TEN YEARS AFTER:

ASSESSMENT OF EXPERIMENTAL OUTPLANTINGS OF THE ENDANGERED VENTURA MARSH MILKVETCH (*ASTRAGALUS PYCNOSTACHYUS* VAR. *LANOSISSIMUS*)

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I. PROJECT OVERVIEW

This report summarizes observations from 2003 through 2012 of experimental introductions of the *Astragalus pycnostachyus* var. *lanosisimmus*- the Ventura marsh milkvetch (VMMV, or milkvetch), a variety listed as endangered under the California Endangered Species Act and federal Endangered Species Act. The only known "wild" occurrence, discovered in 1997 near Oxnard, California, occupies fill capping oil wastes on degraded back dunes. The habitat area is entirely anthropogenically-modified, and atypical of natural habitats on the near-coast (Meyer, 2007).

Our overall approach was to introduce nursery-grown juvenile milkvetch into different habitats and microsites, in order to observe their survivorship, growth, flowering and reproduction with the aim of better understanding habitat preferences and tolerances for this rare species. Historic habitat for VMMV is poorly understood, as very little information was recorded from historic collection sites (USFWS, 2001; Jensen, 2007; Wilken and Wardlaw, 2001).

Nursery-propagated milkvetch were originally installed at a series of introduction sites on the immediate coast of Ventura and southern Santa Barbara Counties in 2002, with additional installations occurring in 2003 and 2004.

Our initial assessment of experimental outplantings for the period from 2003 through 2006 is reported in Meyer, 2007. At the time the report was prepared, the introduction sites had been observed for 4-5 years, founder milkvetch had established well at several key areas, considerable natural recruitment from seed produced by founders had occurred, and milkvetch had successfully dispersed after temporary flooding and established in new areas. Sites where the initial introductions failed early on, yielded valuable information about the environmental tolerances of milkvetch.

Observations over the first four growing seasons suggested the primary factors affecting survivorship, reproductive output and recruitment at various introduction sites included: depth to a perched or near-surface water table, variation in rainfall resulting in episodes of drought or extreme flooding, soil salinity, competition with associated plant species, and herbivory by small mammals like rabbits, non-native snails, isopods and others (Meyer, 2007). Observations since 2007 suggests these factors remain important.

This current report emphasizes results from 2007 through 2012, and summarizes the outcome across a timeframe of eight to ten years since founders were initially installed. A total of 268 founder milkvetch planted in 2002, 2003 and 2004, established in their first year at nine key introduction sites. From these introductions, the total population of naturally recruited flowering milkvetch combined for all sites peaked in 2006 with 463 flowering adults documented in the August-September monitoring sessions (Figure 4). The bulk of these plants were at McGrath State Beach (MSB) Plot 3E, Carpinteria Salt Marsh Reserve (CSMR) Plot 5, and the Coal Oil Point Reserve (COPR) Lagoon Plot. . The peak number of naturally recruited non-flowering plants was reached in 2008 when 1316 milkvetch were observed during the summer monitoring session, most of which were growing at CSMR 5 (Figure 4).

In the last few years, the abundance and extent of milkvetch at the favorable introduction sites has plummeted. Major shifts in the vegetative composition of the herb and shrub layer at many key sites has been observed, particularly since 2009. Low competition

growing sites have become scarce in many of the locations that previously supported open conditions favored for milkvetch establishment and persistence. Expansion of high salt marsh plants at the CSMR planting area suggests soil salinity may be increasing there. Herbivory attributed to small mammals has worsened in the last several years, further contributing to declines at most sites.

This report will explore potential causes for observed vegetation shifts and associated milkvetch decline in subsequent sections.

Previous Investigations

Ventura marsh milkvetch was thought to be extinct and was last collected in 1967 in Ventura, California near a roadside ditch across from McGrath State Beach, where one individual was observed, collected and identified by the County Agricultural Commissioner. VMMV was not seen again until 1997, when a population was discovered near Oxnard, California.

Since its rediscovery in 1997, a series of efforts were undertaken to increase our knowledge of the VMMV's horticultural, life history, and habitat requirements. These are summarized briefly below:

Phase I. 1996-2001. Seed was collected from the wild population and stored for long term conservation at Rancho Santa Ana (RSABG) and Santa Barbara Botanic Gardens (SBBG). Seeds were stored by maternal line, which means that unique identifying numbers were assigned to adult plants and seeds are stored separately representing each line. RSABG established seed germination protocols and has successfully propagated milkvetch in controlled environments. This effort is described in Soza, et al. (2003).

Phase II. 2000-2001. Dr. Dieter Wilken and Trisha Wardlaw from the SBBG undertook a life history and ecological habitat assessment for the population at the wild site, evaluated the habitat of the closest relative, the northern brine milkvetch (*Astragalus pycnostachyus* var. *pycnostachyus*), examined potentially suitable introduction sites in coastal Ventura and Santa Barbara Counties, and made general recommendations for experimental introductions. This effort is summarized in Wilken and Wardlaw (2001).

Phase III. 2001-2003. Three hundred twenty two milkvetch were propagated from known maternal lines (14 maternal lines) and installed by RSABG in April 2002 at McGrath State Beach (MSB) in Ventura County and Carpinteria Salt Marsh Reserve (CSMR) in Santa Barbara County. The principal investigators were Valerie Soza, Michael Wall and Dylan Hannon. Enclaves of around 30 plants were installed in five differing microsites at each location. Survivorship, reproduction and mortality were examined at the various sites, and the results through February 2003 are summarized in Soza, et al. (2003).

Phase IV. 2003-2007. The CDFG took over direct management and monitoring of the original 2002 outplants in March 2003. We contracted with RSABG to propagate an additional 150 milkvetch from known maternal lines. These were installed in spring 2004 in the vicinity of a successful plot at CSMR 5 and in eight other planting plots at four additional sites including Ormond Beach near Point Mugu Naval Air Station south of the Oxnard; Mandalay State Beach (Mandalay), very close to the wild site; and the Coal Oil

Point Reserve (COPR) near Devereux Slough adjoining the campus at UC Santa Barbara in Goleta. This effort is summarized in Meyer (2007).

The Meyer 2007 report provides background on the current project and should be reviewed in its entirety. It summarizes milkvetch propagation methods, outplanting methods, introduction site descriptions, plot management and monitoring methods and results, for the 2002 through 2006 time period.

Additional information regarding historic collections of VMMV, biological background and field evaluations of existing and potential introduction sites in southern Santa Barbara, Ventura, Los Angeles and Orange counties, was undertaken in 2006 by the California Native Plant Society (Jensen, 2007).

Current Project

Phase V. 2007- 2012. This current report is intended to provide updated information on the status of the 2002, 2003 and 2004 introductions. It builds on the background and supporting documentation contained in the Meyer, 2007 report.

No additional founder milkvetch have been installed under the current project. Thirty additional milkvetch were propagated in summer 2012 at the RSABG and will be ready for installation in February 2013. These plants will potentially be installed at the COPR Pond area.

II. CURRENT POPULATION STATUS

Table 1 summarizes the current status of naturally recruited flowering and non-flowering milkvetch at key introduction sites that still support milkvetch in 2012, eight to ten years following their initial introduction to these sites.

Locations Supporting Milkvetch in 2012	Number Flowering	Number Non-Flowering
Mandalay 1B	1	1
MSB 3E	5	
CSMR-5	1	
COPR Pond A	1	
COPR Pond D	1	
COPR Pond feral	1	25

Table 1. The number of flowering and non-flowering milkvetch documented during the August summer monitoring in 2012 at key introduction sites.

Locations Not Supporting Milkvetch	Year Last Seen
MAND 1	2010
MAND 1A	2010
MSB 3	2005
MSB 4	2005
MSB 4E	2010
MSB 5	2010
COPR Lagoon	2010

Table 2. Key milkvetch introduction plots which had no milkvetch growing in 2012 and the year when plants were last seen.

Six introduction sites still supported plants in 2012 (Table 1). Natural recruitment in 2012 was very low, and non-flowering plants observed in late summer were all recruited in 2011. The original 2002, 2003 and 2004-introduced founders are no longer present at any sites as the longevity of milkvetch ranges from 3-4 (6) years.

Table 2 shows the key introduction sites which did not support milkvetch in 2012 and indicates the last year milkvetch grew in the area. Mandalay 1 likely supports seed bank and could potentially produce new milkvetch should we get above average rainfall. The remaining sites not supporting milkvetch in 2012 no longer contain low competition growing sites and have experienced substantial expansion of the herb and shrub layers and related vegetation shifts. These sites also support remnant seed bank which could emerge in the future or disperse to adjacent suitable areas nearby.

III. SUMMARY OF THE BIOLOGY OF VENTURA MARSH MILKVETCH

The Ventura marsh milkvetch is a short-lived perennial herb in the Fabaceae (Pea Family). It produces stout leafy annual growth shoots each year, in winter, from a near-surface root crown. The mean stem height of introduced milkvetch at favorable sites, and in their second year, ranged from 106 to 146 cm (42-58 inches), which is considerably taller than described by Barnaby (1964). Barnaby's description of the variety was based upon old herbarium specimens, and he never viewed entire living plants. The variety *lanosissimus* has densely woolly herbage and leaflets are a muted sage green color. The compound leaves support 27-39 ovate leaflets (Barnaby, 1964). The stout stems are a deep maroon color where sun shines on the stems.

VMMV flowers in summer and produces abundant axillary inflorescences. Flowers have pale butter-yellow petals. The typical mean number of flowers per inflorescence on

plants sampled in 2003 ranged from 31-40 (Meyer, 2007). The fruits are small, deflexed and slightly inflated with an incurved persistent style (appearing like a curved beak on the tip of the pods). Fruits typically produce six or fewer seeds per pod. The fruits are described as tardily dehiscent (Barnaby, 1964) and it is common for some pods and relatively intact infructescences to be retained on the annual growth stems into the next growing season, potentially serving as an aerial seed bank (Meyer, 2007).

Wilken and Wardlaw (2001) examined seed set in bagged and unbagged inflorescences at the wild population and determined they are self-compatible and perhaps partly autogamous. Open-pollinated flowers produced more seeds per fruit than bagged flowers. Flowers are typically visited by native bumblebees, primarily *Bombus vosnenenskii* and carpenter bees (Meyer, 2007). Seeds are sometimes damaged by bruchid beetle larvae and ripening pods can be damaged by various caterpillars, who consume ripening ovules. Theoretical seed production estimated on plants observed in 2003, based upon mean values from monitoring data, suggested that 1-4 million seeds could have been produced at the MSB and CSMR-5 sites (Meyer, 2007).

Some portion of the VMMV seed bank appears to come up readily without noticeable disturbance triggers. Two morphological types of seeds are produced and those with dark, rough looking seed coats germinate more readily than the more abundant smooth olive green/brown seeds (Smith and Sandoval, 2001). The proportion of seed with a rough black seed coat ranged from 3-14% on samples examined in 2003 (Meyer, 2007). *Astragalus* is known to produce some seed with prolonged dormancy of over 40 years (Ikeda and Meyer, 2000). The resurrection of Ventura marsh milkvetch at the wild site provides indirect proof of a dormant seed bank, since no vegetation was present in the area where milkvetch now grow at the time the oil waste dump site was closed in 1982 (Meyer, 2007).

Seeds produced by milkvetch are relatively large and tend to fall close to parent plants. Pods still containing some seeds and intact infructescences are common on the ground beneath milkvetch stems. The appearance of new milkvetch seedlings on previously flooded ground several meters away from the original introduction areas at MSB 3 and 4 suggested the potential for flood dispersal of seeds (Meyer, 2007). This may be facilitated by retention of some seeds in pods, which actually look like little canoes, and probably float. Many seedlings were observed emerging from the line of detritus on the outer edge of the flood margin at MSB 3 and 4 in 2005. Pods sometimes retain dry woolly calyx tissue and this feature, combined with the curved beak, make them stick to hair and clothes, suggesting they could also disperse on animal fur.

Some first year naturally recruited plants achieved sufficient size to flower in their first year and this had not been documented at the wild site (Meyer, 2007). The production of more than one shoot on first year plants is a good indicator of vigor on young plants. Plants growing in open sunny conditions reaching a stem height of 60 cm (23 inches) or greater were more likely to flower in their first season than plants under 60 cm. It should be noted that first year plants sometimes start flowering and produce modest seed after the typical August monitoring session. The ability to mature and make fruits in a single season at sites where milkvetch exhibits good vigor has helped them persist at sites like COPR Pond, where inundation events occur every few years, drowning previously established plants.

Longevity of Milkvetch

Wilken and Wardlaw (2001) estimated longevity of individual naturally recruited plants at the wild location to be at least three years. We found that eight 2004 founders lived for at least six years, and thirteen lived for at least five.

CSMR 5 is the only location where survival of the 2002 founders and the 2004 founders can be compared, because this plot did not experience direct flooding or prolonged inundation. Three of twenty-seven 2002 founders which established in the first year survived through August 2006, and therefore lived over five years (11%). Nine of the thirty-nine 2004 founders which established in the first year lived at least five years (23%). Five 2004 founders persisted through August 2009 and were over six years old (13%).

There could be any number of reasons for longer survival of the 2004 group. One possibility is that our 2004 plants, which were not installed in narrow, shaded tree tubes, achieved higher vigor in their first year that contributed to greater longevity. The mean number of shoots on the 2002 plants at CSMR 5 in their first year was 2.0 (Soza et al. 2003), compared with 5.6 on the 2004 plants. The production of more shoots on first year plants seems to indicate better vigor and a higher likelihood of flowering in the first year (Meyer, 2007).

Founder milkvetch, initially raised in a controlled environment and outplanted as 6-8 month old individuals in open areas with low initial competition, may be longer lived than naturally recruited individuals who often have a patchy, clumped distribution and face more stressors.

The first naturally recruited plant to establish at the CSMR 5 location, which germinated in 2004, persisted for four years and was reshooting in its fifth winter when it abruptly died, potentially due to gopher activity in the vicinity. One plant in the CSMR 2005 cohort lived at least three years. Four plants in the CSMR 2006 cohort, where large numbers of naturally recruits established, lived over four years. At MSB 3E, four plants recruited in 2005 lived for at least four years, and two plants recruited in 2006 lived for at least three years.

Naturally recruited milkvetch sometimes come up in very dense patches under favorable conditions. Where moisture and soil resources are not limiting, these dense patches persist in good vigor for the first year and usually thin down to fewer plants by the second summer. Plants in crowded conditions tend to produce flowers primarily on the top of the stems where there is more light, and side branches don't typically form. Under these conditions, it is difficult to accurately count plants without breaking stems. Once a dense patch establishes, they typically persist for about two years. Cover provided by the twiggy stems of milkvetch growing in dense patches appears to lead to expanded use of the area by rabbit herbivores, and low levels of milkvetch reshooting in winter often occurs thereafter. Juveniles tend to establish poorly when under the canopy of large adults in areas where milkvetch density is high. Both shading and herbivory contribute to low establishment in these conditions.

IV. METHODS

Nursery-raised founder milkvetch, typically around 6-8 months old, were installed at various introduction sites in spring of 2002 and 2004. Some extra milkvetch originating from the original RSABG propagation effort were sixteen months old and growing in one gallon containers when they were installed at Mandalay 1, 2 and 3 in 2003 by volunteers. No additional milkvetch have been installed since 2004. Founder milkvetch, with good root systems (but not root bound) established reasonably well at most sites when outplanted in late winter or early springtime.

2002 Installation of Founders: Six month old, nursery propagated Ventura marsh milkvetch representing 14 maternal lines, were installed in April 2002 at five microsites at McGrath State Beach in Ventura County and Carpinteria Salt Marsh Reserve in Santa Barbara County. All founders were planted in above ground tree tubes anchored to rebar. Plants were hand watered at intervals during the first six months following installation. Below ground gopher cages were used at the CSMR installations. Tree tubes were removed in the fall following the first growing season.

