Island phacelia (*Phacelia insularis* var. *insularis*)

5-Year Review:
Evaluation and Summary

Photo: Andrew Yamagiwa

U.S. Fish and Wildlife Service
Ventura Fish and Wildlife Office
Ventura, California

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5-Year Review: Evaluation and Summary

GENERAL INFORMATION:

Species: *Phacelia insularis* var. *insularis*
FR citation: 62 FR 40954 (as *Phacelia insularis* ssp. *insularis)*
Date listed: July 31, 1997
Classification: Endangered

BACKGROUND:

Most recent status review:
U.S. Fish and Wildlife Service. 2008. Island phacelia *(Phacelia insularis* var. *insularis*) 5-Year Review: Summary and Evaluation. Ventura Field Office. Ventura, California.

FR Notice citation announcing this status review:
Initiation of 5-Year Status Reviews of 66 species in California and Nevada. Notice of initiation of reviews; request for information (85 FR 4692), January 27, 2020.

ASSESSMENT:

Phacelia insularis var. *insularis* (Boraginaceae, formerly Hydrophyllaceae) is an annual forb that occurs only on Santa Rosa Island and San Miguel Island in Santa Barbara County, California, each about 25 miles (40 kilometers) from the mainland. The islands are adjacent and separated by a channel about 3.7 mile (6 kilometers) wide. Santa Rosa Island is entirely owned by Channel Islands National Park (CINP), and San Miguel Island is owned by the US Navy, but is managed by CINP. All land is managed for natural resource conservation.

Santa Rosa Island had non-native ungulate herbivores from 1844 to 2020 (Table 1, McEachern *et al*. 2016 pp. 759-760, Andrew Adams pers. comm. 2021). At time of *Phacelia insularis* var. *insularis* listing in 1997, cattle, mule deer, elk and horses were still on the island. Cattle were removed between listing and the 2000 recovery plan, and elk and mule deer were removed between the 2008 5-year review and the present. The final two horses died of natural causes on the island in December 2020 and were the last non-native ungulates in CINP. San Miguel Island had non-native ungulate herbivores from before 1850 until the 1970s; while the animals were gone by the time of listing, their residual effects remained.

Table 1. Non-native ungulate herbivores on Santa Rosa Island (SRI) and San Miguel Island (SMI) (McEachern *et al*. 2016 pp. 759-760, Andrew Adams pers. comm. 2021). Bold text indicates animals present on the islands after *Phacelia insularis* var. *insularis* listing.
* one radio-collared mule deer swam from Santa Rosa Island to San Miguel Island in 2013.

species	Latin name	SRI dates	SMI dates
elk	*Cervus canadensis*	1879 - **2011**	never introduced
mule deer	*Odocoileus hemionus*	1880 - **2015**	never introduced*
fallow deer	*Dama dama*	1890 - 1949	never introduced

species	Latin name	SRI dates	SMI dates
horses	*Equus ferus caballus*	1844 - **2020**	1851 - 1948
donkeys	*Equus africanus asinus*	1800s	1950s - 1976
pigs	*Sus scrofa domestica*	1853 - 1993	1851 - 1897?
cattle	*Bos taurus*	1844 - **1998**	1851 - 1917?
sheep	*Ovis aries*	1844 - 1960s	<1850 - 1970s
goats	*Capra aegagrus hircus*	1883 - Early 1900s	1880s

At the time of the 1997 listing, *Phacelia insularis* var. *insularis* was known only from Santa Rosa Island, and had not been reported from San Miguel Island for 12 years (Service 1997 p. 4092). The threats to the species at listing were specifically for Santa Rosa Island, but are also applicable to San Miguel Island. At time of the 1997 listing, the threats to *Phacelia insularis* var. *insularis* were soil damage, competition with non-native grasses, habitat alteration caused by cattle grazing and elk and deer browsing, extinction from random naturally occurring events due to its limited distribution, and decreased reproductive vigor because of small population sizes. The 2000 recovery plan did not identify additional threats. The 2008 5-year reviews affirmed the continued importance of these threats and identified climate change as a potential threat. Below we evaluate the current status of and threats to *Phacelia insularis* var. *insularis.*

Information acquired since the last status review:
This 5-year review was conducted by the U.S. Fish and Wildlife Service (Service) Ventura Fish and Wildlife Office. Data for this review were solicited from interested parties through a Federal Register notice announcing this review on January 27, 2020. We also contacted species experts to request any data or information we should consider in our review. Additionally, we conducted a literature search and a review of information in our files.

