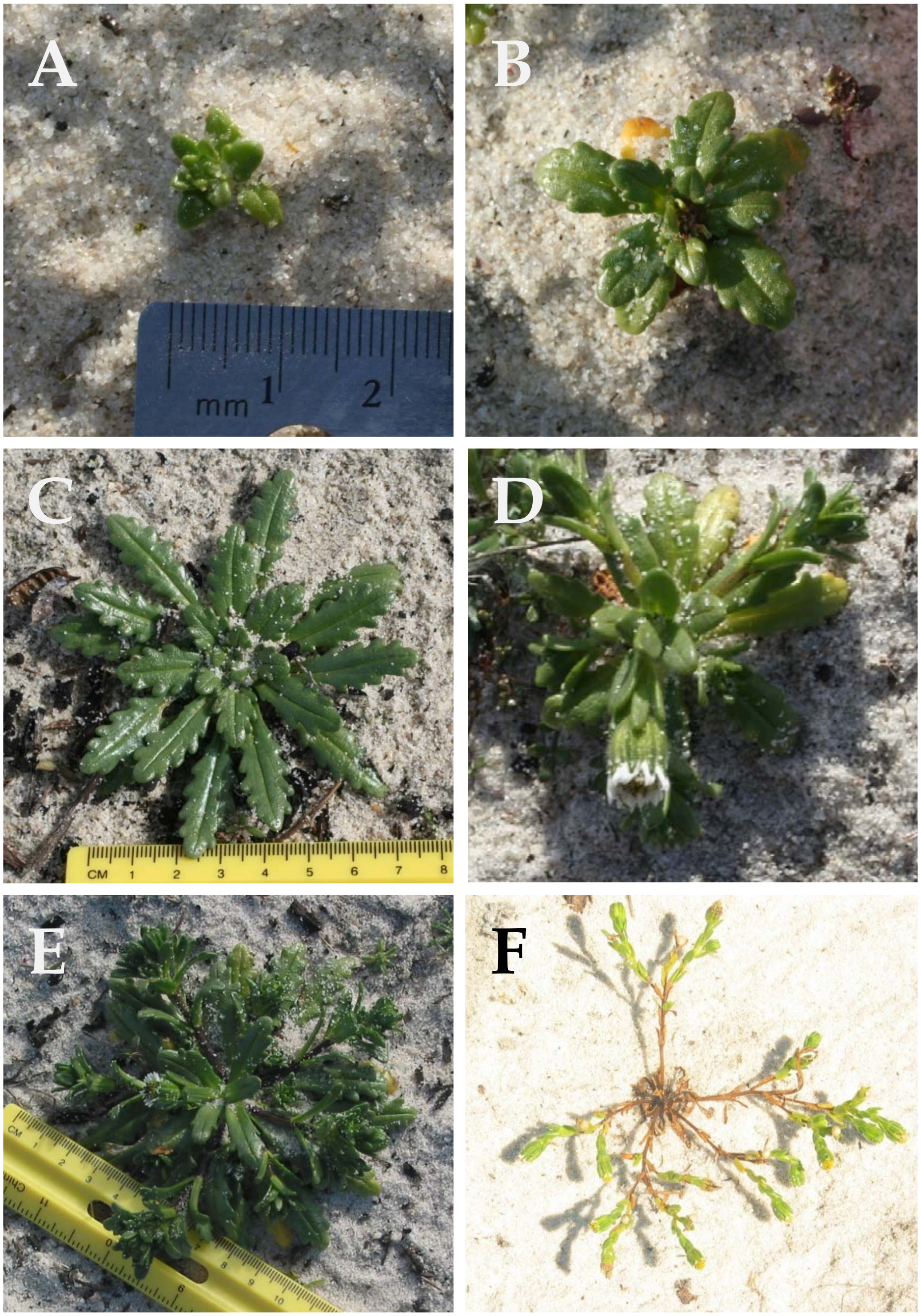
Tibor D. 2001. California native plant society's inventory of rare and endangered plants. 6th Edition. Sacramento, CA: California Native Plant Society.

Thomson D. 2005. Measuring the effects of invasive species on the demography of a rare and endemic plant. Biological Invasions. 7: 615-624.

[USFWS] United States Fish and Wildlife Service. 1998. Recovery plan for seven coastal plants and the myrtle's silverspot butterfly. Portland, Oregon: U.S. Fish and Wildlife Service.

