<u>Chapter 9. *Dalea carthagenensis* (Jacq.) J.F.Macbr. var. *floridana* (Rydb.) Barneby</u>

Jennifer Possley

Introduction

The small shrub *Dalea carthagenensis* var. *floridana* (Florida prairie clover) is a Florida endangered species and a candidate for the USFWS endangered species list. It is endemic to South Florida, and is found only in Miami-Dade and Monroe Counties along the ecotone between hammock and pineland as well as in the coastal strand plant community at CR. *Dalea* can be found only in four protected areas: Big Cypress National Preserve and three small Miami-Dade County preserves: CDE, RHMP and CR. It is also known to be present in two unprotected private properties in the Cutler Bay area of Miami-Dade County.

Update on Miami-Dade pine rockland populations

We have censused *Dalea* at CDE and RHMP once or twice annually since fall 2003. At both locations, population numbers have fluctuated widely. We conduct quick counts of individuals, dividing them into the categories of "woody" or "seedling." In 2009, we conducted an experimental seed augmentation at RHMP, the results of which are discussed below, separately from those for the wild population.

CDE

From 2003 to 2007, the number of woody *Dalea* in CDE's north pineland was between 50 and 80 individuals, with the number of seedlings ranging from 3 to 54. Beginning in 2007, there was a pulse of seedling establishment. The population (woody + seedlings) has not fallen below 300 plants since that time. Given the population's improvement, we are moving to monitoring *Dalea* at CDE every two years. During our most recent monitoring in January 2014 we counted 347 individuals. We will make a full count again by the end of January 2016.

RHMP

From 2004-2008, the *Dalea* population at RHMP diminished from 31 woody individuals to just one woody plant and three seedlings. In summer 2009, the wild population surged to 330 seedlings. From 2011 to the present, the population has hovered around 100 plants, with our most recent monitoring in January 2014 finding 98 individuals. This does not include *Dalea* that resulted from our 2009 seed augmentation at RHMP (see next paragraph). As with the CDE population, we shifted our schedule to monitor *Dalea* at RHMP every two years rather than annually.

Our 2009 *Dalea* seed augmentation at RHMP continues to be a success. Initially, we documented 52 established plants from the 6000 seeds sown. Since that time, those plants have gone on to reproduce, and there are now several generations of *Dalea* within the reintroduction footprint. We conducted a census of these plants in March 2015, documenting 307 individuals. Of these, 295 were seedlings that germinated within three months following a prescribed burn (**Figure 9-1**).

Figure 9-1. Three months after a prescribed burn, there was a pulse of seed germination in the transects where we sowed 6000 *Dalea* seed in 2009.

Next Steps

- Continue monitoring *Dalea* populations in Miami-Dade County preserves (wild and reintroduced populations) at least every two years
- Continue to send seeds from wild plants to the NCGRP for long-term storage.

Population Trends at CR and Factors influencing Pulses of *Dalea* Seed Germination

Joyce Maschinski

Dalea carthagenensis var. *floridana* is under severe threat from fire suppression, invasive exotic species, and human activities that have contributed to an alteration or reduction of its habitat. To understand patterns of population growth especially related to seed biology, we tracked population growth the federal candidate species growing in coastal strand habitat from 2007-2015.

Methods

Demography Study

At Site CR in February 2007 we initiated demographic studies of *D. carthagenensis* var. *floridana* growing in coastal strand. The demographic plot measuring 3m X 10m, stretched randomly through the total population area of 145m^2 and sampled approximately 75% of the population. In 2012 we expanded the demographic monitoring plot to encompass an additional 3 m X 10m area because a portion of the 2007 plot has not supported many plants for several years. In 2014, we estimated the total plants at CR to be 500 plants.

Each year we tagged new individuals, recorded location along the x and y axes of the plot and measured height, perpendicular widths 1 & 2, and counted the number of inflorescences. We categorized plants into one of four growth stages: 1) seeds in the seed bank; 2) seedlings were not woody and had 10 or fewer leaves. Some had cotyledons present. 3) Juveniles were woody plants lacking inflorescences, with > 10 leaves and generally $\geq$ 15 cm tall. 4) Reproductive adults had inflorescences present.