Population data:
Distribution and abundance:
Historically, *Phacelia insularis* var. *insularis* has been documented by the California Natural Diversity Database (CNDDB 2019) as one Element Occurrence (EO) on Santa Rosa Island and five EOs on San Miguel Island (Table 2). Because generally only part of the whole occurrence was surveyed, the reported numbers of plants may be less than the actual number of plants for that occurrence for that year. Part of the occurrence on Santa Rosa Island has been monitored most years from 2003 to 2021 (McEachern 2021 entire); in 2019, plants were found in new locations within the occurrence (McEachern and Bednar 2019 p. 24). San Miguel Island occurrences have been not been regularly surveyed or formally monitored, but have been sporadically observed over the years (Table 2), with recent observations at three of the occurrences in 2019 (McEachern and Bednar 2019 pp. 20-21) and 2020 (Parrino 2020 entire).

Table 2. *Phacelia insularis* var. *insularis* Element Occurrences (EO) in the California Natural Diversity Database (CNDDB), with historic (CNDDB 2019) and more recent (McEachern and Bednar 2019, McEachern 2021, Parrino 2020) plant abundance. Note that EO 2 and EO 3 have been collapsed by CNDDB into other EOs.

CNDDB EO	island	location description	year	source	# of plants
1	Santa Rosa	Carrington Point	1994	CNDDB 2019	35
1	Santa Rosa	Carrington Point	1998	CNDDB 2019	1465

CNDDB EO	island	location description	year	source	# of plants
1	Santa Rosa	Carrington Point	1999	CNDDB 2019	33
1	Santa Rosa	Carrington Point	2001	CNDDB 2019	771
1	Santa Rosa	Carrington Point	2002	CNDDB 2019	16
1	Santa Rosa	Carrington Point	2003	McEachern 2021	448
1	Santa Rosa	Carrington Point	2004	McEachern 2021	370
1	Santa Rosa	Carrington Point	2005	McEachern 2021	38
1	Santa Rosa	Carrington Point	2006	McEachern 2021	2
1	Santa Rosa	Carrington Point	2007	McEachern 2021	34
1	Santa Rosa	Carrington Point	2008	McEachern 2021	440
1	Santa Rosa	Carrington Point	2010	McEachern 2021	1102
1	Santa Rosa	Carrington Point	2011	McEachern 2021	6
1	Santa Rosa	Carrington Point	2012	McEachern 2021	1627
1	Santa Rosa	Carrington Point	2013	McEachern 2021	73
1	Santa Rosa	Carrington Point	2014	McEachern 2021	178
1	Santa Rosa	Carrington Point	2015	McEachern 2021	615
1	Santa Rosa	Carrington Point	2016	McEachern 2021	1495
1	Santa Rosa	Carrington Point	2017	McEachern 2021	4796
1	Santa Rosa	Carrington Point	2018	McEachern 2021	149
1	Santa Rosa	Carrington Point	2019	McEachern and Bednar 2019, McEachern 2021	~3058-~3112
1	Santa Rosa	Carrington Point	2020	McEachern 2021	785
1	Santa Rosa	Carrington Point	2021	McEachern 2021	359
4	San Miguel	NW Green Mountain	1962	CNDDB 2019	unrecorded
4	San Miguel	NW Green Mountain	1998	CNDDB 2019	30
5	San Miguel	below Mammoth Springs	1978	CNDDB 2019	unrecorded
6	San Miguel	Cuyler Harbor Bluffs	1968	CNDDB 2019	unrecorded
6	San Miguel	Cuyler Harbor Bluffs	1995	CNDDB 2019	unrecorded
6	San Miguel	Cuyler Harbor Bluffs	1998	CNDDB 2019	234
6	San Miguel	Cuyler Harbor Bluffs	2001	CNDDB 2019	154
6	San Miguel	Cuyler Harbor Bluffs	2002	CNDDB 2019	4
6	San Miguel	Cuyler Harbor Bluffs	2015	McEachern and Bednar 2019	unrecorded
6	San Miguel	Cuyler Harbor Bluffs	2019	McEachern and Bednar 2019	0
6	San Miguel	Cuyler Harbor Bluffs	2020	Parrino 2020	80
7	San Miguel	SW slopes Green Mtn.	1998	CNDDB 2019	29
7	San Miguel	SW slopes Green Mtn.	2019	McEachern and Bednar 2019	79
8	San Miguel	SE slopes Green Mtn.	1962	CNDDB 2019	unrecorded
8	San Miguel	SE slopes Green Mtn.	1998	CNDDB 2019	2653
8	San Miguel	SE slopes Green Mtn.	2001	CNDDB 2019	3212
8	San Miguel	SE slopes Green Mtn.	2002	CNDDB 2019	493
8	San Miguel	SE slopes Green Mtn.	2019	McEachern and Bednar 2019	727
8	San Miguel	SE slopes Green Mtn.	2020	Parrino 2020	271