As of February 2003, survivorship of the 155 milkvetch installed at CSMR was 44%. Survivorship of the 167 plants installed at MSB was 88%. A detailed description of this effort, including seed germination, nursery propagation, microsite selection, and observations on mortality, survivorship and reproduction are contained in Soza, et al. 2003.

2003 Installation of Surplus Milkvetch and Seed Plots: Sixteen month old surplus milkvetch, propagated at the Rancho Santa Botanic Garden, and growing in one gallon containers, were installed in three different plots at Mandalay State Beach (Mandalay 1, 2 and 3). Milkvetch were planted with assistance from volunteers in late January 2003, and watered in on the day of planting- no additional irrigation was provided. No caging or exclosures were used. Mandalay Plots 2 and 3 performed poorly and are discussed in Meyer, 2007.

Six small direct seeding plots were also installed on January 30, 2003 at the COPR Lagoon and COPR pond sites. This effort is described in section VII of this report, under Milkvetch Performance at COPR Pond.

2004 Installation of Founders: Additional nursery-propagated milkvetch from known maternal lies were installed at new sites and locations- including Ormond Beach (Coastal Conservancy Property); Mandalay State Beach Plots 1A, 1B and 1C; adjacent to CSMR Plot 5; CORP-Lagoon, COPR-Jaumea and COPR Pond (Plots A, B, C and D). Plants were installed between March 26 and May 14, 2004 and were around 8 months old. Water was hand carried to plants, and ½ gallon was delivered to each plant, approximately every two weeks through June 2004. A total of 17 known maternal lines established and produced seeds in the CSMR 5, 5b and 5c area.

Plot Monitoring

The introduction areas were periodically visited several times a year to observe conditions and respond to management needs. Formal monitoring of introduction plots occurred typically between late July and early September of each year, during peak

flowering and fruiting. Plots with first year natural recruits were typically visited again in late fall to determine if more individuals had matured sufficiently to flower and fruit.

Plot monitoring focused primarily upon a census of flowering and non flowering plants. After 2006, large numbers of natural recruits appeared at certain sites, and it was infeasible to tag and measure every plant. In dense patch areas, milkvetch numbers were estimated based upon stem counts and subsampling, extrapolated across the patch or plot. During episodes of high juvenile establishment, plot areas were sometimes divided into sections and seedlings and juveniles were counted and roughly plotted on plot sketch maps.

Associated vegetation was assessed for the general plot vicinity during the August-September monitoring session. Relative cover was visually estimated for the dominant herbs and shrubs growing in the vicinity of the introductions. Relative cover of bare areas and areas of light litter were combined and visually estimated.

Plot Management

The introduction areas where founders were installed have received low levels of management for the last several years, in order to ascertain just how resilient these introductions are when faced with the complex natural condition of surviving unassisted in native habitat areas.

Management actions have focused primarily on reducing non-native weeds; reducing hiding cover for rabbit herbivores; removing non-native snails, slugs and above-normal outbreaks of isopods; thinning or trimming coyote brush; thinning native competitors and installing temporary herbivory exclosures.

The lowest level of management has occurred at the Mandalay and COPR Pond introduction sites. Snails and slugs are rare and have not required control. Fortunately, European milk snails common at the MSB and CSMR sites have not been seen at the COPR Pond. No caging or exclosures have been used at these two locations.

Thinning of new coyote brush or trimming enlarging shrubs has occurred on a couple of occasions at the CSMR and MSB 3E sites in order to reduce rabbit hiding cover. Only a few individuals were thinned or trimmed.

Previously-installed wire exclosures covering several square meters of ground were removed in 2007 at MSB 3E and COPR Lagoon. We had used twenty four inch tall ¼ inch hardware cloth, anchored to rebar, and placed flush to the ground- usually protecting several square meters of ground. Quarter inch hardware cloth is the least likely to trap snakes and lizards in the wire. The exclosures were used to help protect new recruits at locations where herbivory was high. In years of high rainfall, exclosures and cages rapidly become unmanageable as lush, unherbivorized vegetation continues to grow inside the cages (Meyer, 2007), and it was not uncommon to lose the very juvenile or adult one was trying to protect because of excessive growth of unherbivorized competing vegetation. Efforts to trim vegetation inside cages were unable to keep pace with the growing biomass. Herbivory by snails, slugs and other invertebrates who nibble on milkvetch typically increases inside caged areas in wet springs.

Individual wire cages were installed on some established plants at the COPR Lagoon in 2007 at locations where they were experiencing high herbivory from primarily rabbits. Generally, wider cages are best, in order to not impede the growth of milkvetch, who tend to have branches that spread laterally, particularly when vigor is good (about 30 inches or 75 cm diameter). Small, short cages with a piece of wire on top have been used occasionally at MSB 3E to protect smaller juveniles.

The MSB 3E location has experienced the most consistent and severe levels of herbivory of all the introduction sites, attributed primarily to rabbits. This site has received the most caging of individual plants. There is a high rate of failure to successfully reshoot at this location, associated with winter and spring herbivory attributed to rabbits. Without some caging, its likely milkvetch numbers would have declined to few or none. Most of the juveniles observed in August 2011 were uncaged and many disappeared from fall herbivory. Juveniles establishing on the exposed northern edge of the MSB 3E plot experience the least herbivory. While MSB 3E has produced some of the most vigorous milkvetch, the continued loss of plants to rabbit herbivores is confounding and problematic.

Pieces of cardboard were placed on the ground adjacent to the bases of milkvetch at CSMR in spring of 2010 when plants were observed struggling to reshoot. Many small dark slugs were removed and reshooting from the rootstock improved thereafter.

The CSMR 5 and COPR Lagoon sites both supported the most non-native weeds. At COPR Lagoon, invasives like bristly ox tongue (*Picris echioides*), Italian thistle (*Carduus pycnocephalus*), yellow and white sweet clover (*Melilotus* sp.) were removed where they grew close to milkvetch or were occupying open ground favored by juveniles. Once the alkali rye grass (*Leymus triticoides*) started to take over the herb layer, low competition growing sites for these weedy species, and milkvetch, were largely eliminated.

CSMR 5 is a perennially weedy location. There are very few natives in the herb layer. The plot adjoins disturbed land including the rail road corridor to the north. Ruderal habitat to the east (disturbed by flood control activities) is dominated by either- a) poison hemlock (*Conium maculatum*) and Italian thistle, or b) black mustard (*Brassica nigra*). Poison hemlock also is co-mingled in the dense coyote brush stand adjoining the CSMR 5 planting area.

Rabbit herbivory at CSMR seems to do at least a partial job of thinning some of these weedy competitors in winter. They remove Italian thistle and sow thistle (*Sonchus* sp.) at the cotyledon stage, so individuals that are missed continue to mature, become prickly and are subsequently unlikely to be herbivorized. A dense band of this thistle often forms about 2-3 meters from the margin of the coyote brush stand, in the most exposed area of the plot where herbivory pressure seems the lowest. Poison hemlock is removed by rabbits in the cotyledon stage and when they are still small with several leaves (under 2 dm). Grasses of all types are continually cropped, thinned out, or eliminated over the growing season. Species like sweet clover, vetch (*Vicia sativa*), and horseweed (*Erigeron* (*Conyza*) *canadensis*) are preferred rabbit browse and are often entirely eliminated from the herbivorized plot area.

In response to these weeds, removal at CSMR has focused on using loppers to remove individual thistles, hemlock and mustard in mid to late spring once it appears rabbits are no longer removing them. Removal too soon, in winter, could increase direct herbivory

on milkvetch and is not recommended. We've also occasionally used a weed whacker to trim down biomass in fall and we've removed old stems and standing twiggy litter from the plot to keep the area more open. There is potential that the CSMR 5 planting area would have become dominated by hemlock and thistle, or by black mustard, an allelopathic species, had we not done some weeding and thinning over the last decade.

In 2012, previously inundated areas at COPR Pond A and the feral area, exhibited a big increase in Hooker's evening primrose (*Oenothera elata* spp. *Hookeri*). Many plants were in the feral habitat area. Rosettes within one meter of young milkvetch were removed by cutting them just below ground level with hand pruners. This species has also been removed at MSB 3E when rosettes are right next to milkvetch, as they often harbor slugs, snails and isopods. Hooker's evening primrose is abundant at the MSB sites and often occupies the same low competition areas as milkvetch. It appears to be rarely herbivorized and is a strong milkvetch competitor.

V. ANNUAL RAINFALL

Annual rainfall for water year 2000/2001 through 2011/2012 is reported from various stations near the three main introduction areas including Ventura, Carpinteria and Goleta California (Figure 1, 2 and 3). The highest rainfall across the observation period occurred in the winter of 2005. At Carpinteria, rainfall levels (37.56 inches at Station 208) were comparable to the average 25 year recurrence interval (37.61 inches). At Goleta, rainfall in 2011 was nearly comparable to the 2005 levels (30.29 inches in 2011 and 34.99 inches in 2005).

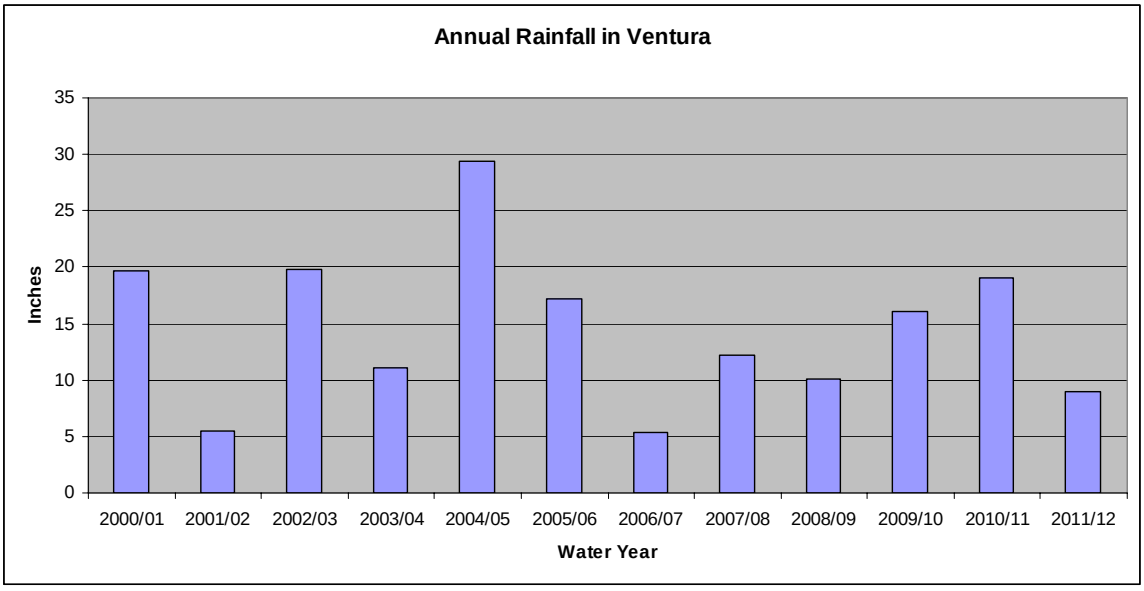


Figure 1. Annual rainfall for the Ventura Marina area across the observation period. (Ventura Marina/Port District Station 216B). Data for 2011/2012 is from the City of Ventura Station 066. Average is 15.35 inches (Meyer, 2007).

Flooding of low lying areas adjoining McGrath Lake including three milkvetch plots occurred on two occasions, about six weeks apart, in water year 2004/2005 as annual rainfall was around 29.35 inches (Meyer, 2007). More extensive flooding occurred in this general area during the El Nino of 1997/1998 and prior to introduction of millkvetch. Most of the low degraded dunes north of the Reliant energy plant and the old "go cart" area east of the lake (elevation around 11 feet msl) were under water as were portions of Harbor Boulevard, in 1998.

Flooding of the dune hollow adjacent to the COPR Pond is not carefully tracked, so we have little information on the duration and physical extent of inundation events there. Inundation at this location seems to occur in most years with above average rainfall. It is a small closed basin watershed, and excess rainfall has no where to escape. We know that some inundation occurred in the winters of 2003, 2005, and 2011. Prior year effects may influence the amount and duration of inundation and temporary flooding the next year. For example, rainfall in winter 2010 was above average, but the prior year had below-normal rainfall and the pond basin did not fill to the outer perimeter of tules, nor were adjoining areas inundated, including the Pond A dune hollow.

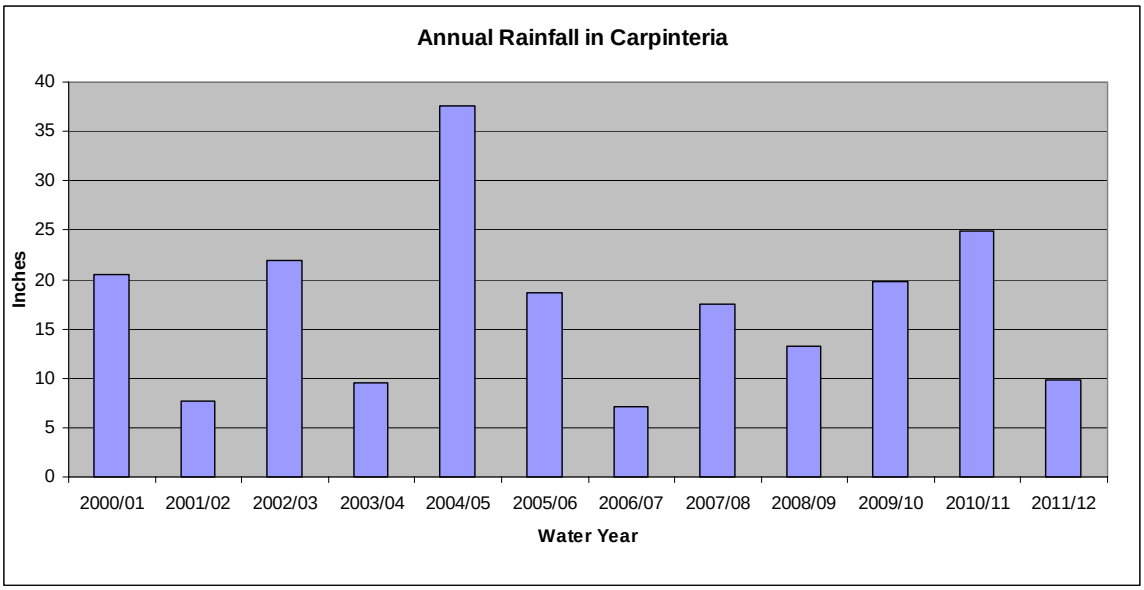


Figure 2. Annual rainfall for the Carpinteria area across the observation period (Carpinteria Fire Station, Station 208). Average for this station is 19.89 inches.
http://www.countyofsb.org/pwd/water/downloads/hydro/graphs/208graph.pdf

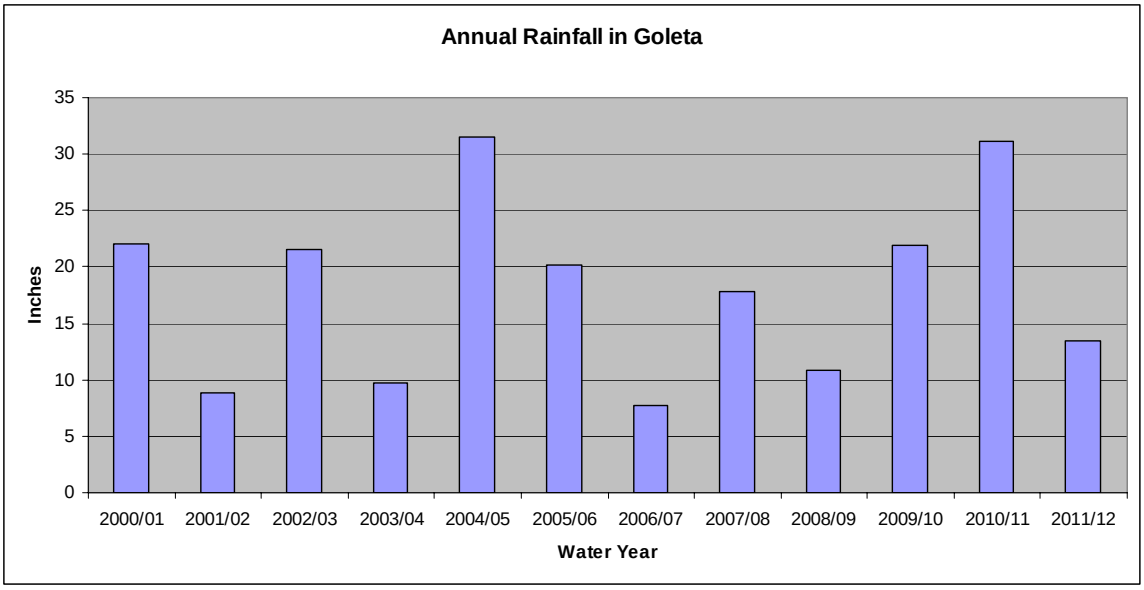


Figure 3. Annual rainfall for the Goleta area across the observation period (UCSB Station #200). Average for this station is 17.74 inches.
http://www.countyofsb.org/pwd/water/downloads/hydro/graphs/200graph.pdf

VI. GENERAL HABITAT CONDITIONS AT INTRODUCTION SITES

The majority of the experimental introduction sites with favorable milkvetch establishment and survival represent ecotonal areas on the immediate coast, and are generally transitional between wetlands (such as salt marsh, lagoon, lake, pond, dune swale, dune hollow) and uplands (such as low backdunes, foredunes, and coastal prairie/upland terraces). The Meyer 2007 report provides extensive background on the physical and ecological environment of the various introduction sites.