We generated population viability models under scenarios of germination from the seed bank where seeds received germination cues (with) and when seeds did not receive germination cues (without cues). We used CR demographic data for eight transition periods between 2007-2014. This timespan included 2009-2010, when high seedling recruitment occurred and six transition years when low seedling recruitment occurred. For each transition year, we created matrices for two scenarios simulating years with environmental germination cues (WITH CUE) and without environmental germination cues (NO CUE). Vital rates for percent survival and transitions to larger stages for plants in three stages (seedlings, juveniles, and reproductive adults) were fixed for each transition year based upon observations of survival and mortality of plants in the stages. We varied seed bank stasis, seedling emergence from seed bank, and reproductive value to simulate years with and without environmental germination cues. We used field control and freezing pretreatment germination rates as the vital rates for seedling emergence from the soil seed bank (Field Control (no cue) = 4%; Frozen (with cue) = 9%). To estimate the seed bank size we examined the number of viable seed present within 15 inflorescences by visually assessing the proportion of good seeds and testing their germination and viability in the laboratory. We determined that the average proportion of good seeds within an inflorescence was 0.54. We derived values for adult-seedbank cells with and without germination cues from the formula: flowers/adult*average number of good fruits per inflorescence (.54)*average germination or contribution to seedlings with cue (.96) or without cue (.205). Adult-seedling cells = seedling yr $_{n+1}$/ adults yr $_{n}$ * 2. Because we had no measure of seed mortality in the seed bank from herbivory or other causes, we assumed 26% mortality for seeds in the seed bank based upon Chambers (2001). In addition we modeled a range of seed bank mortality from 1%-100% for 2010-2011 to assess how this assumption affected elasticity values and lambda. Using the stochastic simulation program RAMAS GIS (Akcakaya, 2005), we generated models with 1000 simulations over 50 years, and calculated population growth rate, extinction risk, and elasticities for each transition year and scenario.

Results

Population Growth

The population at CR has fluctuated considerably. Since 2007 the number of adult plants has declined steadily. In most years we observed low levels of recruitment, but exceptions occurred in 2010 and 2014 when we observed high seedling recruitment (**Figure 9-2**). Most seedlings recruited in partial shade beneath adult plants.

Because the number of individuals in our plots dropped below 100, in 2014 we extended our plots to the north and captured over 178 more individuals in 2014 (total 288) and 64 individuals in 2015 (total 168).

Aboveground patterns in the last 8 years have shown a boom and bust pattern in two transition years. This pattern is characteristic of short-lived species. Whether there is a cyclic pattern to high germination pulses is yet to be determined, but it has intriguing implications for population stability. As we study these plants for more years we will be able to gather more information to substantiate this idea.

It is important to consider the seed bank also, as our studies have shown that seeds have long-term survival even if exposed to moisture. Incorporating seeds also poses much more optimistic picture than when the seed bank is not considered (**Figure 9-3**).