Trends in abundance:
It is difficult to determine any trends in the abundance of *Phacelia insularis* var. *insularis* because almost no data have been collected in the same way in the same years over repeated years. However, some patterns emerge within the single occurrence on Santa Rosa Island, EO 1 at Carrington Point (Table 3), where four defined plots have been monitored almost annually. The dimensions and areas of the four plots are all different, so numbers cannot be directly compared or combined. Choosing 10% of the maximum abundance of plants ever recorded in a plot as a benchmark for that plot, there seem to be "high" years when all plots surveyed have greater than that plot benchmark (2004, 2010, 2017), "low" years when all plots surveyed have less than that plot benchmark (2005, 2006, 2007, 2011, 2013, 2014, 2019, 2021), and mixed years when the plots are not in concordance (2003, 2008, 2012, 2015, 2016, 2018, 2019). These high and low number years are not correlated with total rainfall, but are likely a response to low temperature after the first major rainfall event (Levin *et al.* 2008 pp. 798-804). Table 3 also demonstrates the extreme variability of plant numbers within a plot between years (*e.g.* 10 plants in 2013 and 3368 plants in 2017 for Sand Ridge).

Table 3. Abundance of *Phacelia insularis* var. *insularis* within monitoring plots on Carrington Point, Santa Rosa Island, from 2003 to 2021 (McEachern 2021). Numbers in parentheses after plot names are 10% of maximum number of plants ever recorded at that plot. *High* years are years where all plots surveyed that year had plant numbers greater than 10% of maximum number of plants ever surveyed for that plot. *Low* years are years where all plots surveyed that year had plant numbers less than 10% of maximum number of plants ever surveyed for that plot.year.

year	**relative population abundance**	**Crest** (50)	**North of Road** (129)	**Swale** (31)	**Sand Ridge** (337)
2003		52	88	308	not surveyed
2004	high	118	172	80	not surveyed
2005	low	12	14	12	not surveyed
2006	low	1	0	1	not surveyed
2007	low	18	13	3	not surveyed
2008		316	91	33	not surveyed
2010	high	503	552	47	not surveyed
2011	low	0	6	0	not surveyed
2012		11	10	2	1604
2013	low	2	48	13	10
2014	low	1	2	0	175
2015		147	281	1	186
2016		1	not surveyed	0	1494
2017	high	137	1291	not surveyed	3368
2018	low	0	22	0	127
2019		13	305	1	2172
2020		2	271	not surveyed	512
2021	low	0	14	not surveyed	345

Seed banking:
There are only a few accessions of *Phacelia insularis* var. *insularis* seed in a Center for Plant Conservation approved conservation seed bank, the Santa Barbara Botanic Garden (Table 4). Not all occurrences on San Miguel Island are represented, and half of the accessions are from a single year, 2019.

Table 4. *Phacelia insularis* var. *insularis* conservation seed banking. CNDDB = California Natural Diversity Database, EO = Element Occurrence. Data from CaPR 2021 and *McEachern 2018.