Most sites support a near-surface perched aquifer ranging in depth from 53 cm bgs at MSB 5 to 128 cm bgs (21-50 inches) at Mandalay 1 (Meyer, 2007). Depths reported were haphazardly sampled and are subject to seasonal and annual variability. The water table in the vicinity of COPR Pond and the dune hollow seems to drop or disappear in years of low rainfall, suggesting there may not be a persistent perched aquifer at this location.

Soil texture varies between sites, ranging from very sandy with low levels of fines and organic matter, to sandy loams (Soza, et al. 2003; Wilken and Wardlaw, 2002). CSMR 5 soils harden at the surface in summer and form open cracks, suggesting more clay is present in this remnant deltaic, alluvial deposit. Soils at COPR Lagoon and Pond have not been sampled. Lagoon soils appear to be a sandy loam with considerable litter and organic matter. COPR Pond A exhibits more silt at the surface but the overall dune hollow is very sandy.

The phreatophyte, coyote brush (*Baccharis pilularis* var. *consanguinea*), is present at both the wild site and all the key milkvetch introduction sites with favorable milkvetch

establishment (Meyer, 2007). This shrub occurs as scattered individuals, in linear bands, or in patches adjoining introduction areas. Establishment of new coyote brush from seed often occurs following years of above- average rainfall, and juveniles favor open ground with low herb competition. Periodic die-off has been observed associated with prolonged inundation or from defoliation by baccharis beetles.

Bands and patches of coyote brush typically provide good hiding cover for cottontail and brush rabbits. Areas within 1 meter of coyote brush stands typically exhibitr high levels of rabbit herbivory, resulting in less cover in the herb layer with canopy gaps that favor milkvetch establishment. The majority of original introductions occurred in areas we now understand to be experiencing high levels of rabbit herbivory. Unfortunately, rabbit herbivory can also negatively affect milkvetch at various life history stages and was confounding and problematic at certain sites such as MSB 3 and 3E (Meyer, 2007).

Large, shrubby arroyo willows (*Salix lasiolepis*) are also common near most of the favorable introduction sites. The CSMR introduction areas are the only location where there were no arroyo willows in or near the milkvetch plots. Arroyo willows were not present in the COPR Pond planting area initially, but have started appearing in the last few years. Arroyo willow is deciduous, and the leafy understory is a bit more open in winter, but is typically depauperate. Milkvetch sometimes come up from seed under the edge of the arroyo willow canopy, but do not typically establish due to herbivory and shading which reduces vigor. Established arroyo willow thickets were adjacent to several introduction plots but we did not plant underneath them.

Deeply-rooted phreatophytes like arroyo willow and coyote brush provide improved soil moisture in their vicinity due to their ability to tap into and lift sub-surface water. They also potentially provide some weather mediating benefits to milkvetch stands, including blocking drying Santa Ana winds and transpiring moisture into the surrounding air. Their large biomass facilitates greater condensation and fog drip.

Western ragweed (*Ambrosia psilostachya*) was universally present at all the favorable introduction sites, and its wetland indicator status is FAC (Meyer, 2007). This rhizomatous species varies considerably in wet years and dry years with respect to stem height, density of stems and overall biomass. Milkvetch recruitment can occur within more open stands of western ragweed, but in years with higher rainfall or lower herbivory, recruitment and establishment of VMMV in dense stands of western ragweed with high biomass is generally poor. Dense robust patches also provide hiding cover for rabbits and herbivory is typically more severe in these locations.

With the onset of the winter rainy season, new stems of western ragweed are produced from below ground rhizomes. Western ragweed appears to be a most favored rabbit browse, and they forage primarily on its stems. Rejected leaves, stripped from the stems, and leafy tips lay about the ground in rabbit herbivory areas. Since stems are still short in early winter, low levels of a favored food source in winter may account for intense herbivory pressure on reshooting adult milkvetch at certain sites, such as MSB 3 and 3E. Herbivory in fall can sometimes be severe and shortages of favored foods appears to increase herbivory pressure on milkvetch. Since rabbits tend to discard the leafy tops of milkvetch, some fruits may survive if they are sufficiently mature.

Western ragweed is so favored by rabbits that there is potential for it to be eliminated from sites where the stands are limited in extent. Several years after the introduction of

milkvetch at CSMR-5, we noticed that there was almost no western ragweed present in the stand. We then found unherbivorized stems, 2-3 meters from the coyote brush cover, embedded and protected by the leafy biomass of the prickly non-native Italian thistle. In 2010, we introduced some new western ragweed along the southern margin of the plot and 3 meters from most of the coyote brush cover and to date, the patch has established and is enlarging.

Ideal conditions for milkvetch recruitment in western ragweed seems to occur when stands are not dense, and light still reaches the ground in between stems. This condition typically occurs at sites where the introduction area transitions to drier conditions, in years of low rainfall, or after inundation events. For example, MSB 3E abuts dry shallow dunes; COPR Pond A transitions to drier dune scrub and coyote brush stands just beyond areas subject to temporary or season flooding. The prior year's biomass of western ragweed typically does not form dense continuous thatch at the ground surface, which also favors milkvetch recruitment.

Other rhizomatous wetland perennial herbs, such as *Juncus mexicanus* (Mexican rush), *Carex praegracilis* (slender carex), and *Distichlis spicata* (salt grass), form dense thatch at the ground surface, which blocks light, and seems to result in higher levels of competition for space and soil resources that reduces and displaces milkvetch. Expansion of these herbs has occurred in the last few years at most key sites resulting in poor conditions for milkvetch establishment and persistence.

Vegetation shifts at key introduction sites are discussed in more detail in Section VII of this report.

Soil Moisture and Salinity

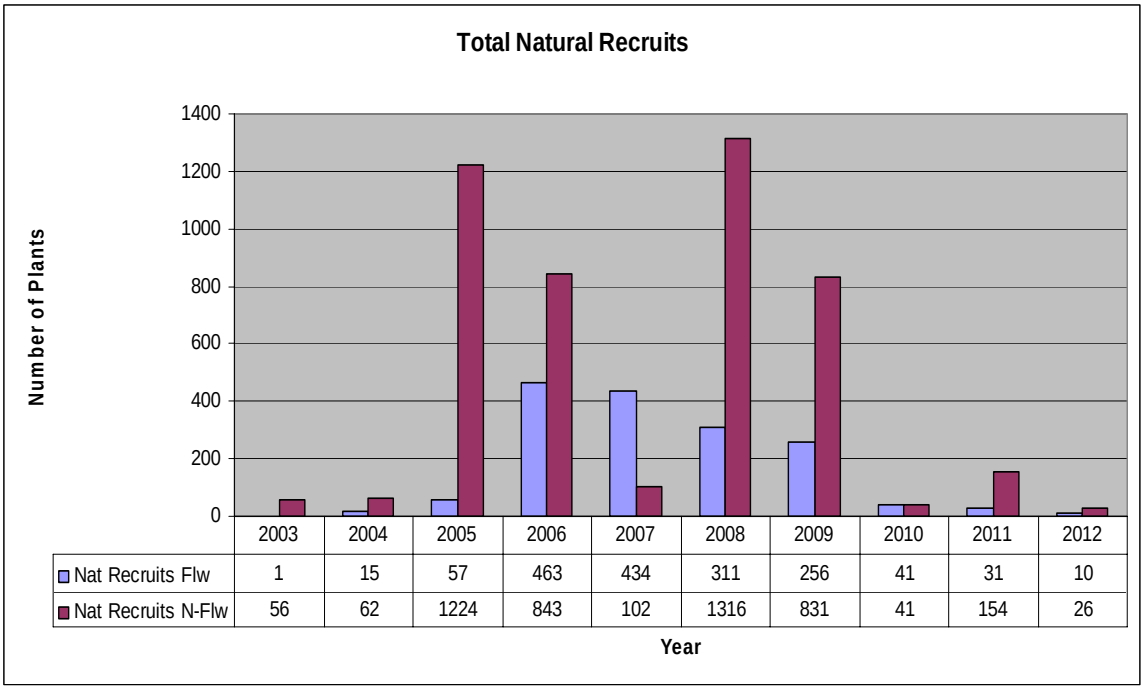
Preliminary examination of in-situ soil moisture at milkvetch introduction sites indicates that herbaceous rhizomatous perennials are typically found at locations with higher soil moisture in the upper six inches (15 cm) (Arcadis, 2012). Introduced milkvetch tend to survive in areas where the top six inches of soil dries out during the summer months, versus areas where the top six inches stays moist (Arcadis, 2012). Preliminary soil moisture measurements at 12 to 18 inches bgs (30-45 cm) suggest that VMMV tends to survive at locations where soil moisture in summer remains at 70-80 percent (Arcadis 2012). Moisture at depth is often associated with semi-perched shallow aquifers (Meyer, 2007). Salinity measurements at outplanting sites also indicate that VMMV are more likely to survive in soils with lower salinity and have failed in areas where salinity exceeded 2.5 milliSiemens (mS) (Arcadis, 2012).

Soil moisture levels and salinity strongly influence the composition of vegetation at introduction sites. Shifts in these physical conditions at introduction sites over the observation period are reflected in changes in plant species in ecotonal areas between uplands and wetlands.

VII. RESULTS AND DISCUSSION

Overview of Natural Recruitment from Seed Bank

Figure 4 shows the total number of naturally recruited flowering and non-flowering milkvetch for all of the key introduction sites, combined and across the period of observation.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Nat Recruits Flw	1	15	57	463	434	311	256	41	31	10
Nat Recruits N-Flw	56	62	1224	843	102	1316	831	41	154	26

Figure 4. Total number of naturally recruited flowering and non-flowering milkvetch for all the key introduction sites combined.

Natural recruitment was first observed in February 2003 several months following seed ripening in the first year batch of 2002 founders. This indicated that some portion of the seed produced was capable of germinating relatively quickly. By summer, most plots where seed was produced had some juveniles present in August. Most of these did not establish. By 2004, more recruitment occurred and establishment increased, especially at MSB 4. Eight of these plants reached sufficient size to flower in their first year (Meyer, 2007).

The first large recruitment event was documented in 2005 at the MSB sites where hundreds of plants established after the 2005 inundations following dry down and at MSB 3 and 4, they were also growing in new adjoining areas (MSB 3E and MSB 4E) (Meyer, 2007). Rainfall that year was nearly twice normal levels (Figure 1). Seedlings emerging out on the more open dry dunes on the fringes of flooding established well. Juveniles in the original MSB 3 and 4 locations were unable to keep pace with competing herbaceous vegetation and many were damaged by snails and slugs. Some juveniles established in the sunny front of the MSB 5 plot area, but most were under

shade of willows and did not thrive. This was also the only year that recruitment occurred at the Mandalay 1 location.

The first year producing abundant juveniles across most of the key sites was 2006. A large spike in recruitment at CSMR and the COPR Lagoon was observed. Annual rainfall was near-average and less competing vegetation was growing compared to the very wet conditions in 2005. Snails and slug levels seemed lower and herbivores had plenty of other vegetation to eat. Masses of milkvetch juveniles were growing in remarkably crowded conditions at both sites and many established. Examination of monthly rainfall in 2006 shows that although levels were nearly average, considerable rain fell in April (5.88 inches in Carpinteria) and almost an inch fell in May (0.90 inches). This represents the wettest April across the observation period and a fairly wet May as well. Moist spring conditions potentially contributed to high levels of establishment of new milkvetch at these two locations.

Recruitment at CSMR 5 and COPR Lagoon over the next three years diverged between the two sites. At COPR Lagoon, natural recruitment declined steadily over each year, as did the number of flowering adults. This declining trend was associated with the continued expansion of the herb layer and changed vegetation conditions as canopy gaps declined and suitable low competition growing sites became more and more limited. Herbivory also increased as the herb layer expanded, and both rabbits and meadow voles were utilizing the area.

At CSMR, natural recruitment dropped in 2007 (the driest year across the period of observation), but spiked again in 2008 and was still high in 2009 (Figure 2). Large numbers of juveniles recruited at CSMR 5 in 2008 despite the fact that almost no rain fell between March and June. This suggests that rainfall in spring may not have contributed to better germination and survival of these juveniles at this location. Despite the low level of rainfall in spring, the site was described as “soggy” on April 2, and the shallow well had free water at 46 cm bgs (18 inches). It is possible that increased water levels below ground contributed to germination and survival of juveniles, and low levels of gopher activity were noted through the summer, reducing losses to herbivory. Evidence of meadow voles has not been observed at the CSMR 5 area, which is relatively distant from the upland grassland habitats they typically prefer.

We also observed an increased pulse in recruitment in 2011 at MSB 3E and at COPR Pond. The dune hollow was inundated for many weeks. Rainfall levels that year at Goleta were comparable to the very wet conditions seen in water year 2004/2005 (Figure 3). Numerous plants came up very close together at the feral patch following dry down, and a new milkvetch established and matured at the relatively dry location in Pond D.

A few plants were able to come up at the relatively dry Mandalay 1B in 2010, a summer with considerable fog which may have helped them survive. Several new plants established here again in 2011 when rainfall was higher than normal. Remnant shallow iceplant thatch at this location appears to benefit recruitment.

These observations suggest that high levels of VMMV germination occur on recently flooded ground and in wetter-than-normal years provided that low competition growing sites are available and competition with other species is not too intense. The highest

numbers of juveniles were observed at CSMR 5 in the 2006 and 2008, both years of around average rainfall.

Seedling recruitment has plummeted to zero in the last two year at the CSMR 5 location One adult is still alive and none of the other adults present in 2010 were able to reshoot. Causes for this are unknown, but there is some potential that salinity is increasing in the general area- more high marsh species are occupying the plot area and halophytes are increasing. If this is the case, the location may no longer be suitable for milkvetch in the future.

Milkvetch Performance at Introduced Sites

Previously Failed Plots

Failed 2002 installations were located at McGrath State Beach in dry, sandy low dunes (Ventura County, MSB 1 and MSB 2) and the Carpinteria Salt Marsh Reserve in areas transitional to or within high salt marsh (Santa Barbara County, CSMR 1, 2, 3 and 4). The 2003 installations at Mandalay 2 and 3 in drier, low relief dune swales established poorly although some plants persisted until fall of 2005, when the remaining founders and several juveniles all died (Meyer, 2007).