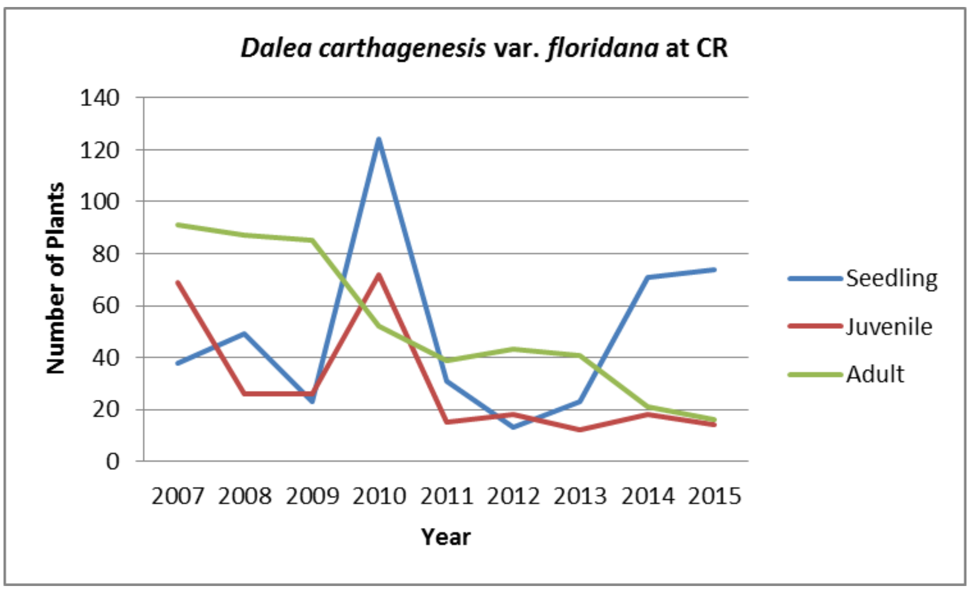

Figure 9-2. Numbers of *Dalea carthagenensis* var *floridana* seedlings, juveniles, and adults alive in demographic plots at CR in 2007 - 2015**.** Extended plots are not included in this figure.

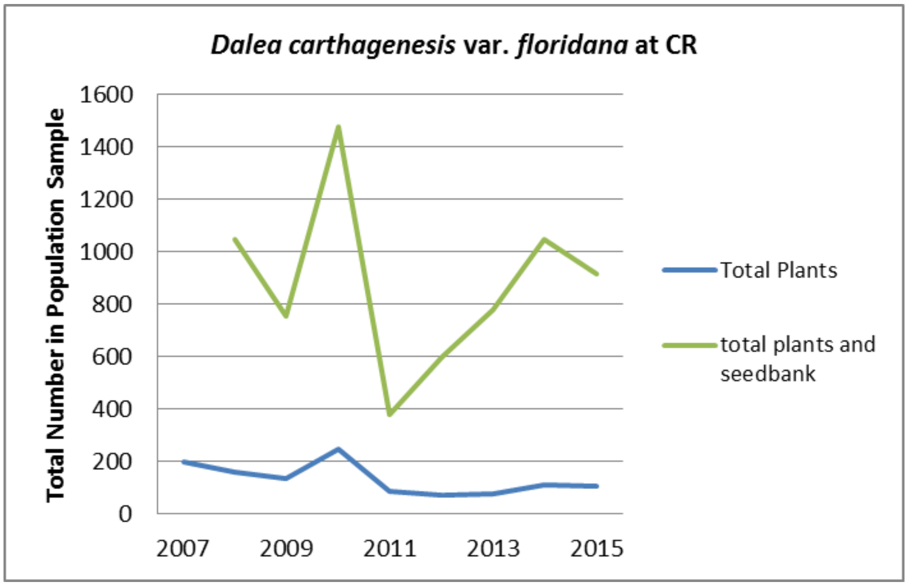

Figure 9-3. Total aboveground plants compared to estimated population of seedbank and total plants at CR 2008 – 2015. Seed banks are important for buffering the population through inhospitable times. Extended plots are not included in this figure so that comparisons are directly applicable.

PVA Models

Using data gathered from laboratory seed studies and the field seed introduction at RHMP (Maschinski et al. 2014), we have enough information to include a seed bank into our models. We found that pulses of high seedling emergence from the seed bank is an important buffer for the population. Because seeds are out of site, it is easy to forget their contribution to total population, but it is substantial (**Figure x-3**). At CR, years with high seedling recruitment coincided with years of high flower production. Note that at the time of our observations, seedlings are emerging from the seed bank, because seeds in inflorescences are immature at this time. Apparently conditions that favor flower production also favor seedling recruitment.

It is not surprising that high recruitment events increased population numbers in the year of the event, but mortality of seedlings afterwards determined the overall impact on the population. Our population viability models indicated that the external cues required to break dormancy positively influenced *D. carthagenensis* var. *floridana* population dynamics, but if coupled with seedling mortality, serious population decline resulted (**Table 9-1**). This was the case in 2010-2011, when high seedling mortality at CR occurred. Since 2013 there has been good population growth and we are hopeful that this trend will help to stabilize the population. Between 2014 and 2015 we had high seedling mortality, but we also had good new seedling establishment.