CNDDB EO #	collection date	facility	location description	maternal line or unknown	# maternal lines	# seeds
1	5/8/2004	SBBG	Santa Rosa Island	maternal line	1	unknown
1	4/2/2017*	SBBG	Crest and North of Road study plots	maternal line	37	unknown
1	4/14/2017*	SBBG	North of Road study plot	maternal line	37	unknown
1	4/6/2019	SBBG	Santa Rosa Island, Carrington Point, ridges and swales N of long-term monitoring area	maternal line	10	484
1	4/21/2019	SBBG	Santa Rosa Island, Carrington point, North of Road	maternal line	45	1425
7	4/14/2019	SBBG	San Miguel Island, Jackass flats area.	maternal line	51	1711
8	4/15/2019	SBBG	San Miguel Island	maternal line	19	522
unknown	unknown	SBBG	unknown	unknown	unknown	100

EVALUATION OF THREATS:

At the time of the 1997 listing, the threats to *Phacelia insularis* var. *insularis* were identified as soil damage, competition with non-native annual grasses, habitat alteration caused by cattle grazing and elk and deer browsing, extinction from random naturally occurring events due to a limited distribution, and decreased reproductive vigor because of small population sizes. The 2000 recovery plan did not identify additional threats. The 2008 5-year review confirmed the continued importance of the listing threats and added climate change effects. In this 5-year review we add the threat of thatch accumulation of non-native grass, *Bromus diandrus,*, which prevents successful completion of *Phacelia insularis* var. *insularis* life cycle, and the threat of non-native, *Malva psuedolavatera,* which has been identified as a likely threat to the native vegetation at Carrington Point on Santa Rosa Island (McEachern 2019 pp. 1-2). These identified threats are evaluated below.

Soil damage:
With the complete removal of non-native ungulates from Santa Rosa and San Miguel Islands, there has been passive vegetation recovery similar to that of neighboring Santa Cruz Island

(Beltrane *et al.* 2014 entire), and there is little current indication of ongoing soil erosion in areas where *Phacelia insularis* var. *insularis* occurs. This threat has largely been minimized.

Competition with non-native grasses:
The study by Levine *et al*. 2010 (pp. 134-139) confirmed that *Phacelia insularis* var. *insularis* responds negatively to the competitive effects of the non-native grass *Bromus diandrus*. *Bromus diandrus* is the most common component of the vegetation at the Santa Rosa Island Carrington Point occurrence (Handley et al. 2013 p. 212), and the most common competitor of *Phacelia insularis* var. *insularis*. The relationship between the two species on San Miguel Island is unknown, but is likely similar. The threat of competition with non-native grasses remains.

Habitat alteration caused by cattle grazing and elk and deer browsing:
While direct impacts of non-native ungulate herbivores are gone, it is likely that the high abundance of *Bromus diandrus,* an important competitor of *Phacelia insularis* var. *insularis* at Carrington Point, is an effect of long-term herbivory by non-native ungulates. The vegetation at the *Phacelia insularis* var. *insularis* occurrences on San Miguel Island is undescribed. This residual habitat alteration remains a threat.

Extinction from random naturally occurring events due to limited distribution:
At time of listing there were five known occurrences of *Phacelia insularis* var. *insularis* on San Miguel Island and one on Santa Rosa Island; this is unchanged. Little is known about the general abundance of the species. The threat of extinction from random naturally occurring events due to limited distribution remains.

Decreased reproductive vigor because of small population sizes:
Both above-ground and seedbank population sizes are generally unknown for *Phacelia insularis* var. *insularis*. As shown by demographic monitoring at Carrington Point (Table 3), above-ground abundance in plots can vary widely between years, with some years having extremely low numbers of plants. Experimental field germination rates at Carrington Point have been low, below 5% (Levine *et al*. 2011 p. 2243), and the natural number of seeds in the soil seed bank there is unknown. For annual plants in variable environments, seeds in the soil can have variable and often small germination fractions, but can remain viable in the soil for years (Pake and Venable 1996 pp. 1431-1434). Given that actual population sizes of *Phacelia insularis* var. *insularis* are unknown, and may be small, the threat of decreased reproductive vigor because of small population sizes likely remains.