Milkvetch failed to establish in 2004 at Ormond Beach in areas of high salt marsh (*Jaumea carnosa* dominated) and the adjoining small upland transition zone. At COPR Lagoon, an initial 2004 installation in a plot dominated by dense *Jaumea carnosa* also failed to establish. The 2004 outplanting at COPR Pond A, B, C and D also largely failed - the combination of late outplanting, inadequate irrigation, rapidly draining sandy soils and loss of the near-surface water table in a summer following low annual rainfall, contributed to failure of these plants to establish (Meyer, 2007). One individual from the 2004 installation at COPR pond was subsequently determined to have successfully established when it was observed in full flower and fruit in August 2006. The 2004 installation of millkvetch at the Mandalay 1C also failed to establish due to high levels of initial herbivory attributed to rabbits.

Key Introduction Areas

The following section summarizes the status of founder, nursery-raised milkvetch and naturally recruited milkvetch, for each of the key introduction areas where milkvetch installation was initially successful.

Mandalay State Beach

Mandalay 1

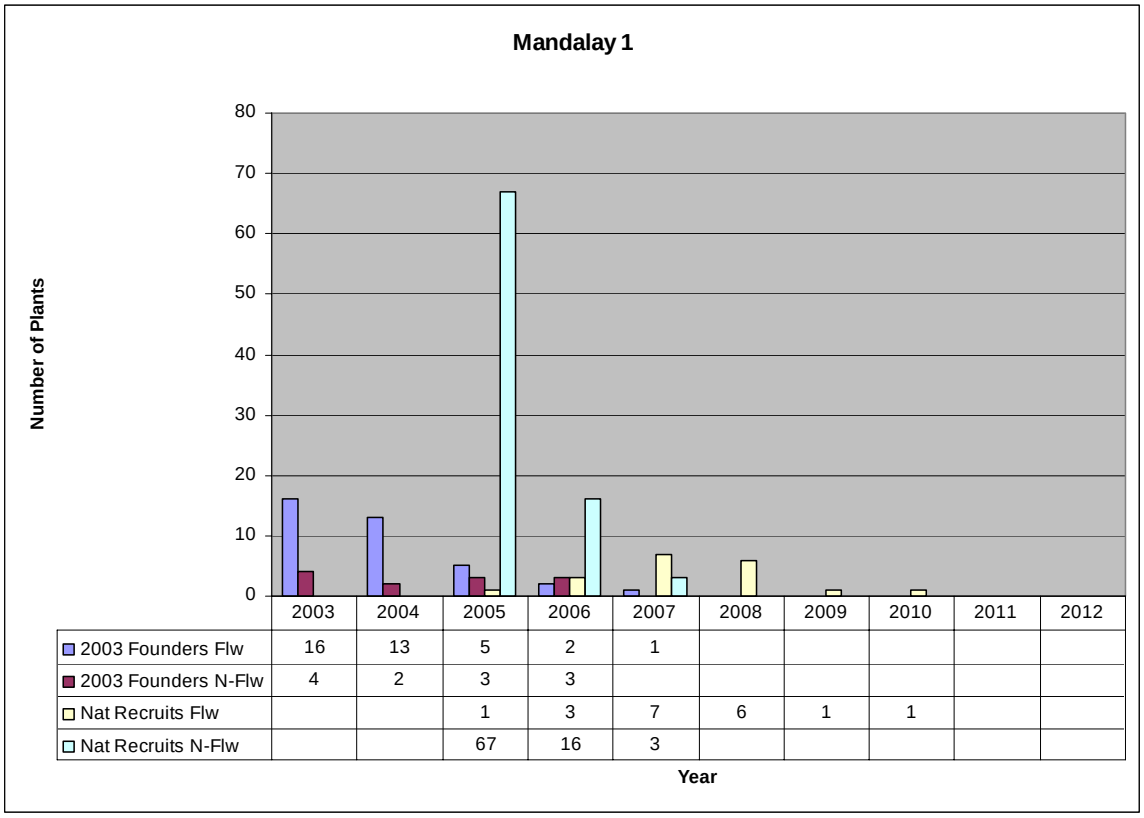
Figure 5 summarizes the number of flowering and non-flowering founders and natural recruits at the Mandalay 1 introduction site across the observation period of 2003 through 2012.

Twenty surplus plants in one gallon containers, and approximately 16 months old, were installed in late February 2003 and watered in. Fifteen plants were installed in one group, and a second group of five were placed about three meters to the east, adjoining

a patch of basket rush (*Juncus textilis*). Rainfall in 2003 was above normal, and no further watering was required.

Founders established reasonably well, and no plants were lost to herbivory. Sixteen of the twenty plants flowered and producing seed in their first summer (Figure 5). Two of the five plants in the east group flowered their first summer, but overall vigor was poor in August 2003, and they failed to reshoot the following year. The remaining founders gradually declined with five persisting for at least four growing seasons before failing to reshoot; their age was therefore approximately 5 ½ years. One individual, associated with maternal line 19, lived for 6 ½ years.

No seedling germination was observed at Mandalay 1 until the wet winter of 2005. On June 4, 2005, we counted approximately 430 seedlings and young juveniles. Some were dessicating and some were very crowded. Sixty-eight juveniles survived through August 5, 2005 and one of these reached sufficient size to flower. This cohort declined over the next three years. No plants remain in the plot area as of 2011.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2003 Founders Flw	16	13	5	2	1					
2003 Founders N-Flw	4	2	3	3						
Nat Recruits Flw			1	3	7	6	1	1		
Nat Recruits N-Flw			67	16	3					

Figure 5. Status of 2003 founders and natural recruits documented during the August summer monitoring session. Original 2003 founders N = 20.

Germination of new individuals from seed bank has not been observed since 2005. Lack of seedling recruitment prior to 2005 was attributed to the sandy soil conditions in the Mandalay 1 plot area. The rapidly-draining coarse sandy soils at this location appear to be too dry at the surface, in most years, for milkvetch seedlings to establish and persist.

The Mandalay 1 plot area has also experienced an expansion in rhizomataous thatch-producing wetland herbs, specifically Mexican/Baltic rush (both species are co-mingled in the vicinity). The original plot area abutted a band of coyote brush adjacent to dense arroyo willow thicket and had almost no herb layer. Since 2005, rushes have expanded beneath the edge of the arroyo willow and coyote brush band, eliminating local canopy gaps favored by milkvetch. This band of rushes remains narrow, however, and does not extend into the drier adjacent low dunes.

The plot area exhibits very high levels of herbivory by rabbits, with few no herbaceous plants persist on the open sandy ground beyond the coyote brush stand. The open ground here supports severely cropped individuals of scouring rush (*Equisetum laevigatum*), indicating continued removal by rabbits. An abundance of rabbit pellets cover the ground (Photo 6). Despite high herbivory in the general area, herbivory exclosures have generally not been used at this location, and herbivory on juvenile milkvetch and established founders by rabbits has been low.

Considerable seed has been previously produced at the Mandalay 1 plot, and it is likely that seed bank is still present in the plot area. Should a winter with higher-than-normal rainfall occur, there is potential for new millkvetch to appear from seed bank in the vicinity.

Mandalay 1A

Figure 6 shows the number of flowering and non-flowering founders and natural recruits at the Mandalay 1A introduction site across the observation period of 2004 through 2012.

Ten milkvetch were installed at this location in spring 2004, just north of Mandalay 1 and separated by about three meters, in a small opening in the arroyo willows. The location was shady at the time of outplanting, with only midday sunlight, in summer. Flowering levels were generally low, but some seed was produced in 2004 and 2005, and was sufficient to result in occasional seedlings and leggy juveniles. No milkvetch remained in 2011.

The Mandalay 1A plot area is becoming entirely shaded by expansion of the adjoining arroyo willow. The herb layer is also more vegetated and currently supports expanding Mexican rush and western goldenrod (*Euthemia occidentalis*). Shady conditions may be allowing an occasional milkvetch juvenile to establish and persist through the summer months, but vigor is consistently low and flowering does not typically occur.

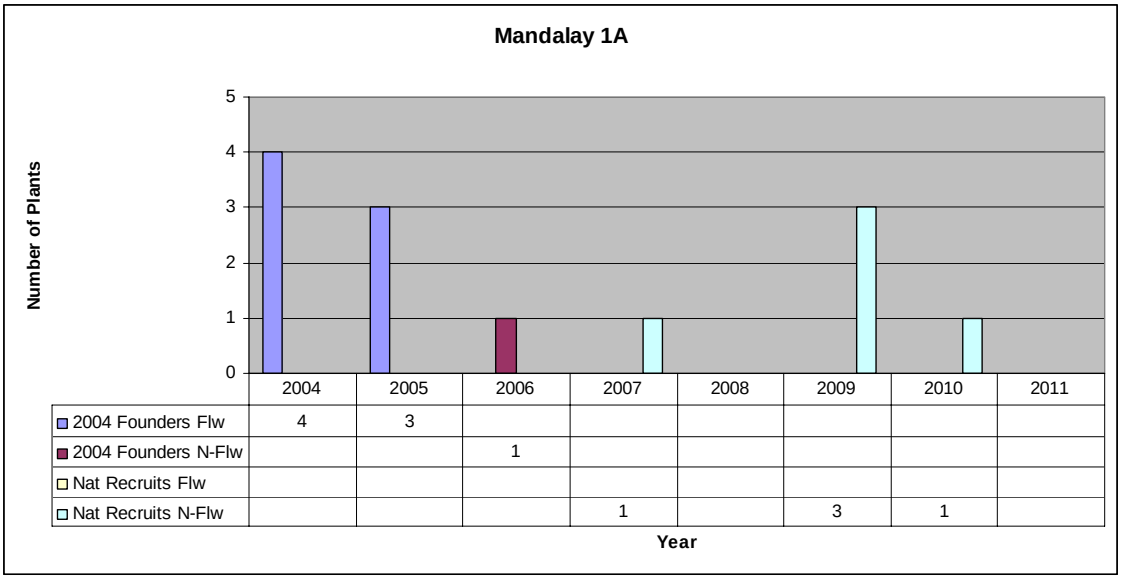


Figure 6. Status of 2004 founders and natural recruits documented during the August summer monitoring session. Original 2004 founders N=10.

Mandalay 1B

Figure 7 summarizes the number of flowering and non-flowering founders and natural recruits at the Mandalay 1B introduction site across the observation period of 2004 through 2012. This planting area is similar to the Mandalay 1 location but is about 65 meters (214 feet) to the west, abutting an arroyo willow thicket.

Fifteen plants were installed in this location in spring 2004. Natural recruitment was first observed during the very wet winter of 2005 and two persisted for the next two years. Three new natural recruits were observed in late summer 2010. Cool temperatures over the summer months and considerable episodes of fog may have contributed to survival of these three juveniles. In 2011, two of the 2010 recruits matured sufficiently to flower and one new 2011 recruit established adjacent to the willow canopy.

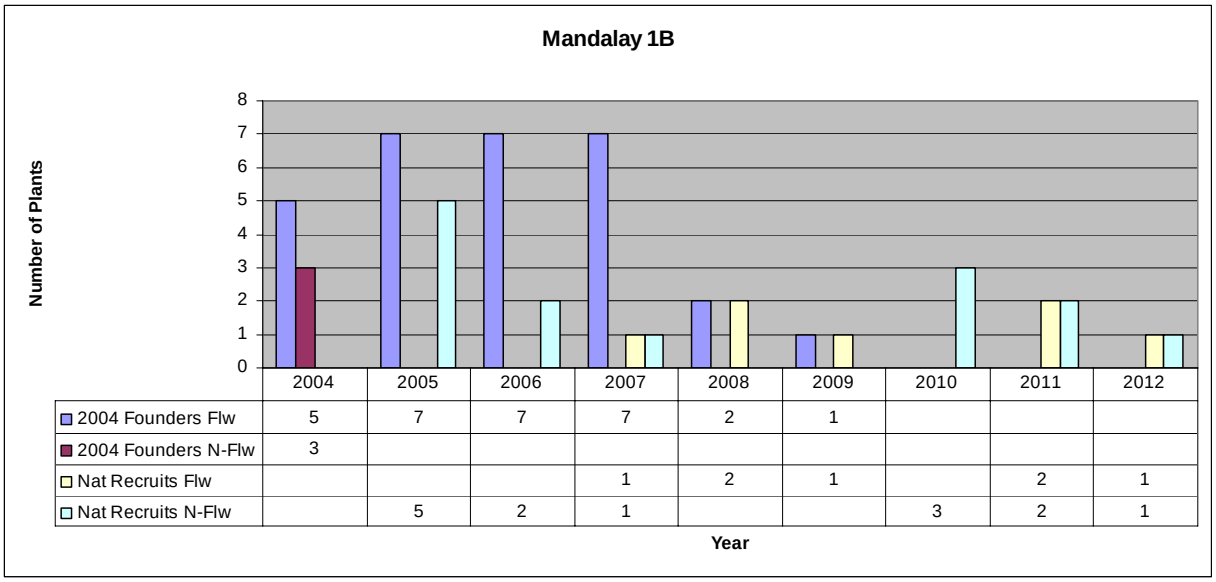


Figure 7. Status of 2004 founders and natural recruits documented during the August summer monitoring session. Original 2004 founders N= 10.

Seven of the original 2004 founders persisted for over four growing seasons. One founder was potentially over six years old when it failed to reshoot in the winter of 2010.

Seedling establishment at this site may be benefiting from extremely low cover of rhizomatous wetland herbs combined with the presence of remnant iceplant thatch on the otherwise open sandy soil surface. Three of the four naturally recruited plants observed in 2011 were located in areas with several centimeters of old iceplant thatch. Iceplant had previously been controlled in this area prior to 2003, by the site manager, Ventura County Parks Department. In 2012, several juvenile millkvetch were observed in early summer, along the shady margins of the edge of the arroyo willows, and growing in several decimeters of arroyo willow leaf litter. Only one of these plants survived to the summer monitoring session, and the remainder appear to have been potentially removed by rabbits (no sign of the plants).

McGrath State Beach

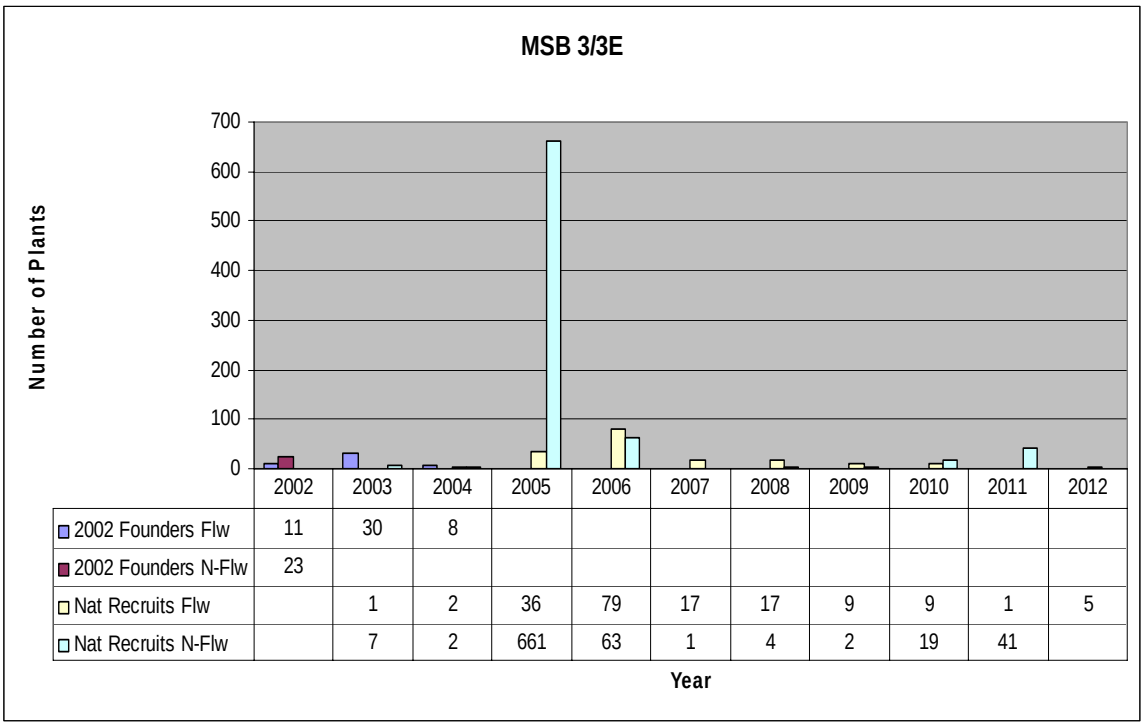
McGrath State Beach 3/3E

Figure 8 summarizes the number of flowering and non-flowering founders and natural recruits at the MSB 3 and adjoining 3E area, combined, across the observation period of 2002 through 2012.