Next Steps:

We will continue our demographic monitoring of *Dalea* and have plans for publishing this research in peer-reviewed literature.

Table 9-1. Transition matrices, population growth (lambda or λ) and estimated extinction risk (ER) for all transition years from 2007-2015 for *Dalea carthagenesis* var. *floridana* growing at CR. Scenarios for conditions when seeds receive a germination cue (WITH CUE) vs. when seeds do not receive a germination cue (NO CUE) are indicated.

WITH CUE	***2007-2008***			λ = 1.13	**NO CUE**	***2007-2008***		λ = 0.97
				ER= 0			ER = .002	42 yrs
	Seedbank	**Seedling**	**Juvenile**	**Adult**	**Seedbank**	**Seedling**	**Juvenile**	**Adult**
Seedbank	0.65	0	0	9.76	0.7	0	0	2.09
Seedling	0.09	0.18	0	1.08	0.04	0.18	0	1.08
Juvenile	0	0.24	0.17	0.07	0	0.24	0.17	0.07
Adult	0	0.05	0.46	0.59*	0	0.05	0.46	0.59*

WITH CUE	***2008-2009***			λ= 1.19	**NO CUE**	***2008-2009***		λ = 1.01
				ER = 0				ER = 0
	Seedbank	**Seedling**	**Juvenile**	**Adult**	**Seedbank**	**Seedling**	**Juvenile**	**Adult**
Seedbank	0.65	0	0	7.03	0.7	0	0	1.502
Seedling	0.09	0	0	0.53	0.04	0	0	0.53
Juvenile	0	0.32	0.19	0.13	0	0.32	0.19	0.13
Adult	0	0.1	0.63	0.67	0	0.1	0.63	0.67*

WITH CUE	***2009-2010***			λ = 1.15	**NO CUE**	***2009-2010***		λ = .977
				ER= 0			ER= 0.002	48 yrs
	Seedbank	**Seedling**	**Juvenile**	**Adult**	**Seedbank**	**Seedling**	**Juvenile**	**Adult**
Seedbank	0.65	0	0	22.66	0.7	0	0	4.84
Seedling	0.09	0	0	2.92	0.04	0	0	2.92
Juvenile	0	0.25	0.23	0.14	0	0.25	0.23	0.14
Adult	0	0.04	0.19	0.56	0	0	0.19	0.56

WITH CUE	***2010-2011***			λ = 0.78	**NO CUE**	***2010-2011***		λ = 0.75
				ER= 1.00	25 yrs		ER= 1.00	23 yrs
	Seedbank	**Seedling**	**Juvenile**	**Adult**	**Seedbank**	**Seedling**	**Juvenile**	**Adult**
Seedbank	0.65	0	0	7.2	0.7	0	0	1.54
Seedling	0.09	0.15	0	1.19	0.04	0.15	0	1.19
Juvenile	0	0.01	0.38	0.17	0	0.01	0.38	0.17
Adult	0	0	0.25	0.61	0	0	0.25	0.61

WITH	***2011-2012***			λ = 1.05	**NO CUE**	***2011-2012***		λ = 0.91

CUE

				ER= 0			ER= 0.90	50 yrs
	Seedbank	**Seedling**	**Juvenile**	**Adult**	**Seedbank**	**Seedling**	**Juvenile**	**Adult**
Seedbank	0.65	0	0	11.66	0.7	0	0	2.48
Seedling	0.09	0.04	0	0.67	0.04	0.04	0	0.67
Juvenile	0	0.21	0.45	0.03	0	0.21	0.45	0.03
Adult	0	0	0.3	0.7	0	0	0.3	0.7

WITH CUE	***2012-2013***			λ = 1.02	**NO CUE**	***2012-2013***		λ = 0.89
				ER= 0			ER= 0.85	39 yrs
	Seedbank	**Seedling**	**Juvenile**	**Adult**	**Seedbank**	**Seedling**	**Juvenile**	**Adult**
Seedbank	0.65	0	0	16.4	0.7	0	0	3.505
Seedling	0.09	0.5	0	1.07	0.04	0.5	0	1.07
Juvenile	0	0.14	0.16	0	0	0.14	0.16	0
Adult	0	0	0.21	0.7	0	0	0.21	0.7