Climate change:
In the 2008 5-year review, climate change was introduced as a threat to *Phacelia insularis* var. *insularis.* Changes in climate could threaten *Phacelia insularis* var. *insularis* in two ways. First, as habitat shifts with climate change, *Phacelia insularis* var. *insularis* might not be able to disperse to suitable habitat (Levine *et al.* 2008 p. 796). Second, the proper combination of rainfall and temperature (and/or other environmental cues) could occur less frequently or not at all, decreasing germination success of *Phacelia insularis* var. *insularis* and causing declines in abundance and possible extirpations (Levine *et al.* 2008 pp. 800-805; Levine *et al.* 2011 pp. 2241-2246). Expected climate change for the geographic region of the islands predicts both

rising annual temperatures (Langridge 2018 pp. 13-15) and more episodic rainfall (Langridge 2018 pp. 16-17).

Another prediction with increasing annual temperature in California is an increasing dominance of grasslands by non-native annual grasses (Sandel and Dangremond 2012 entire). If *Bromus diandrus* cover increases further, both competitive effects of the grass species and suppressing effects of its thatch (see below) are likely to even further negatively impact *Phacelia insularis* var. *insularis.*

Thatch:
Since the last 5-year review, the accumulation of thatch (dead plants from previous years) from the non-native grass *Bromus diandrus* has been recognized as a threat to *Phacelia insularis* var. *insularis*. This thatch accumulation is likely a threat to *Phacelia insularis* var. *insularis* because it can physically suppress successful seedling establishment of *Phacelia insularis* var. *insularis* (Kathryn McEachern pers. comm.). *Bromus diandrus* is the primary cover at Carrington Point on Santa Rosa Island (Handley *et al.* 2013 p. 212), and thatch accumulation can be deeper than 20 centimeters (K. Niessen pers. obs.). *Phacelia insularis* var. *insularis* primarily is found in the relatively few unvegetated gaps within the dense *B. diandrus* grassland (Levine *et al.* 2010 p. 132). Molinari and D'Antonio (2020 entire) have shown that accumulation of thatch of *B. diandrus* can physically suppress native forbs to almost complete exclusion.

Non-native* Malva psuedolavatera *at Carrington Point:
The increasing density of the non-native herb *Malva psuedolavatera* (previously *Lavatera cretica*) at Carrington Point on Santa Rosa Island has been recognized as a possible threat to the native vegetation in which *Phacelia insularis* var. *insularis* occurs (McEachern 2019 pp. 1-2). There has been little recent effort to reduce *Malva* numbers.

Summary of threats:
At the time of the 1997 listing, the threats to *Phacelia insularis* var. *insularis* were identified as soil damage, competition with non-native annual grasses, habitat alteration caused by cattle grazing and elk and deer browsing, extinction from random naturally occurring events due to a limited distribution, and decreased reproductive vigor because of small population sizes. The 2000 recovery plan does not identify additional threats. The 2008 5-year review evaluated the continued importance of threats at time of listing and added climate change effects. In this 5-year review, we add the threat of the non-native grass *Bromus diandrus* thatch accumulation preventing successful completion of *Phacelia insularis* var. *insularis* life cycle, and the threat of the increasing population of the non-native *Malva psuedolavatera*. The current importance of these threats are summarized below.

The threat of soil erosion to *Phacelia insularis* var. *insularis* from past activity of non-native ungulate herbivores has been largely eliminated. Habitat alteration from these herbivores remains, which has resulted in an increased cover of the non-native grass *Bromus diandrus*, detrimental both through competition and thatch accumulation. Because *Phacelia insularis* var. *insularis* is limited in distribution and little is known about abundance of the species across its range, the threat of extinction from random natural events remains. At long term monitoring plots, *Phacelia insularis* var. *insularis* shows wide variation in abundance between years, with

generally small numbers of reproductive plants and an unknown number of seeds in the soil seed bank, so the magnitude of the threat of decreased reproductive vigor because of small population sizes is unknown. Climate change remains a threat for *Phacelia insularis* var. *insularis* because of habitat alteration, possible changes in climatic germination cues, and increase in annual grasses which both compete with the *Phacelia insularis* var. *insularis* and deposit thatch that prevent successful completion of the life cycle of the species. The threat of a relatively new increasing non-native herb, *Malva psuedolavatera*, also has been identified.