Thirty four nursery-raised milkvetch were installed in the original MSB 3 plot area in April 2002. Outplants were protected inside tree tubes, which were removed in November 2002 (Soza, et al. 2003).

By 2003, the MSB 3 plot produced some of the most vigorous growth in milkvetch plants with abundant flowering and fruit production in their second summer (Meyer, 2007). The

western ragweed growing beneath the thriving founders was almost entirely eliminated over the growing season by cottontail rabbits residing beneath the dense milkvetch patch. Conditions for milkvetch persistence looked promising.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2002 Founders Flw	11	30	8								
2002 Founders N-Flw	23										
Nat Recruits Flw		1	2	36	79	17	17	9	9	1	5
Nat Recruits N-Flw		7	2	661	63	1	4	2	19	41	

Figure 8. Status of 2002 founders and natural recruits documented during the August summer monitoring session. Talleys for 2005 utilize data from October 2005. Original 2002 founders N=34.

These conditions changed dramatically in 2004, when reshooting founders were unable to form new shoots due to severe winter and spring herbivory. Milkvetch rootstocks were repeatedly cropped, preventing new shoots from forming. This damage was attributed to rabbits. The eight plants which survived into summer of 2004 were all caged in springtime to prevent further herbivory.

In the wet winter of 2005, the entire MSB plot area was submerged for an extended period of time on two occasions, following episodes of very heavy rainfall and temporary flooding of extensive areas around the McGrath Lake margins. Following each inundation event, a large cohort of millkvetch seedlings were observed (Meyer, 2007). All established founders and natural recruits subjected to prolonged inundation (typically 2-3 weeks at a time) did not survive. Once flooded conditions ended in early March 2005, an abundance of new seedlings appeared along the drier outer margin of the MSB-3 plot area, in a new area labeled MSB 3E (extension to the north). We installed 9 large herbivory cages in the front plot area around groups of maturing juveniles, four cages around more vigorous recruits in the interior back of the MSB 3 plot, and a 1 meter X 3 meter exclosure in the interior of MSB 3. We haphazardly marked 26 plants in good vigor throughout the area and those were measured and monitored in August 2005.

As summer progressed, growth of competing vegetation, including wetland obligates and shrubs, eliminated low competition growing sites and canopy gaps in herb and shrub layers. At least 416 juveniles were documented during the August monitoring session in the original MSB 3 plot area and an additional 251 were observed in 3E extension. By October, 36 natural recruits had matured sufficiently to flower and produce some seed. Most of these were in the new open MSB 3E area.

By 2006, the original MSB 3 area was becoming more overgrown and shaded. Some milkvetch were buried under other individuals and could not be reached to measure them. Most cages were still in place. The large exclosure was taken down and few milkvetch persisted there. Seventy-six plants from the 2005 cohort remained, and at least 49 flowered. New 2006 recruits were present, but scarce and often growing underneath larger milkvetch and their vigor was low. One of 27 flowered.

Growth of competing vegetation and overtopping of the original MSB 3 area continued, and few plants remained here in spring 2007. By summer, 18 plants remained in the MSB 3E area, and 17 flowered.

In 2008, nine 2005-recruited adults flowered and were still in moderately good vigor; eight plants recruited in 2006 were still present, with seven flowering; and four 2008 recruits had established, with one flowering and 73 cm tall. Most of these plants were not in cages or exclosures.

The MSB 3E plot area continued to produce modest recruitment and occasional adults. Five larger cages were used to protect single adults and moved around between 2009 and 2012. Some plants survived without caging, and others were lost. In 2012, the only plants persisting into summer were inside five cages.

Milkvetch on the outermost edge of the MSB 3E plot area adjoining low dunes and growing in areas with little or no rabbit hiding cover are typically able to establish and mature without caging. Conditions in 2012 suggest that even with careful management of stand architecture to maintain open conditions, herbivory near hiding cover remains a serious problem that shows no sign of abating.

McGrath State Beach 4/4E

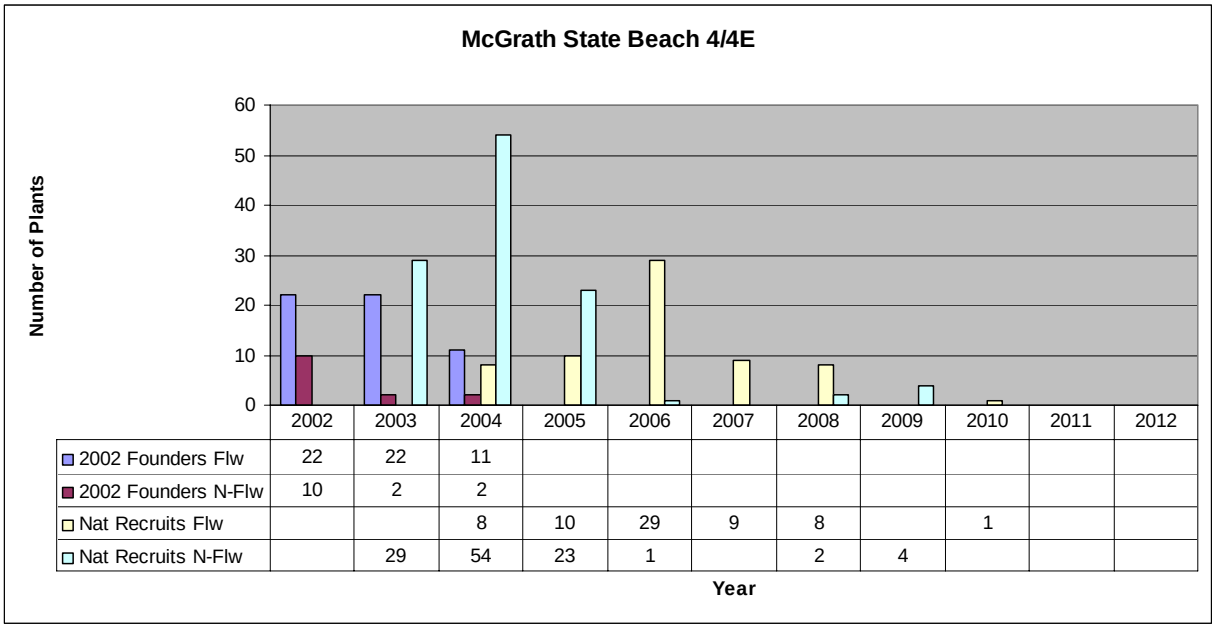
Figure 9 summarizes the number of flowering and non-flowering founders and natural recruits at the MSB 4 and the nearby 4E area, combined, across the observation period of 2002 through 2012.

Thirty three nursery-raised were installed at the original MSB-4 in April 2002. Outplants were installed in tree tubes, which were removed in November 2002 (Soza, et al. 2003). In summer 2003, milkvetch exhibited excellent vigor and produced abundant flowers and fruits at this location (Meyer, 2007).

Conditions changed in winter of 2004, when winter and spring herbivory was first detected, preventing new annual growth shoots from forming on the majority of founders. Impacts were similar to that seen in the MSB-3 plot area. However, MSB-4 exhibited higher cover in the herb layer, including expanding patches of salt grass, slender carex, abundant horseweed (*Erigeron canadensis*) and western ragweed. Narrow cropped

runways were seen radiating between the bases of several adult milkvetch, suggesting that meadow voles were causing damage. Disruption of the runways with a steel rake, caging of several adults and use of anti-herbivory products applied directly to the herb layer, appeared to reduce this herbivory (Meyer, 2007). The vigor of founders improved and increasing numbers of naturally recruiting juveniles established. Eight natural recruits matured sufficiently to flower by October.

In 2005, the MSB-4 area was also inundated on two occasions during episodes of flooding, resulting in the complete loss of the original founders, at least sixty two juveniles, and several seedling cohorts (Meyer, 2007). The MSB 4 plot area rapidly transformed following the flooding, and no longer supported low competition growing sites or canopy gaps. Lush growth of wetland margin vegetation ensued and harbored high levels of snails which could not be controlled. An area to the south east of MSB-4 and adjoining drier low dunes was on the edge of the flooded area and it appears that milkvetch seed, dispersed from MSB-4, were carried to this area, labeled MSB 4E.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2002 Founders Flw	22	22	11								
2002 Founders N-Flw	10	2	2								
Nat Recruits Flw			8	10	29	9	8		1		
Nat Recruits N-Flw		29	54	23	1		2	4			

Figure 9. Status of 2002 founders and natural recruits documented during the August summer monitoring session. Original 2002 founders N= 33.

From 2006 through 2010, the associated vegetation along the MSB 4E area continued to expand, eliminating low competition growing sites in the herb layer. Recruitment of new arroyo willows and coyote brush was observed throughout areas of previously flooded ground. By 2010, these willows had entirely overtopped and were now shading the MSB 4E area. Snails continue to reside in the adjoining wetland vegetation and further damaged young milkvetch.

Conditions in 2012 suggest this area is no longer suitable for milkvetch. Should this plot area be inundated again, seed bank could potentially shift spatially to new areas and allow for new milkvetch to establish nearby.

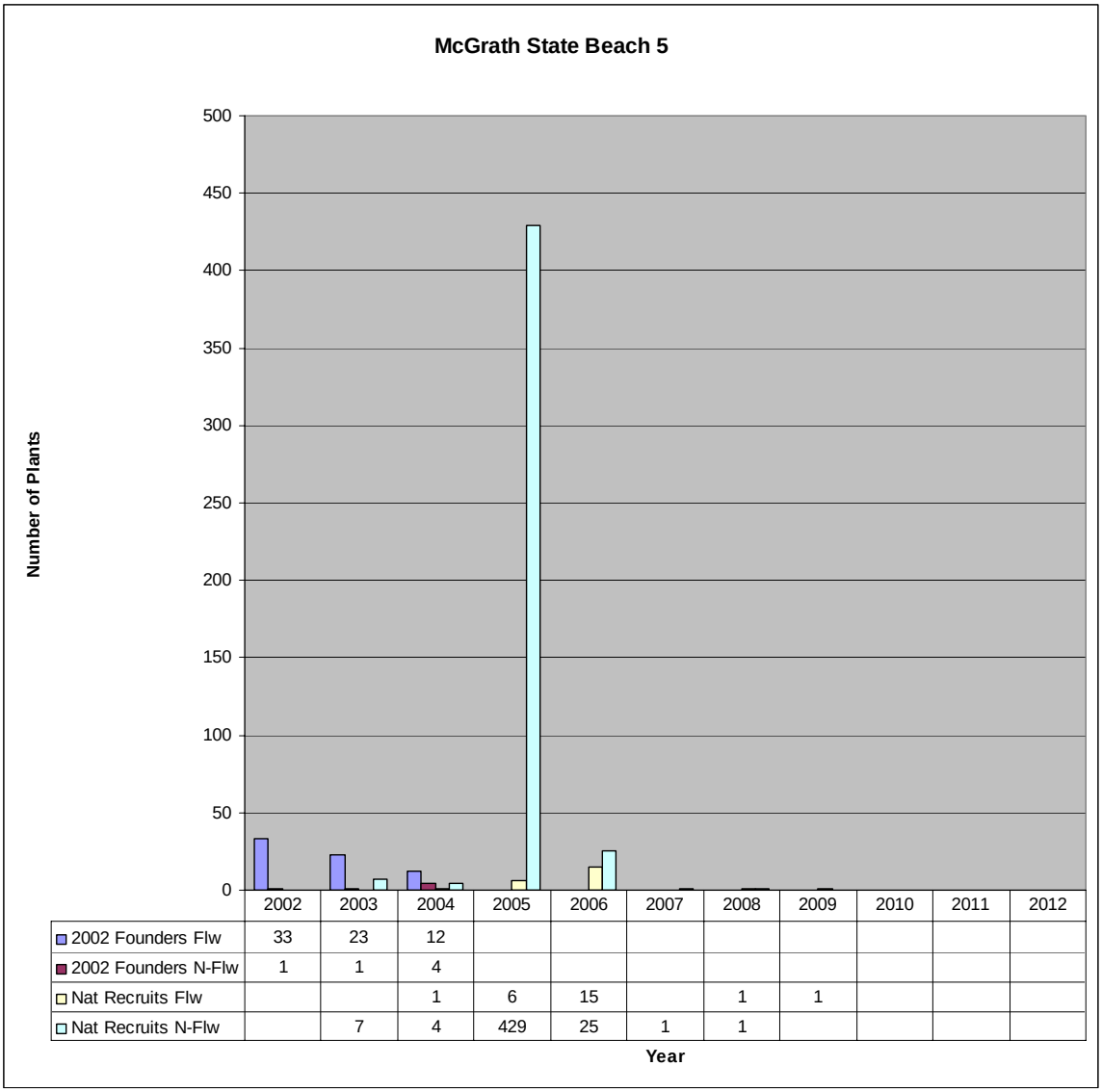
McGrath State Beach 5

Figure 10 summarizes the number of flowering and non-flowering founders and natural recruits at the MSB 5 introduction site across the observation period of 2002 through 2012.

Thirty-four nursery-raised milkvetch were installed at the original MSB-5 in April 2002. Outplants were installed in tree tubes, which were removed in November 2002 (Soza, et al. 2003). In summer 2003, milkvetch exhibited excellent vigor and produced abundant flowers and fruits at this location (Meyer, 2007). The tallest single stem measured was produced in this plot (227 cm, or 89 inches).

MSB-5 was the most mesic of the three wetland margin plots at MSB and adjoined both arroyo willow and sand bar willow. Following the 2002 installation, the arroyo willow enlarged in 2003 and shaded much of the planting area. New stems of sand bar willow, which form thickets from below-ground rhizomes, increased, overtopping the millkvetch.

Following the 2005 inundation, hundreds of new milkvetch seedlings covered the previously flooded ground. However, only a narrow dense band of plants outside the shade of willows was able to mature sufficiently to flower. The remaining hundreds of juveniles, growing in full shade, exhibited low vigor, showed evidence of mites, and were etiolated, weak stemmed and did not flower.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2002 Founders Flw	33	23	12								
2002 Founders N-Flw	1	1	4								
Nat Recruits Flw			1	6	15		1	1			
Nat Recruits N-Flw		7	4	429	25	1	1				

Figure 10. Status of 2002 founders and natural recruits documented during the August summer monitoring session. Original 2002 founders N=34.