WITH CUE	***2013-2014***			λ = 1.68	**NO CUE**	***2013-2014***		λ = 1.44
				ER= 0				ER= 0
	Seedbank	**Seedling**	**Juvenile**	**Adult**	**Seedbank**	**Seedling**	**Juvenile**	**Adult**
Seedbank	0.65	0	0	42.88	0.7	0	0	9.16
Seedling	0.09	0.00	0	3.46	0.04	0.00	0	3.46
Juvenile	0	0.48	0.4	0.08	0	0.48	0.4	0.08
Adult	0	0.08	0.4	0.68*	0	0.08	0.4	0.68*

WITH CUE	***2014-2015***			λ = 1.12	**NO CUE**	***2014-2015***		λ = 0.99
				ER= 0				ER= 0.004
	Seedbank	**Seedling**	**Juvenile**	**Adult**	**Seedbank**	**Seedling**	**Juvenile**	**Adult**
Seedbank	0.65	0	0	48.79	0.7	0	0	10.42
Seedling	0.09	0.13	0	7.04	0.04	0.13	0	7.04
Juvenile	0	0.13	0.27	0	0	0.13	0.27	0
Adult	0	0.00	0.18	0.67*	0	0.00	0.18	0.67*

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Conservation Action Plan
Dalea carthagenensis var. *floridana*

Species Name: ***Dalea carthagenensis*** (Jacq.)J.F.Macbr. var. ***floridana*** (Rydb.) Barneby
Common Name(s): Florida prairieclover
Synonym(s): Parosela floridana *Rydberg*
Family: Fabaceae
Species/taxon description: a shrub to 6 feet tall with a light brown woody stem and non-woody, light brown or reddish branches. **Leaves** have 11-23 oval, gland-tipped leaflets and are gland-dotted on underside. **Flowers are** in small loose heads at ends of hairy, glandular stalks. **Flower** is less than 0.4 inches long; whitish turning maroon; wing, keel, and banner petals are different lengths and shapes; stamens 9 or 10. **Fruit** a tiny, 1 seeded pod, mostly enclosed by the hairy, gland-dotted calyx (description modified from Chafin, 2000).
Legal Status: Federal candidate, Florida endangered
Biogeographic Value: Native, endemic to South Florida

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Dalea carthagenensis var. *floridana* flowers.

Background and Current Status

Range-wide distribution – past and present

Florida
(Historic) Collier, Miami-Dade, and Palm Beach Counties and the Monroe County mainland (IRC, 2002).

(Current) Found in four conservation areas in Collier, Miami-Dade and Monroe Counties: BCY; CDE, RHMP, and CR. Three populations of *Dalea carthagenensis* var. *floridana* occur on unprotected land in Miami-Dade County (Maschinski, 2014). A third population, also on private land, was present in the same vicinity but we have been unable to confirm the current status.

Population and reproductive biology/life history

Annual/Perennial: Perennial
Habit: Shrub
Short/Long-Lived: Short (typically <7 years)
Pollinators: Unknown
Flowering Period: October through March
Fruiting: November through April
Annual variability in flowering: Unknown
Growth Period: Rainy season (plants often die back in the dry season, November-March)
Dispersal: Gravity and wind may disperse seeds short distances.
Seed Maturation Period: Jan through May with peak in Feb-March
Seed Production: Varies with plant size. Large individuals may produce 500 plus seeds.
Seed Viability: High, 98% when the seed coat is scarified (Fairchild internal data, Norcini and Frances 2006).
Regularity of Establishment: Pulses of seed germination have been documented following cool and cold winters. Seeds can persist in the seed bank. High emergence follows germination cues or may rely on a 2-3 year period to wear down seed coat for germination. Most sites we've monitored have periodic germination with at least 2 year intervals.
Germination Requirements: Seed coat scarification, cold stratification, freezing or fire
Establishment Requirements: Most seedlings establish beneath conspecifics that probably provide some shelter from cold and desiccation.
Population Size: As of 2014, we observed approximately 500 adult plants and with an additional 600 juvenile and seedling plants.
Annual Variation: Populations cycle in a typical short-lived perennial profile. We have observed pulses of high recruitment every 3 or more years in the 3 largest wild populations.
Number and Distribution of Populations: 7 populations in 4 protected areas and two unprotected areas in Collier, Miami-Dade and Monroe counties.