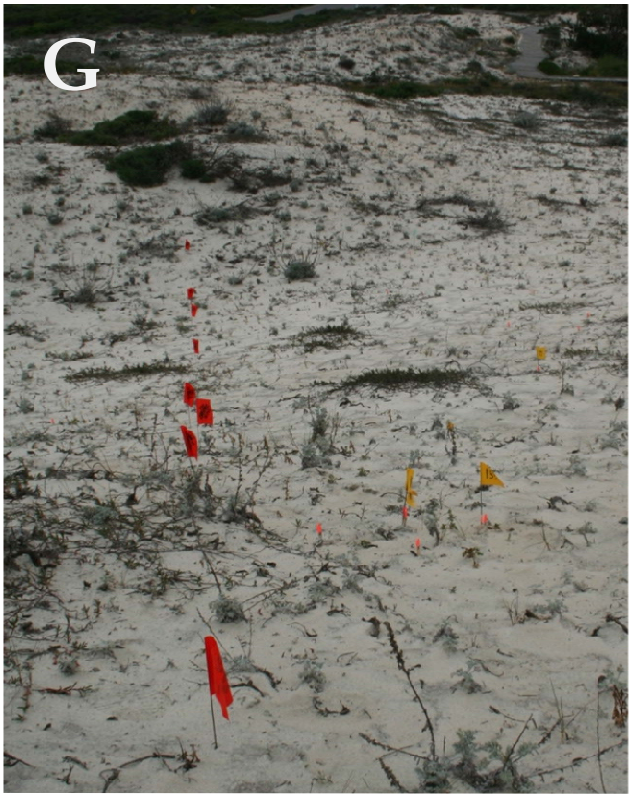
Warner J, Cushman J. 2002. Influences of herbivores on a perennial plant: variation with life history stage and herbivore species. Oecologia. 132:77-8

APPENDIX I (Plates A-F)



Plants smaller than 10mm in diameter were difficult to identify (A). Typical 15-20mm diameter plant (B). Succulent fleshy lobed leaves of a 60-70mm diameter plant (C). Example of a flowering head on a 40-50mm diameter plant (D). Large 100mm diameter plant with multiple stems and flowering heads (E). Example of plant towards the end of the sampling period, noticed dried leaves and flowers that have begun to release seeds (F).

(Plates G-I)



Row of red flags along the baseline marking the beginning of quadrats used for sampling density, with orange colored wooden sticks marking individual plants and yellow flags marking sample plants (G). Example of a dune landscape along west facing slope of ER2 at Indian Village Dunes, most common plants in plate are sagewort (*Artemisia pycnocephala*) (H). A species of box elder beetle on a beach primrose (*Camissonia cheiranthifolia),* was seen on *L. carnosa* and may be a potential pollinator (I).

APPENDIX II ***Native Species at Indian Village Dunes (April 2009)***

Scientific Name	***Common Name***	***Presence***
Abronia latifolia	yellow sand verbena	
Abronia umbellata	pink sand verbena	x
Ambrosia chamissonis	beach burr	
Amsinckia spectabilis	fiddleneck	x
Armeria maritima	sea thrift	
Artemisia californica	CA. Sagebrush	
Artemisia pycnocephala	sagewort	x
Baccharis pilularis	coyote brush	x
Camissonia cheiranthifolia	beach primrose	x
Camissonia micrantha	small primsose	x
Cardionema ramossisima	sand mat	x
Carex pansa	dune sedge	x
Castilleja latifolia	Indian paintbrush	x
Chorizanthe pungens	Mon. spineflower	x
Claytonia perfoliata	miner's lettuce	x
Crassula connata	sand pgymy	x
Cryptantha leiocarpa	popcorn flower	x
Dudleya caespitosa	liveforever	x
Ericameria ericoides	mock heather	x
Erigeron glaucus	seaside daisy	x
Eriogonum parvifolium	dune buckwheat	x
Erysimum ammophilum	coast wallflower	
Erysimum menziesii ssp. menziesii	Menzie's wallflower	x
Eriophyllum staechadifolium	lizardtail	x
Eschscholzia cal. var. maritima	CA. poppy	x
Gilia tenuiflora ssp. arenaria	sand gilia	
Grindelia latifolia	coastal gum plant	x
Juncus patens	spreading rush	x
Layia carnosa	beach layia	x
Lessingia filaginifolia	CA. beach aster	x
Linaria canadensis	blue toad flax	x
Lotus heermanii	wooly lotus	x
Lotus scoparius	deerweed	x
Lupinus arboreus	tree lupine	x
Lupinus tidestromii	Tidestrom's lupine	x
Lythrum californicum	CA. loosestrife	x
Pinus radiata	Monterey pine	x
Psilocarpus brevissimus	dwarf woolly heads	x
Poa douglasii	sand dune bluegrass	x
Polygonum paronychia	knotweed	x
Rhamnus californica	CA. coffeeberry	
Stachys bullata	wood mint	x