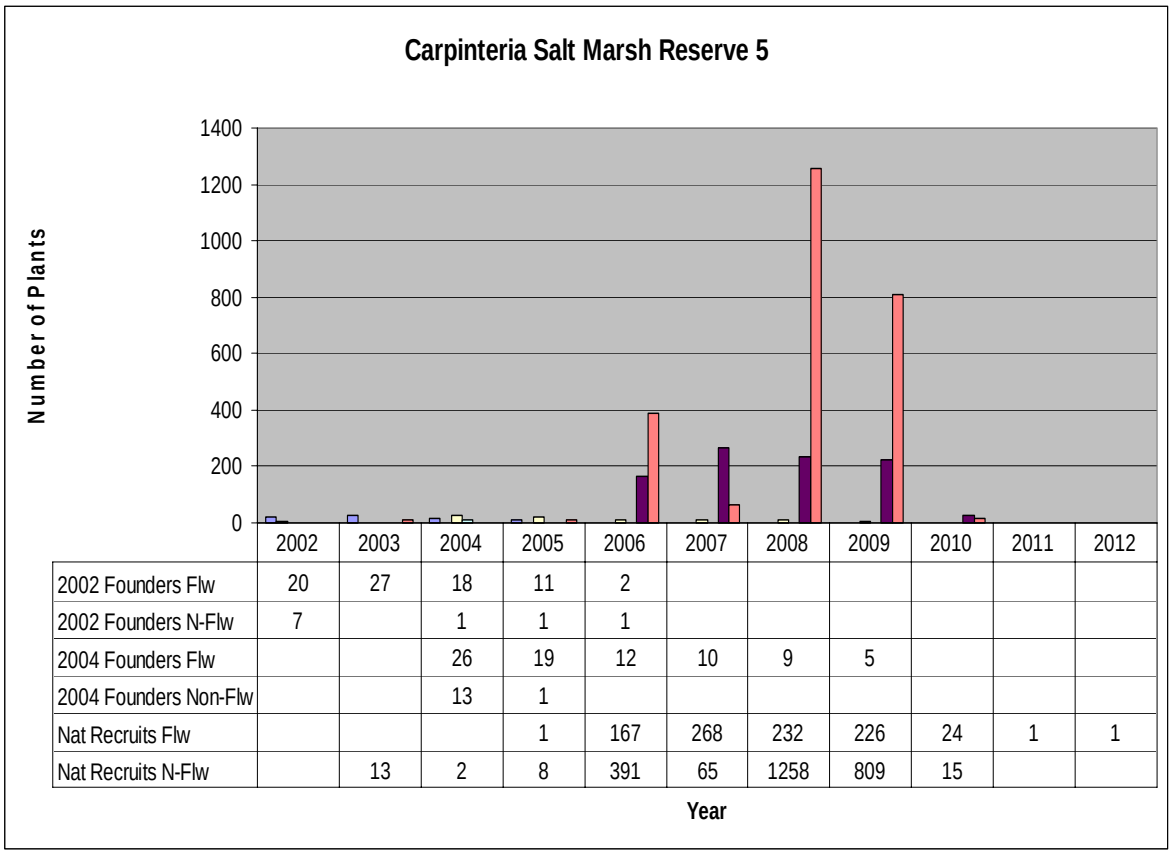
As of 2012, sand bar willow and arroyo willow now entirely dominate the MSB 5 area, and suitable growing conditions for milkvetch no longer occur. Should inundation occur again, there is only a low potential for seed bank to be carried to new locations. Areas immediately adjoining MSB-5 are densely vegetated, including a broad meadow of horsetail, two natural drainage swales and the lake margin itself. Low competition growing sites are distant from the plot area.

Carpinteria Salt Marsh Reserve

CSMR 5

Figure 11 summarizes the number of flowering and non-flowering founders and natural recruits at the CSMR 5 introduction site across the observation period of 2002 through 2012. Observations are combined for the 2002 CSMR 5 plot and the adjoining 2004 plots 5B and 5C.

Survivorship, vigor and reproductive output of founders were excellent in the CSMR 5 plot area during the second and third summer (2003 and 2004). The additional plants installed in spring 2004 established reasonably well, with the exception of the northern end of Plot 5B, where rabbit herbivory was intense and plot was surrounded by dense shrub cover on three sides.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2002 Founders Flw	20	27	18	11	2						
2002 Founders N-Flw	7		1	1	1						
2004 Founders Flw			26	19	12	10	9	5			
2004 Founders Non-Flw			13	1							
Nat Recruits Flw				1	167	268	232	226	24	1	1
Nat Recruits N-Flw		13	2	8	391	65	1258	809	15		

Figure 11. Status of 2002 and 2004 founders and natural recruits documented during the August summer monitoring session. Original 2002 founders N=31. 2004 founders include Plot 5B (immediate NW of Plot 5) N=15; and Plot 5C (immediately E of Plot 5) N= 25. Natural recruitment represents the combined total for the three subplots.

Natural recruitment in 2003 and 2004 was quite low at CSMR 5 compared with what we had been observing at the MSB lake margin sites. None of the 2003 natural recruits established. Dessicated seedlings were commonly observed, as well as losses attributed to herbivory by rabbits and gophers. Conditions in 2004 were similar, but one individual established and persisted in the plot area for the next five years. Low

numbers of observed seedlings and poor establishment was concerning, especially when compared with considerable amount of natural recruitment observed at the MSB 4 plot. Soils here are disturbed alluvium, with a high content of clay and silt particles (Wilken and Wardlaw, 2002). Compacted dry surface soils and more distance to the subsurface water table suggested the CSMR 5 plot area may have not been well-suited for milkvetch recruitment (Meyer 2007).

Seedling emergence changed abruptly in 2005. Moist conditions in the very wet winter of 2005 stimulated considerable numbers of new seedlings. But lush growth of annual grasses and weedy forbs overtook most of these small juveniles. Rabbit herbivory on competing vegetation appeared beneficial. Snail and slug levels were high in the moist lush herb layer and difficult to control. Only two milkvetch successfully established from this 2005 cohort (Meyer, 2007).

Conditions in CSMR Plot 5 changed dramatically again in 2006. Carpets of seedlings appeared across the introduction site and by August, hundreds of young plants were present across the site. An extremely dense patch with many hundreds of milkvetch established in the Plot 5C area, and we estimated about 1/3 of these plants reached sufficient size to flower in their first summer.

From 2006 through 2009, the plot area supported large numbers of new natural recruits, and several cohorts of plants recruited in prior years. Some milkvetch in the extremely dense 2006-recruited patch persisted but had low vigor in their fourth year. Expansion in adjoining areas was observed in 2008, with some milkvetch now occupying the northern edge of the high marsh, on the edge of the *Lolium* meadow (about 1-2 meters southward of the original plot area).

In 2009, many of the prior year recruits were still present along with new recruits of the year, but soil moisture levels were in decline. Rainfall levels were low (rain table X), and increased gopher activity within the plot was concerning. Milkvetch were being pulled below ground by gophers operating from their tunnel system and also utilizing large cracks in the clayey soil. The southern margin of the plot looked hot and dry and milkvetch exhibited moisture stress and low levels of flowering and fruiting. The shallow well showed no free water at the floor (dry at 115 cm bgs).

With the onset of the 2010 growing season, rainfall returned to average levels (Figure 2). Weeds expanded in areas previously disturbed by gophers. Coyote brush was also increasing in the plot area, creating more hiding cover for rabbits. Their herbivory zones were in localized scattered locations across the plot, rather than in a continuous band adjacent to the dense coyote brush stand. We thinned out and trimmed back several coyote brush individuals in order to reduce localized rabbit hiding cover. Snails and slugs increased, and were hand removed. Cardboard pieces were laid on the ground and lifted several days later, to enable the capture and removal of slugs. A small native mustard, not yet observed in the plot area, was documented in winter and early spring in 2010 (*Cardamine oligospermum*).

The overall number of milkvetch in the plot in 2010 declined precipitously. By September, most milkvetch along the southern exposed edge of the plot were removed by gopher activity. No live milkvetch remained in the dense 2006 patch area. Milkvetch were concentrated in the north end of the Plot 5 area. Milkvetch vigor during flowering

and fruiting was reasonably good on the north end of the plot, more distant from the high salt marsh.

Annual rainfall in water year 2010/2011 was about 20% above normal (Figure 2). In early February, we visited the plot and observed no new seedlings or juveniles. No evidence of new basal shoots was observed on any of the remaining adults, even though they did not exhibit evidence of herbivory and did not seem to be dead (rootstocks and stem base tissue felt firmly rooted without decay). Water levels in the shallow well were high (21 cm bgs) and the ground was very soggy. The majority of the plot area exhibited high levels of herbivory attributed to rabbits, with annual grasses and weedy forbs less herbivorized along the southern, exposed edge of the plot, further from hiding cover.

In late February 2011, we established a 2 meter X 4 meter direct seeding plot just west of the original Plot 5 location. Three hundred milkvetch seed (from a bulk seed collection produced by founders at CSMR in 2004 and representing up to 17 maternal lines) were mixed with sandy potting soil and distributed across the top of the seed plot. Twenty four inch tall hardware cloth was installed around the perimeter to discourage rabbit herbivory. It started raining as we finished applying the seed. Additionally, we placed several pieces of hardware cloth at ground level and caged five prior year adults that appeared to not be reshooting, in order to exclude rabbit herbivores.

No milkvetch seed was subsequently observed to have germinated in the seed plot, nor did any milkvetch emerge from seed bank under the hardware cloth pieces. The seed plot quickly became carpeted in young grasses and forbs. Three forbs, sweet clover, (*Melilotus* sp.), sheep sorrel (*Rumex acetosella*), and vetch (*Vicia sativa*) were common in the seed plot exclosure but entirely absent outside, indicating these species can be entirely removed by herbivores. One adult milkvetch finally started to reshoot and flowered and fruited in the north central area of Plot 5. Gopher activity was extremely low throughout the growing season.

As of 2012, only the single adult milkvetch, recruited in 2010, was extant in the plot area. Virtually no seedlings or juveniles were observed. The southern edge of the plot supported annual grasses and weedy forbs, while the remainder had very low cover of annuals. Expansion of halophytes in the plot area and just to the west, was also observed, suggesting salinity may be increasing, and milkvetch may no longer be able to persist here.

Coal Oil Point Reserve

COPR Lagoon and COPR Pond 2003 Introductions

We initiated modest outplanting trials in January of 2003 at two sites at the Coal Oil Point Reserve- COPR Lagoon and COPR Pond. This consisted of installing nursery-raised milkvetch, and direct seeding. This effort was not described in detail in the Meyer, 2007, report.

Eight milkvetch plants, about one year old, and growing in one quart milk cartons were installed at each site in late January 2003 and watered in on the day of outplanting. These milkvetch were propagated at the Coal Oil Point nursery, overseen by COPR

Preserve Manager Dr. Cristina Sandoval. The COPR Lagoon plants were provided supplemental water on four occasions, about every two weeks, with no further irrigation after March 17, 2003. The COPR pond plants received no supplemental irrigation. No caging or exclosures were used.

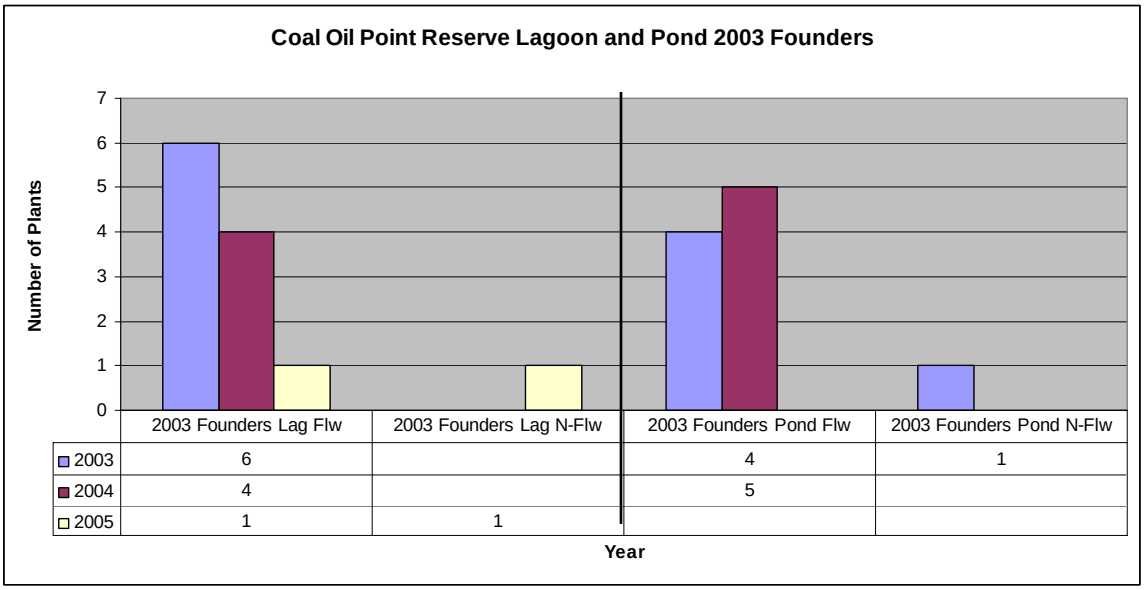


Figure 12. Status of 2003 founders at COPR Lagoon and COPR-Pond, observed during the August summer monitoring session. Original 2003 founders N= 8 for each site.

Figure 12 shows the status of these founders at both sites, for 2003 – 2005. The nursery-raised plants established reasonably well, and produced abundant flowers and fruits in the summers of 2003 and 2004. At COPR Pond, the onset of drought conditions in July 2004 reduced plant vigor and fruit production. Flooding of the dune hollow at COPR Pond in 2005 inundated this group of plants, along with those in the adjacent direct seeding plot.

At COPR Lagoon, the 2003 cohort declined in the wet winter and spring of 2005 as the herb layer expanded and direct herbivory increased, attributed to rabbits and meadow voles. Meadow vole use of the COPR Lagoon area was not initially evident in 2003 and 2004, as much of the herb layer was unvegetated. Annual grass cover was very low in the previous two years, but conditions shifted in the wet winter of 2005 and increased cover of annual grasses and continued expansion of western ragweed were observed. It is likely that as annual grass cover increased, meadow voles began residing in the plot area. In 2006, cropped runways were evident and closely-cropped grass patches were common around the bases of the original 2003 founders and the seed introduction plot. None of the founders or seed plot plants were able to reshoot under this herbivory pressure in 2006. It should also be noted that the surviving 2003 founders were over four years old in the summer of 2005, and were therefore nearing the end of their typical lifespan.

2003 Direct Seeding Trials

On January 30, 2003, we installed six direct seeding plots at several locations at COPR Lagoon, COPR Pond A and nearby backdune areas. Plots were 60 cm X 60 cm. Two hundred seeds were sprinkled by hand into five shallow trenches made with a knife, and a cup of sandy soil was applied over the seeded rows, and lightly tamped down. Seeds were not pre-treated, but were probably being stored in a refrigerator. Coal Oil Point Reserve nursery-regenerated seed, of unknown maternal lines, was used for these trials. The COPR Lagoon seed plot # 2 was irrigated on three occasions by UC Reserve staff, but not watered after March 14. The other seed plots near COPR Pond were not irrigated.

The two direct seeding plots located in low areas within sandy backdunes were not observed to produce any seedlings. Plot # 5 was a low swale with sparse cover of western ragweed and scattered dune lupines and coyote brush. Plot #6 was about 22 meters (75 feet) to the north, but with similar sandy soil, sparse to dense western ragweed and scattered dune lupines.

Direct seeding plot # 1 was located in a shallow moist swale at the Lagoon plot, near patches of salt marsh plants such as *Jaumea carnosa* and *Frankenia salina*. The location exhibited evidence of surface sheetflow following late winter and spring rains, and milkvetch did not establish. The seed may have been washed out of the plot and into the high salt marsh. Seed Plot # 4 at COPR Pond also experienced sheet flow during rain events but seven seedlings were observed there in July. They disappeared by November 2003.

Figure 13 shows the number of seedings/juveniles present over the growing season in 2003 at the two most successful direct seeding plots. Several seedlings were first observed on March 8 at the lagoon plots (email from University staff). Forty one seedlings were observed approximately 7 weeks after initial planting at the COPR Lagoon seed plot # 2. Additional germination occurred after April 3, and by mid-July, eighty one juveniles were documented, two of which reached sufficient size to flower (Photo 1). The pond site exhibited less initial germination but by July, 23 juveniles were present (Photo 2). When the plot was checked in November, one juvenile reached sufficient size to bloom.