Habitat description and ecology

Type: Pine rockland, pine flatwoods, pineland/hammock ecotone, coastal strand and disturbed sites.

Physical Features:
- **Soil:** Limestone covered by little or no organic matter.
- **Elevation:** The Miami rock ridge ranges from 7-4 m above sea level (Snyder et al., 1990).
- **Aspect:** Unknown
- **Slope:** All populations grow on level substrate
- **Moisture:** Low
- **Light:** Fairchild's seed reintroduction at RHMP showed no significant relationship between seedling establishment and light conditions. However, field observations show that young seedlings do best in shade from adjacent grasses and low vegetation, but adults perform best and flower most in full sun.

Biotic Features:

Community: Associated species in the pine rocklands of Miami-Dade County include *Pinus elliottii* var*. densa, Serenoa repens, Sabal palmetto,* and a variety of native grasses, herbs and shrubs. Many of these same common pine rockland species also occur in the pine flatwoods and coastal strand communities where the plant is also found.

Interactions:

Competition: *Dalea carthagenensis* var. *floridana* is a poor competitor with larger native hardwoods and more fast-growing non-native weedy species.
Mutualism: Unknown
Parasitism: Frequently parasitized by love vine (*Cassytha filiformis*) and lobate lac scale at RHMP and CDE.
Host: Not applicable
Mycorrhizae associations: Unknown
Other: Not applicable

Animal use: Unknown

Natural Disturbance:

Fire: *Dalea* has evolved in a fire dependent system and likely depends on fire for long term population stability.
Hurricane: Hurricanes could both help and harm this species. The CR population would be vulnerable to hurricane debris and storm surge. More inland populations might benefit from hurricanes by increased light, which would promote growth and flowering of adults and stimulate germination of seeds in the soil seed bank.
Slope Movement: Not applicable
Small Scale (i.e. Animal Digging): Small scale disturbance may trigger seed germination.
Temperature: Unknown

Protection and management

Summary: There are 9 known sites for this taxon. In 2014 Fairchild visited 7 of them. Three are in a federally owned conservation site, three are in Miami-Dade county natural areas and three of the sites are privately owned and are at high risk of extirpation.
Availability of source for outplanting: We have 24 plants available for outplanting.
Availability of habitat for outplanting: County lands with appropriate habitat exist south of Coconut Grove extending towards Everglades National Park. Areas where fire is able to be implemented on a regular basis would be ideal. Potential sites for reintroductions include parcels in the Richmond Tract, Nixon Smiley and Navy Wells.

Threats/limiting factors

Natural:

Herbivory: Fairchild staff have observed occasional apparent herbivory at RHMP whereby an unknown animal scrapes sections of bark away from the main stem. In cases where the stem is completely girdled, the plant will die.
Disease: Unknown
Predators: See “herbivory” above
Succession: The succession of hardwoods that comes with fire suppression means decreased light and increased leaf litter, which have negative effects on adult growth and flowering and on seed germination.
Weed invasion: Weed invasion is not currently a serious threat in the managed populations. In the unmanaged populations, large quantities of *Schinus terebinthifolius* along with a host of other invasive exotics threaten populations through shading and competition. Additionally, exotic pest plant removal and off target damage from treatment with herbicides might threaten the populations if crew members are unaware of the plants presence.
Fire: An intense fire would kill seedlings and most/all adult plants but it would likely stimulate

seed germination and would promote ideal habitat for new seedlings.
Genetic: Unknown

Anthropogenic

On site: In the protected sites, trampling can break plants, though they usually survive. Mowing of plants along the firebreak frequently occurs at CDE, despite flags put in place to alert landscaping staff to the plants present. Mowing will not necessarily kill *Dalea* but we have observed it to kill a large flowering plant at CDE. At privately owned sites, dumping, homeless activity and human activity are serious threats. At one site, the plants seem to be routinely mowed.
Off site: Habitat loss and fragmentation have heavily impacted this endemic taxon in South Florida.