APPENDIX III

Data gathered during the weekly measurement of a random sample of 55 plants at Indian Village Dunes during the month of March, 2009. ID's correspond to the random number label, Ridge is the specific ridge line the sample is located (Figure 5), Diam is the rosette diameter between the widest points of the plant, Ht class was the scale for which the height measurements were made (Table 1), Bud is the number of buds counted per plant, Flower is the number of flowering heads per plant, #Lv. Is the number of full leaves counted per plant (note these measurements were made for only the first two weeks). Gray highlighted rows indicate a mortality.

(Growth Measurements Week 1: Mar 09, 2009)

ID	*Ridge*	*Diam (mm)*	*Ht Class*	*Bud*	*Flower*	*#Lv.*
3	MR	36	3	0	0	16
11	MR	30	2	0	0	6
28	MR	35	4	0	0	18
32	MR	42	3	0	0	10
67	MR	26	2	0	0	10
80	MR	20	5	0	0	16
96	MR	25	4	0	0	10
106	MR	32	3	0	0	10
124	MR	26	2	0	0	8
134	MR	45	4	0	0	16
153	MR	28	4	0	0	9
154	MR	21	3	0	0	8
172	MR	15	3	0	0	8
185	MR	20	2	0	0	6
187	MR	10	1	0	0	4
224	MR	10	3	0	0	8
239	MR	35	3	0	0	11
242	MR	24	3	0	0	10
264	MR	15	1	0	0	6
265	MR	14	2	0	0	4
318	SR	45	3	0	0	17
340	SR	21	3	0	0	14
345	SR	46	3	0	0	18
350	SR	22	4	0	0	11
367	SR	13	2	0	0	6
387	WR	27	2	0	0	8
398	WR	53	5	0	0	16
391	WR	41	3	0	0	8
407	WR	15	2	0	0	7

417	WR	22	3	0	0	6
424	WR	48	4	0	0	17
432	WR	43	5	5	0	20
435	WR	34	6	0	0	15
463	ER	26	2	0	0	14
476	ER	10	1	0	0	4
480	ER	12	2	0	0	8
483	ER	25	1	0	0	6
497	ER	22	2	0	0	6
499	ER	29	2	0	0	6
523	ER	41	2	0	0	8
527	ER	55	3	0	0	17
535	ER	9	1	0	0	4
554	ER	14	3	0	0	8
559	ER	21	2	0	0	6
564	ER	30	3	0	0	5
588	ER	23	1	0	0	7
613	ER	19	1	0	0	8
697	ER	30	3	0	0	9
730	ER	35	3	0	0	14
776	ER	11	2	0	0	6
780	ER	21	2	0	0	8
804	ER	15	3	0	0	7
846	ER	43	2	0	0	14
888	ER	33	2	0	0	16
965	ER	28	2	0	0	8

(Growth Measurements Week 2: Mar 16, 2009)

ID	*Ridge*	*Diam (mm)*	*Ht Class*	*Bud*	*Flower*	*#Lv.*
3	MR	41	4	0	0	18
11	MR	36	1	0	0	8
28	MR	33	5	0	0	18
32	MR	44	4	0	0	12
67	MR	30	2	0	0	11
80	MR	21	6	0	0	14
96	MR	26	4	0	0	14
106	MR	33	3	0	0	10
124	MR	28	3	0	0	10
134	MR	51	6	4	0	14
153	MR	26	4	0	0	9
154	MR	21	3	0	0	10
172	MR	15	4	0	0	8
185	MR	21	3	0	0	7

187	MR	11	2	0	0	4
224	MR	0	0	0	0	0
239	MR	36	3	0	0	14
242	MR	26	4	0	0	12
264	MR	18	2	0	0	6
265	MR	15	2	0	0	6
318	SR	48	6	4	0	14
340	SR	24	3	0	0	14
345	SR	48	5	0	0	17
350	SR	20	4	0	0	13
367	SR	14	2	0	0	7
387	WR	30	3	0	0	9
398	WR	55	5	0	0	16
391	WR	38	3	0	0	10
407	WR	14	3	0	0	8
417	WR	25	3	0	0	6
424	WR	45	5	4	0	16
432	WR	42	7	6	0	16
435	WR	35	7	4	0	11
463	ER	28	3	0	0	12
476	ER	10	1	0	0	4
480	ER	16	2	0	0	10
483	ER	24	2	0	0	8
497	ER	22	2	0	0	8
499	ER	30	1	0	0	8
523	ER	38	1	0	0	10
527	ER	55	2	1	0	16
535	ER	8	1	0	0	6
554	ER	15	2	0	0	10
559	ER	20	2	0	0	10
564	ER	28	2	0	0	10
588	ER	20	2	0	0	10
613	ER	19	1	0	0	8
697	ER	0	0	0	0	0
730	ER	30	3	0	0	14
776	ER	12	1	0	0	8
780	ER	25	2	0	0	10
804	ER	15	3	0	0	8
846	ER	45	2	1	0	16
888	ER	33	3	1	0	16
965	ER	30	3	0	0	8