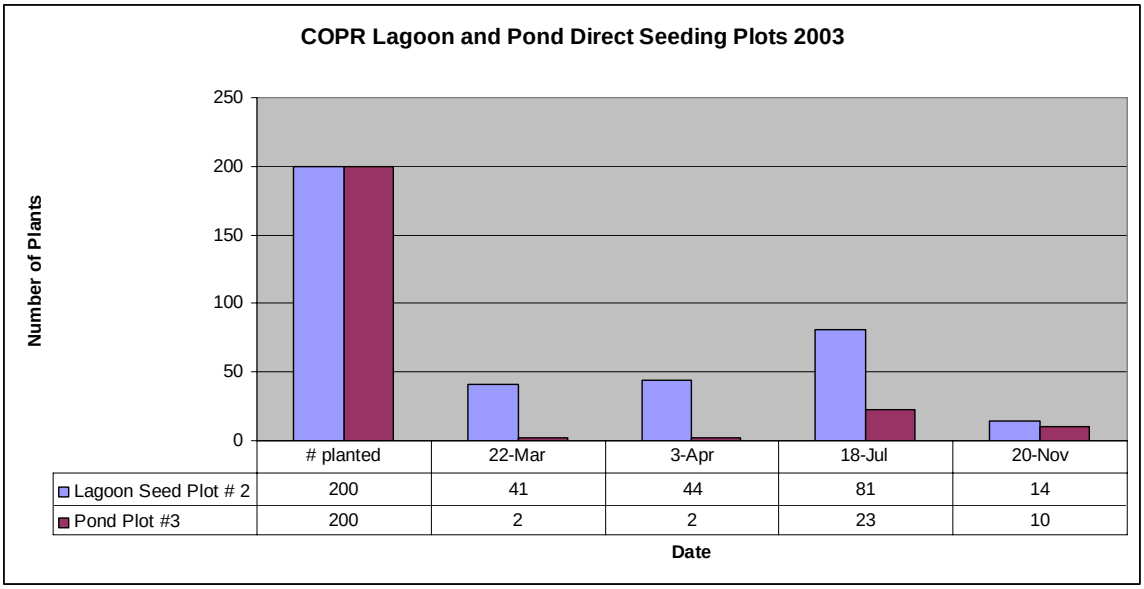


Figure 13. Number of seedlings/juveniles at Coal Oil Point Reserve direct seeding Plots 2 and 3, in 2003. Plots installed January 30, 2003.

We had no idea how many seeds might germinate in the plots, and so we were surprised when about 40 percent of the seed germinated and established so quickly in Lagoon Plot # 2. During the 2004 growing season, Lagoon Plot # 2 and Pond # 3 were both dense patches of numerous stems and counting individual plants proved difficult. In 2004, Lagoon Plot # 2 supported numerous plants growing very densely together, included a stem measured 124 cm, 24 cm taller than any of the 2003 founders growing on their own nearby. In 2005, this plot again contained numerous dense flowering stems but we could not count individuals. By spring 2006, increased grass cover was followed by expansion of meadow voles and milkvetch in the seed plot were unable to successfully reshoot.

In 2004, COPR Pond Seed Plot # 3 contained 47 stems, 32 vegetative, 11 flowering, and we estimated it appeared to be four individuals. The pond plot area exhibited dry conditions in summer 2004, so fewer flowers and fruits formed in this patch compared with the lagoon site. Plants in this seed plot did not survive the inundation of winter 2005.

Photo 1. COPR Lagoon direct seeding Plot # 2, July 18, 2003, with 81 milkvetch, growing next to a planted *Jaumea carnosa*. Note taller stems are producing flowers. *Melaleuca* mulch litters the open soil surface.

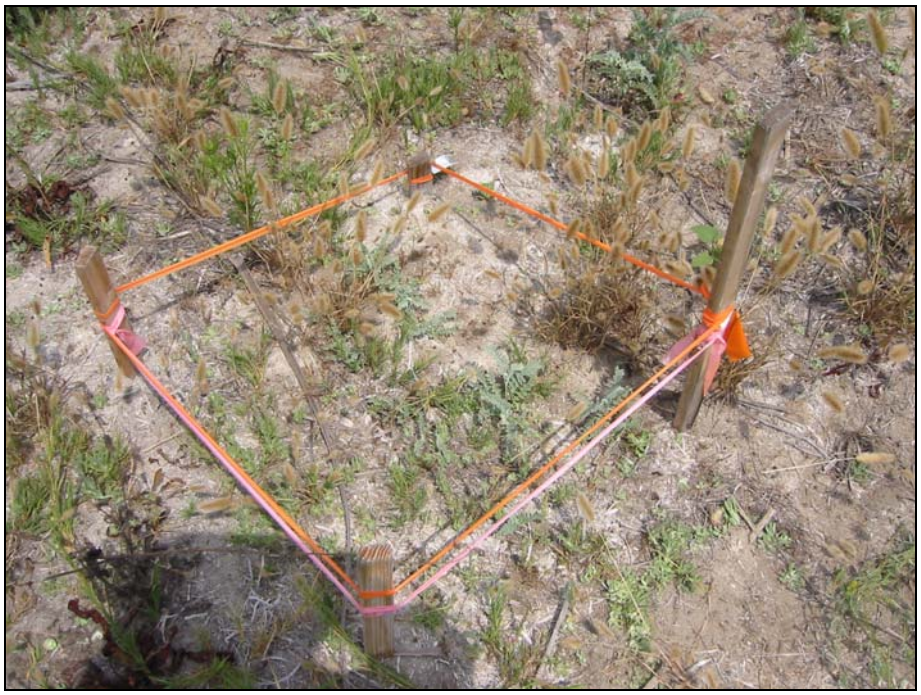
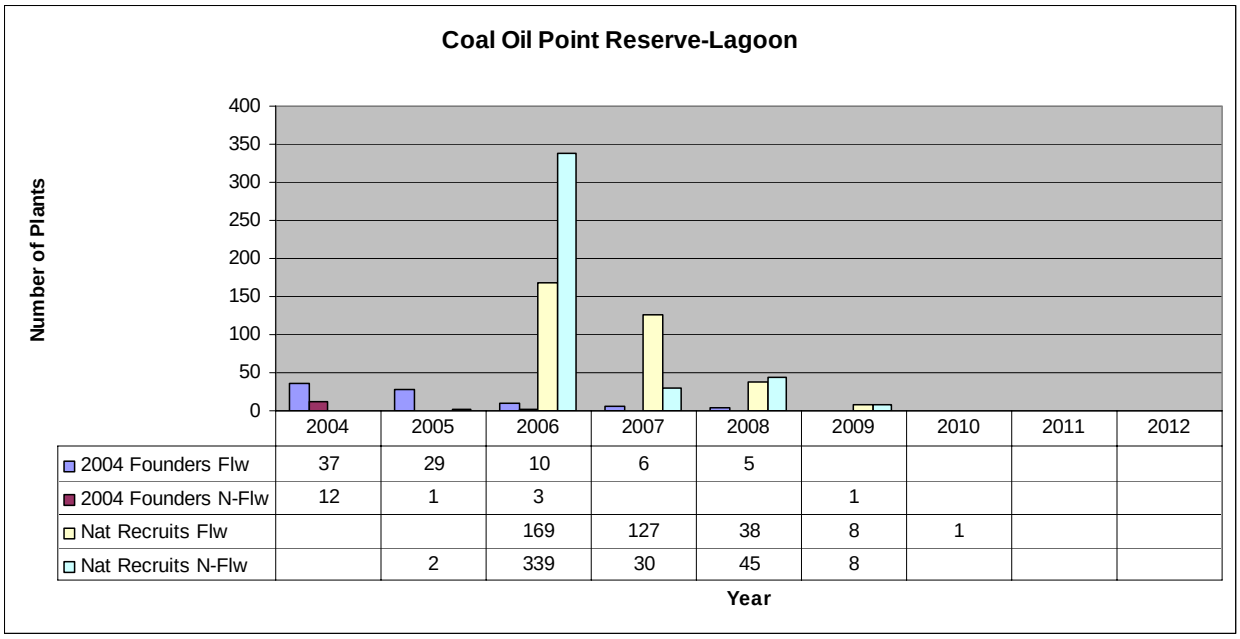


Photo 2. COPR Pond direct seeding Plot # 3, July 18, 2003, with 23 juveniles. This plot was potentially inundated briefly in spring 2003.

COPR Lagoon 2004 Introductions

Figure 14 summarizes the number of flowering and non-flowering 2004 founders and natural recruits at the COPR Lagoon plot across the observation period of 2004 through 2012. The previous 2003 installation of founders and direct seeding Plot #2 produced seeds that contributed to the natural recruitment described below.



	2004	2005	2006	2007	2008	2009	2010	2011	2012
2004 Founders Flw	37	29	10	6	5				
2004 Founders N-Flw	12	1	3			1			
Nat Recruits Flw			169	127	38	8	1		
Nat Recruits N-Flw		2	339	30	45	8			

Figure 14. Status of 2004 founders and natural recruits documented during the August summer monitoring session at COPR Lagoon. Original 2004 founders N= 54.

The 2004 founders established reasonably well, with 91% survival and excellent vigor in their first summer. A single naturally recruited juvenile was observed on April 2, but it disappeared by summer.

High rainfall in 2005 contributed to increased growth and cover of the herb layer. Western ragweed, annual grasses and ruderal forbs expanded. Localized rabbit herbivory zones became more apparent as bare areas declined. A small patch of salt grass and planted fleshy jaumea, both located near the seed plot, increased substantially. Thirteen seedlings were observed on February 4. Only one remained by May 2. Two were documented during the August monitoring session, and two more were found in October. One juvenile was located in the patch of salt grass, and this individual persisted into 2006, but was stunted and never matured.

In 2006, continued expansion of the western ragweed stand occurred, and more open growing conditions were limited to the eastern half of the plot area. In early winter, localized areas were turbated at the surface, which was attributed to skunk foraging. No seedlings came up on the turbated ground. Around forty juveniles were observed in early April, and additional fresh surface turbation was seen (appearing as both surface rototilling and divets). Meadow voles were residing in the 2003 introduction area, and no prior year adults were reshooting in that area. Direct herbivory on 2004 founders, attributed to rabbits (chomped stems) was increasing throughout the plot. In response,

two wire above-ground exclosures were installed in April around several founders and concentrations of juveniles (covering about 2 meters X 11 meters in total). Individual wire cages were placed around seven 2004 founders as well. By August, hundreds of juveniles were occupying the ground within the exclosures, and thirteen were outside, growing in rabbit-cleared areas around three 2004 founders. About 1/3 of the 2006 natural recruits matured sufficiently to flower. The exclosures were removed in fall 2006. Individual wire cages remained in place.

Rainfall in 2007 was the lowest recorded across the period of observation (44% of normal, Figure 3). Forty five juveniles were documented on March 29, concentrated beneath founders in two relatively bare areas, likely cleared by rabbits. By May 23, the number of juveniles had doubled to ninety one. Just over an inch of rain fell in the month of April 2007, which may have helped these juveniles. Thirty were still present during the August monitoring session. Hundreds of 2006 recruited juveniles persisted in a very dense patch, occupying about 31 square meters. It was not feasible to count individual plants within the dense patch, so numbers in Figure 14 include estimates for 2007. Alkali rye grass (*Leymus triticoides*) was observed at scattered locations along with occasional blue wild rye (*Elymus glaucus*). Both species were first observed in 2005, but appeared to be expanding.

In spring 2008, many new juveniles were observed in the less vegetated portion of the introduction area and were too numerous to count. However, many were seen dessicating on May 20, and the soil surface was quite dry. While annual rainfall for water year 07/08 was near normal, most of this rain fell in the months of December, January and February. Almost no rain fell in March, and no rain was recorded for April through August. By late July, only a few juveniles remained in small groups at locations with sparse cover of annual grasses, in herbivorized areas or under shrub canopies which may have contributed some fog drip.

The plot area continued to experience expansion of alkali rye grass and salt grass in 2009. Very few of the 2006-recruited cohort in the dense patch were reshooting. The large amount of prior years' milkvetch twiggy biomass and expanding alkali rye grass was providing increased hiding cover for rabbits and meadow voles. By August, the only surviving flowering individuals were eight plants recruited in 2008 growing in a small area still supporting annual brome and slender fescue. This location appeared to be the driest and most open portion of the plot.

One 2008-recruited milkvetch survived and flowered in 2010. No juveniles were observed. No plants were seen at this location in 2011. As of 2012, the entire plot area was now supporting a continuous dense stand of alkali rye grass, with thick, tall residual thatch (50 cm or greater) surrounded by tall coyote brush and adjacent arroyo willow thickets. Conditions no longer appear suitable for milkvetch, although considerable seed likely remains in the plot area.

COPR-Pond

The COPR Pond introduction area has proven to be one of the most interesting introduction sites. From an initial 2003 installation of five nursery-grown plants and 200 seeds (in direct seeding plot # 3), naturally recruited milkvetch have continued to emerge, establish, and occasionally mature sufficiently to produce fruits. One satellite

area has established to the south of the original Pond A introduction area. A milkvetch established here ("feral") after the 2005 flooding and new recruitment continues in this location. A single survivor of the 2004 introduction at Pond D (west of Pond A) also initiated a satellite area. Genetic diversity of source material used for these introductions is likely low, as plants originated from unknown maternal lines.

During winters with above-normal rainfall, the outplanting area in the dune hollow experiences inundation and is temporary flooded, sometimes for a couple of weeks, and in very wet years (2005, 2011), for months. Exact periods of inundation are not known. Longer periods of inundation (greater than 10 days) are believed to result in loss of the previously recruited milkvetch cohorts (Meyer, 2007).

Temporary flooding of the dune hollow in wet winters can have a variety of positive effects. Localized bare areas favoring milkvetch and annual herbs are sometimes observed in small patches after flooding. Most importantly, milkvetch seeds germinate after inundation events and sometimes successfully establish. Temporary flooding also potentially carries milkvetch seed to new areas distant from the original parent plants. Dry down following flooding appears to represent a condition that allows juvenile milkvetch to establish at locations where the soil surface otherwise may be too dry in years of normal rainfall.

Small mammal herbivores which eat milkvetch, or collect their seeds- in particular rabbits, pocket gophers, mice and meadow voles, are displaced during inundation events or may even experience mortality, reducing direct herbivory pressure on milkvetch to varying degrees until their populations recover, or they return from adjoining non-flooded areas.

Longer periods of inundation appear to influence survivorship of shrubs. Dune lupine and coyote brush tend to drown during longer flooding episodes, reducing hiding cover for rabbits in the herb-dominated dune hollow. Following the 2005 and 2011 inundation events, new recruitment of arroyo willows was noted. In relatively dry 2012, many of these small shrubby willows appeared stressed by drought, with summer leaf drop. It remains to be seen whether these willows will establish and enlarge. Dense cover of willows would probably have a negative effect on milkvetch persistence if open growing conditions disappear.

Figure 15 summarizes the number of flowering and non-flowering 2003 and 2004 founders and natural recruits at the COPR Pond area across the observation period of 2003 through 2012. Figure 15 does not include the four plants that flowered and fruited in 2004 in a direct seeding plot (see Figure 13 for direct seeding plot data for 2003). Seed produced in the direct seeding plot contributed to the seed bank. The 2003 introductions were located more specifically at Pond Plot A.