EVALUATION OF DOWNLISTING AND DELISTING CRITERIA:

The current status of criteria in the 2000 Recovery Plan (Service 2000, pp. 67-68) is as follows:

Downlisting criteria for *Phacelia insularis* var. *insularis*

1. *Discover or establish 10 populations per island (San Miguel and Santa Rosa)*
    - No new populations of *Phacelia insularis* var. *insularis* have been found or established on either island. This criterion has not been met.
2. *Maintain stable populations for a period of 15 years that includes the normal precipitation cycle.*
    - The population on Santa Rosa Island changes dramatically in abundance from year to year, as is often typical of annual plants, where the bulk of individuals are likely in the soil seed bank. It is likely, especially with climate change, that 15 years is not enough to evaluate trends in abundance. Populations have not been monitored on San Miguel Island. This criterion has not been met.
3. *Seed stored in CPC cooperating facilities.*
    - There is seed in CPC (Center for Plant Conservation) cooperating facilities, but it is not comprehensive across the species range or across years. This criterion has not been met.
4. *Seed germination and propagation techniques understood.*
    - Levine *et al.* (2008, 2010, 2011) studied the seed germination of the species in the field. This criterion has been met.
5. *Successful outplanting techniques developed.*
    - Field planting of seeds in an experimental setting has been successful (Levine *et al.* 2008, 2010, 2011). This criterion has been met.
6. *Life history research conducted.*
    - Levine *et al.* (2008, 2010, 2011) focused on life history aspects of the species. This criterion has been met.
7. *Weed management plan developed and implemented.*
    - CINP has no weed management plan. This criterion has not been met.
8. *If declining, determine cause and reverse trend.*
    - Data are not available to evaluate trends in abundance and/or if the species is declining, especially in the seed bank. This criterion has not been met.

Delisting criteria for *Phacelia insularis* var. *insularis*

1. *Discover or establish five additional populations per island.*
    - This criterion has not been met.
2. *No decline after downlisting for 10 years.*

- This criterion is not currently applicable.

3. *All potential habitat surveyed.*
    - Surveys have not been conducted frequently enough to cover all potential habitat in space and time on both islands. This criterion has not been met.

CONCLUSION:

The evaluation of threats affecting the species under the factors in 4(a)(1) of the Act and the analysis of the status of the species in our 2012 5-year review remain accurate reflections of the species current status. After reviewing the best available scientific information, we conclude that *Phacelia insularis* var. *insularis* remains an endangered species.

RECOMMENDATIONS FOR FUTURE ACTIONS:

1. Continue monitoring the Santa Rosa Island occurrence of *Phacelia insularis* var. *insularis* and establish regular surveys on both Santa Rosa and San Miguel Islands.
2. Better define suitable germination and growth microhabitat for *Phacelia insularis* var. *insularis*, especially in relationship to non-native *Bromus diandrus* competition and thatch accumulation, and if needed determine how to manage *Bromus diandrus*.
3. Determine efficient methods to reduce *Bromus diandrus* thatch without harming *Phacelia insularis* var. *insularis* individuals.
4. Control non-native *Malva psuedolavatera* in the Carrington Point area on Santa Rosa Island.
5. Improve the completeness of coverage of *Phacelia insularis* var. *insularis* in conservation seed banks, with more occurrences over more years.

APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approved STEPHEN HENRY Digitally signed by STEPHEN HENRY Date: 2021.06.14 10:51:13 -07'00'

LITERATURE CITED:

Beltran, R.S., N. Kreidler, D.H. Van Vuren, S.A. Morrison, E.S. Zavaleta, K. Newton, B. Tershy, and D.A. Croll. 2014. Passive restoration of vegetation after herbivore eradication on Santa Cruz Island, California. Restoration Ecology 22: 790-797.