(Growth Measurements Week 3: Mar 24, 2009)

ID	*Ridge*	*Diam (mm)*	*Ht Class*	*Bud*	*Flower*
3	MR	35	5	1	0
11	MR	28	2	0	0
28	MR	30	6	4	0
32	MR	45	4	1	0
67	MR	25	3	1	0
80	MR	15	7	1	0
96	MR	25	4	1	0
106	MR	35	3	0	0
124	MR	23	4	1	0
134	MR	42	5	4	0
153	MR	25	3	1	0
154	MR	20	5	1	0
172	MR	16	4	0	0
185	MR	20	2	0	0
187	MR	10	2	0	0
224	MR	0	0	0	0
239	MR	30	4	1	0
242	MR	22	4	1	0
264	MR	17	3	0	0
265	MR	14	3	0	0
318	SR	50	4	4	1
340	SR	23	4	1	0
345	SR	50	5	4	0
350	SR	20	5	1	0
367	SR	15	3	0	0
387	WR	30	3	0	0
398	WR	55	7	4	0
391	WR	42	4	1	0
407	WR	15	3	0	0
417	WR	16	3	0	0
424	WR	50	6	5	0
432	WR	50	7	6	2
435	WR	35	11	3	0
463	ER	26	3	1	0
476	ER	10	1	0	0
480	ER	12	3	0	0
483	ER	24	2	0	0
497	ER	25	2	0	0
499	ER	31	2	0	0
523	ER	38	2	0	0

527	ER	53	4	4	0
535	ER	10	1	0	0
554	ER	15	2	0	0
559	ER	18	3	0	0
564	ER	32	3	0	0
588	ER	15	2	0	0
613	ER	18	2	0	0
697	ER	0	0	0	0
730	ER	33	4	3	0
776	ER	0	0	0	0
780	ER	20	3	0	0
804	ER	15	3	0	0
846	ER	40	5	1	0
888	ER	30	4	1	0
965	ER	37	3	0	0

(Growth Measurements Week 4: Mar 30, 2009).

ID	*Ridge*	*Diam (mm)*	*Ht Class*	*Bud*	*Flower*
3	MR	32	4	3	0
11	MR	30	4	1	0
28	MR	35	5	4	1
32	MR	41	5	1	0
67	MR	30	4	1	0
80	MR	20	9	2	1
96	MR	20	5	1	0
106	MR	33	4	1	1
124	MR	18	4	1	0
134	MR	50	6	4	1
153	MR	23	4	0	1
154	MR	15	5	1	0
172	MR	15	4	0	0
185	MR	20	3	0	0
187	MR	11	3	0	0
224	MR	0	0	0	0
239	MR	32	5	2	0
242	MR	22	4	3	1
264	MR	16	3	0	0
265	MR	14	3	0	0
318	SR	50	7	4	1
340	SR	18	4	2	0
345	SR	45	4	5	0
350	SR	20	6	1	0

367	SR	12	3	0	0
387	WR	30	5	0	0
398	WR	45	10	3	1
391	WR	37	5	1	0
407	WR	12	4	0	0
417	WR	15	5	0	0
424	WR	60	9	4	1
432	WR	75	7	4	2
435	WR	50	9	4	1
463	ER	0	0	0	0
476	ER	8	1	0	0
480	ER	15	2	0	0
483	ER	24	2	0	0
497	ER	24	3	0	0
499	ER	30	3	0	0
523	ER	35	3	0	0
527	ER	0	0	0	0
535	ER	11	1	0	0
554	ER	13	3	0	0
559	ER	20	3	0	0
564	ER	30	4	0	0
588	ER	25	3	0	0
613	ER	15	2	0	0
697	ER	0	0	0	0
730	ER	34	4	2	1
776	ER	0	0	0	0
780	ER	24	3	0	0
804	ER	16	3	0	0
846	ER	40	5	2	0
888	ER	28	3	1	1
965	ER	35	3	0	0