Collaborators

National Park Service
U.S. Fish and Wildlife Service
Miami-Dade County
The Institute for Regional Conservation
USDA National Center for Genetic Resources Preservation (NCGRP)

Conservation measures and actions required

Research history: *Dalea carthagenensis* var. *floridana* was one of four species studied by Anne Frances for her doctoral research at University of Florida. She focused on germination cues and dormancy breaking mechanisms. Fairchild Tropical Botanic Garden has also conducted germination trials including ones geared toward suitability for long-term storage, for which this taxon is an excellent candidate. In 2009, Fairchild staff initiated an experimental seed introduction of *D. carthagenensis* var. *floridana* at RHMP, whereby they sowed 6000 seeds and measured germination and growth that resulted from different seed pre-treatments, habitats, light levels, and associated vegetation. The germination resulting more than doubled the population of *Dalea* in the preserve and showed that a seed freezing pre-treatment resulted in higher germination than untreated seed. Additionally, they showed a much higher germination in fire-suppressed pine rockland compared to a recently disturbed restoration site (Maschinski et al., *in prep*).

Significance/Potential for anthropogenic use: Although we have not seen recorded uses for this species, related species in the genus *Dalea* have been used for a wide variety of purposes including ritualistic use in ceremonies and medicinal applications.

Recovery objectives and criteria: Recovery objectives include establishing a permanent stable, secure and self-sustaining population. Reintroductions in conservation areas throughout the historic range need to be planned and implemented. Germplasm needs to be collected from populations occurring on privately owned land. Current populations need to be protected from vandalism, dumping, exotic pest plants and other potential sources of mortality. Populations would thrive with periodic fire.

Management options

- <u>Raking</u> – In early 2009, after a population crash at RHMP, Miami-Dade County's Natural Areas Management staff raked away heavy pine straw from the last known location of *Dalea* and saw a massive seed germination and seedling establishment event within their raked plot (Possley et al. 2010). Raking appears to be a low-cost, easy option to stimulate *Dalea* germination in fire-suppressed areas.
- <u>Prescribed fire</u> – Very few of the Miami-Dade County *Dalea* have experienced prescribed fire since the 2003 onset of our monitoring program. A 2008 fire at CDE burned a few plants but most resprouted after the fire, and many seedlings germinated soon after. *Dalea* is endemic to a fire-dependent plant community and it is apparent that fire suppression is harmful; increased prescribed fire is highly recommended for an improved outlook.

An adult *Dalea carthagenensis* var. *floridana* resprouts in February 2010, three months after a prescribed fire at CDE
(Photo: J. Possley)

- **Hardwood thinning** – Most of the remaining *Dalea* populations persist in fire-suppressed pine rockland. For areas that are unlikely to burn, hardwood thinning would provide the increased light needed for growth of adults and germination of seeds. Subsequent to hardwood thinning in 2008, the number of *Dalea* seedlings at CDE went from 198 to 453, the highest number Fairchild has recorded since we began monitoring that population in 2003 (Possley et al. 2010).
- **Augmentations** – The seed augmentation that Fairchild conducted at RHMP in 2009 more than doubled the population at that preserve. Given the success of that project, we highly recommend seed augmentation for this taxon in cases where a *Dalea* population has been reduced but the habitat is being appropriately managed.
- **Reintroductions** – Introductions by seed or whole plants to extirpated sites or to appropriate habitat within the taxon's range would serve to reduce extinction. Appropriate sites in Miami-Dade County might include BB and LUD.
- **Translocations** – Relocating some plants that are currently on privately held lands might be appropriate given the degraded state of these areas and the lack of protection. This would need to be planned well in advance to have the translocation occur with all legal issues covered and with a minimal amount of stress to the plants.

Next Steps: Continue monitoring all populations on at least a bi-annual basis. Support USFWS in gathering information for proposed listing under the Endangered Species Act. Meet with private landowners for permission to collect seed and or plants for relocation. Educate landowners about the presence of plant populations that might be impacted during exotic removal. Attempt more reintroductions into secure areas with appropriate habitat.

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