[CaPR] California Plant Rescue. 2021. Online seed collection database. Retrieved March 31, 2021, from https://www.caplantrescue.org/collections-database.html#memberssearch

[CNDDB] California Department of Fish and Wildlife. 2019. California Natural Diversity Database (CNDDB) – Government version dated August 6, 2019. Retrieved August 8, 2019 from https://nrm.dfg.ca.gov/cnddb/view/updates.aspx

Handley, T., D. Rodriguez, J. Yee, and A. K. McEachern. 2013. Draft: Exploring long-term trends in vegetation of Santa Barbara and Santa Rosa Islands, Channel Islands National Park. Unpublished technical report, U.S. Geological Survey, WERC, Channel Islands Field Station, Ventura, California. 275 pp.

Langridge, R. 2018. Central Coast Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-006.

Levine, J. M., K. McEachern, and C. Cowan. 2008. Effects of a fluctuating rainfall environment on rare island annual plants. Journal of Ecology 96:795-806.

Levine, J. M., K. McEachern, and C. Cowan. 2010. Do competitors modulate rare plant response to precipitation change? Ecology, 91:130–140.

Levine, J. M., K. McEachern, and C. Cowan. 2011. Seasonal timing of first rainstorms affects rare plant population dynamics. Ecology 92:2236-2247.

McEachern, K. 2018. Santa Rosa Island threatened and endangered plant seed collections for long-term banking at the Santa Barbara Botanic Garden (USFWS Research permit TE-044846-4). 4 pp.

McEachern, K. 2019. Cretan mallow (*Malva psuedolavatera*) control near the island phacelia (*Phacelia insularis* var. *insularis*) population on Santa Rosa Island. Ventura Fish and Wildlife Office project proposal. 4 pp.

McEachern, K. 2020. USGS Threatened and endangered plant recovery research activities in the northern Channel Islands, California, 2020: U.S. Geological Survey WERC Channel Islands Field Station annual report– 2020 Annual Report to the Santa Barbara Botanic Garden, National Park Service and U.S. Fish and Wildlife Service. 29 pp.

McEachern, K. 2021. Counts of Island Phacelia (*Phacelia insularis* v. *insularis*) plants in plots, Santa Rosa Island, California, 2003 – 2021. Data summary for U.S. Fish and Wildlife Service, Ventura Field Office under Threatened and Endangered Species Recovery Research Permit TE_044846-4rev1. 7 pp.

McEachern, K., T. Atwater, P.W. Collins, K. Faulkner, D.V. Richards. 2016. Managed Island Ecosystems. pp 755-778 in H. Mooney and E. Zavaleta (eds.) Ecosystems of California. University of California Press. 984 pp.

McEachern, K, and S. Bednar. 2019. Draft Annual Project Summary: U.S. Geological Survey 2019 rare plant surveys, seed collections, monitoring, planting and data management – Information for the Section 6 Annual Report to Santa Barbara Botanic Garden. 25 pp.

Molinari, N.A., and C.M. D'Antonio. 2020. Where have all the wildflowers gone? The role of exotic grass thatch. Biological Invasions 22:957-968.

Pake, C.E. and D.L. Venable. 1996. Seed banks in desert annuals: implications for persistence and coexistence in variable environments. Ecology 77:1427-1435.

Parrino, B. 2020. *Phacelia insularis* on San Miguel Island 2020. Unpublished report to USGS. 10 pp.

Sandel, B., and E.M. Dangremond. 2012. Climate change and the invasion of California by grasses. Global Change Biology 18: 277-289.

[Service] U.S. Fish and Wildlife Service. 1997. Endangered and Threatened Wildlife and Plants; Final Rule for 13 Plant Taxa from the Northern Channel Islands, California FR 62 40954-40974.

[Service] U.S. Fish and Wildlife Service. 2000. Thirteen plant taxa from the northern Channel Islands recovery plan. Portland, Oregon. 94 pp.

[Service] U.S. Fish and Wildlife Service. 2008. Island phacelia *(Phacelia insularis* var. *insularis*) 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office, Ventura, California. 18 pp.