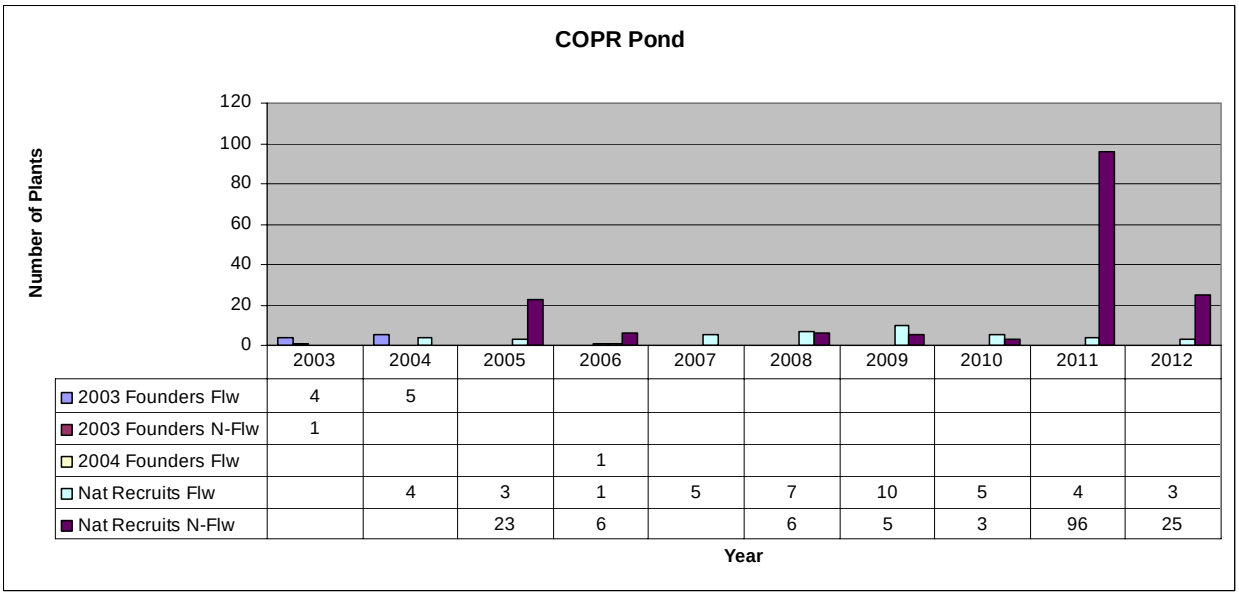


Figure 15. Status of 2003 and 2004 founders and natural recruits at the Coal Oil Point Reserve-Pond introduction area during the August monitoring sessions. Original 2003 founders N= 8. This table combines all observed milkvetch in Pond Plot A (the original 2003 introduction area), Pond Plot D (where one 2004 founder established) and a satellite area nicknamed "Feral".

The 2004 introduction was largely unsuccessful. Contributing factors include a late outplanting date (mid-May), inadequate irrigation exacerbated by rapidly draining sandy soil, onset of drought conditions in summer and loss of subsurface moisture when the adjoining pond dried out. The single 2004 founder in Pond Plot D that did establish was observed in poor condition and noted as dying during the August 2004 monitoring session. We did not check this specific location in 2005. The plant was discovered in full bloom in August 2006. This individual was located about 23 meters (75 feet) west of the original plot area and is in the vicinity of the 2005 inundation boundary. It appeared to have either survived the 2005 inundation, or probably was not inundated for very long. This individual exhibited good vigor and had produced considerable seed in August 2006 when we discovered it was still alive. Twenty seedlings were observed here in February 2007, but were dessicated by May. Seedlings were not observed here in 2008 or 2009, but it is possible there was germination that was missed. In 2010, numerous seedlings were again noted in the vicinity, but none established. Soil moisture improved in the wet winter and spring of 2011. By summer, a single stemmed milkvetch was observed in flower and fruit, and a juvenile was nearby. In summer of 2012, the single adult milkvetch was mature, in full flower with eight robust stems, but no juveniles or seedlings were observed.

Following the 2005 extended inundation, another milkvetch, labeled Feral, was discovered in August 2006, and was about 30 meters (100 feet) to the south of the original introduction area at Pond Plot A. The location was close to the backdunes, and it is likely that seed dispersed there by shallow flooding during the 2005 inundation. The area is a localized topographic low spot that experiences more inundation than the adjacent surrounding area several meters away. From this single individual, new recruits continue to establish into 2012. Pulses of new recruits are typically seen at this location

following wet winters. The natural recruits are often crowded and congested in a small area (4 meters X 3 meters). Crowding at this location produces small plants that are less likely to flower. A large pulse of new individuals established following extended inundation in the winter of 2011. The 2010 milkvetch in this area were directly observed standing in water in March 2011. Due to crowding and low vigor, most of these plants did not flower in 2011 or 2012.

Two other milkvetch were observed in August 2006 about 18 meters (60 feet) west of the original outplanting area. These two plants potentially arose from flood-distributed seed, and each had one long stem clambering through dense 1 meter tall skeletons of sweet clover and western ragweed. These plants did not flower and were dried out when revisited in the fall. They were not detected in subsequent years.

Rainfall in water year 2009/2010 was around 22 inches, about 20% above normal (Figure 3). However, the prior year experienced below normal rainfall which likely contributed to the poor milkvetch establishment in 2010. The pond refilled in winter, but only to the level of an inner row of tules, and did not extend out to the more normal outer ring of tules. Seedlings in the vicinity of Plot D, which appears drier than the Pond A and Feral area, were observed dessicating on March 22, 2010 and failed to establish.

An unusual condition was documented during the 2010 season. Masses of millkvetch seedlings and young juveniles, originating from hundreds and probably thousands of germinating seeds, were observed in the Pond A plot on March 22, 2010. The Pond A area exhibited very high continuous cover of salt grass, with scattered western ragweed. Few bare areas or sparsely vegetated areas remained. Masses of milkvetch seedlings and young juveniles were concentrated in areas where native herbivores had reduced salt grass thatch and cover. These were typically located under the bases of the prior year milkvetch; along meadow vole runways and near entrances to meadow vole tunnels; and along rabbit-grazed paths and bedding areas (Photo 3).

Several distinct, germinating seed caches were observed several meters away from the location of prior year adults, containing large numbers of milkvetch seedlings and including another legume, *Melilotus* sp. (Photo 4). The discreet seed caches represent stashes of seed collected by small herbivores, most likely some type of pocket mouse or meadow vole. The masses of juveniles beneath prior year adults could represent cached seed as well. It is also possible that accumulated seed emerged in areas with reduced thatch where meadow voles and rabbits graze, which happened to include beneath the cover of adult milkvetch.

The dense masses of juveniles and occasional single individuals were still doing well on June 1, 2010 (Photo 5). Some leaves were dessicating but overall vigor still looked good. By the end of summer, a few individuals in less competitive conditions had reached about 20 cm in size, but eventually, all of these juveniles dessicated in fall and failed to establish.

Photo 3, Left. March 22, 2010. Numerous milkvetch juveniles at the outer entrance to a meadow vole tunnel in thick *Distichlis* thatch. Rabbit pellets visible as well. Voles often process trimmed vegetation or consume previously accumulated food items at tunnel entrances (Meyer, personal observation).

Photo 4, **Below.** Germinating seed cache, including milkvetch and *Melilotus* sp., at COPR Pond A.

Photo 5. COPR Pond A June 1, 2010. Masses of juveniles have continued to grow and enlarge, despite very high density. By late summer, none of these established.

In 2010, two plants in the Feral plot achieved sufficient size and vigor to potentially flower. However, we were surprised to find they did not flower, including the largest plant (stems 75 cm) recruited in 2008. Flowering levels were noted as modest to low on five adults in Pond A. A potential reason for low levels of flowering in summer 2010 was an increase in summer fog. A local newspaper article describes that the summer of 2010 was one of the gloomiest and foggiest summers recorded (Stewart, 2010). The article describes University of California Santa Barbara researcher Park Williams' examination of old weather records associated with fog at the Santa Barbara Airport in Goleta, about four km (2.5 miles) from the COPR Pond introduction area. The article states that June 1 through August 8, 2010 has seen the most number of hours with fog from 6 am to 12 pm, since the airport started recording such things 52 years ago.

The COPR Pond dune hollow was again flooded in winter 2011 for an extended period of time. Drydown in the vicinity of the feral location generated a new set of individuals from seed, growing in generally crowded conditions. Eighty-eight stems were counted in September, and the estimated number of plants was 46, most of which were not flowering. Some buds were forming on the taller stems. Two individuals in the feral plot observed on January 13, 2012 exhibited evidence of having flowered and produced fruits.

Fifty one milkvetch in good vigor were observed in the COPR Pond A area on September 8, 2011, mostly growing as individual scattered plants in small localized bare areas within the salt grass patch. These plants were shorter than the bulk of the feral group, and likely germinated later. On January 13, 2012, only 9 plants were relocated,

one had pods, and all appeared to have been topped, probably by rabbits. Most of the remaining stems exhibited epithelial stripping, possibly caused by mice. This represents the highest amount of direct herbivory on first year plants observed at this location.

Rainfall in 2012 was low, and a dry spell from January through February occurred which may have contributed to low recruitment from seed. The feral patch was still crowded and plants were in low vigor. Conditions appeared highly competitive, and only one produced flowers. Low soil moisture was evident in the general dune hollow area in 2012, and some of the salt grass that had expanded on 2011 flooded terrain was contracting and looked stressed. Western ragweed stems were short and limp near the Pond A area. Thousands of new rosettes of Hooker's evening primrose were present on the 2011 patches of flooded ground, and many looked moisture-stressed. Some new patches of alkali heath (*Frankenia salina*) were also drying in late summer 2012. The salt grass in Pond A looked dry in summer but was still continuous and thick. Gopher activity increased but was concentrated several meters beyond the Pond A salt grass patch, and was most evident in western ragweed stands.

Weather conditions are likely to change again in 2013, and continued observation of this introduction area is warranted.

Shifts in Associated Vegetation at Key Introduction Sites

In the following section, shifts in vegetation observed across the study period over the last decade are discussed relative to each of the introduction sites where milkvetch established and where natural recruitment has occurred. Wetland indicator status is based upon Reed, 1988. Vegetation shifts are also discussed for several failed sites at the CSMR salt marsh, where there is some indication of potential sea level rise over the last decade.

Observations for the 2002 introduction areas are reported in Soza, et al. 2003, and are compared here with conditions observed in 2012. Their vegetation assessments were reported for February 2003, about nine months after milkvetch were first introduced and these data are reflected in the tables below, where applicable. Base photos taken in July 2002 (Soza, et al. 2003) were used for comparison with conditions in late summer of either 2011 or 2012. Observations in 2012 were conducted in August and September 2012. Vegetation assessments in or around the plot areas typically consisted of visual estimates of relative cover emphasizing the herb layer and shrub layers. Plot photographs were also used to inform these estimates.

Vegetation shifts at introduction sites appear to be the single most important factor contributing to changed suitability for milkvetch. Loss of canopy gaps/bare areas has led to declines at the majority of outplanting sites.

Mandalay State Beach

Introduction sites at Mandalay 1 and 1B are located on relatively flat open ground with course sandy soils, and are adjacent to a large band of established arroyo willow in a shallow dune swale. A band of coyote brush abuts the willows at Mandalay 1. The

vicinity of both plots appears severely herbivorized by rabbits. Surface litter adjacent to Mandalay 1 is covered in rabbit pellets, and the southern exposed edge of the plot supports severely cropped horsetail stems (*Equisetum laevigatum*), another species apparently favored as browse for rabbits (Photo 6). The semi-perched aquifer at this location is the most distant from the surface, and measured at 128 cm bgs in January 2004 (Meyer, 2007).

Photo 6. Severely and persistently herbivorized horsetail and high density of rabbit pellets on open low dunes, two meters south of the Mandalay 1 plot. This ground has changed little over the last decade of observation.

The primary shift that has occurred at Mandalay Plot 1 is the expansion of Mexican rush (*Juncus mexicanus*), a thatch producing rhizomatous perennial (FACW). The original plot area in 2003 had a small amount of Mexican rush, but an adjacent denser patch spread across the narrow plot and now dominates the herb layer (Figure 16).

Recruitment at Mandalay 1 is very low, and occurred only in the wettest year we observed (2005). Future recruitment from seed bank is still possible and the plot area should be checked in years of high annual rainfall.

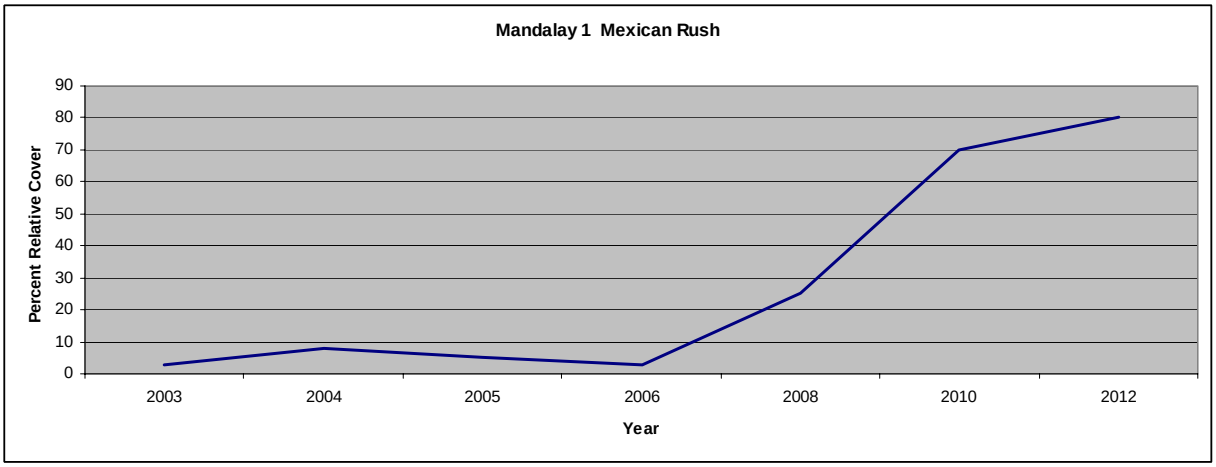


Figure 16. Changes in relative cover of *Juncus mexicanus* at the Mandalay 1 introduction site.

The other primary change at Mandalay Plots 1, 1A, and 1B has been an increase in the height and breadth of coyote brush and arroyo willow. Arroyo willow has overtopped and expanded into a small herbaceous gap in the willow thicket at Mandalay 1A, and the area is now shaded much of the time. Two wetland obligates, basket rush (*Juncus textilis*) and western goldenrod (*Euthemia occidentalis*), were not observed at Mandalay 1A in the first couple of years, but now dominate much of the herb layer in dense willow shade.

At Mandalay 1B, the established arroyo willow thicket has increased in width to such an extent that the branches extend 1.75 meters (5.75 feet) and now overtop locations where 2004 founders were installed adjacent to them in full sun.

The general area on the south end of Mandalay State Beach adjoining West 5th Street, is a broad low dune hollow that is traversed to reach the introduction sites. This area has also exhibited an increase in the cover and extent of obligate and facultative wetland herbs. Areas that were typically dominated by western ragweed and scattered Mexican and Baltic rush in 2003 are now dense rush-dominated meadows. Patches of basket rush, a wetland obligate, have enlarged and expanded. Localized patches of yerba mansa (*Anemopsis californica*), a wetland obligate, have also enlarged and vigor has improved. Heliotrope (*Heliotropium curassavicum*), a wetland obligate, is much more abundant. Overall, the general area appears far more mesic than it was in 2003.

McGrath State Beach

Three of the five 2002 introduction sites at MSB where milkvetch established were located in wetland transition zones between McGrath Lake and adjacent low sandy dry dunes. These three sites (MSB 3, 4, and 5) were also close to a semi-perched aquifer (Meyer, 2007) and this likely contributed to milkvetch persistence and high vigor, once they establish. The largest introduced founders grew in these plots in 2004 during their second summer (Meyer, 2007). The largest number of inflorescences on a single random stem, measured during our monitoring sessions, was 442 at MSB 3E on a 2006 plant recruited in 2005.

Extreme flooding occurred in 2005 and altered the three original 2002 planting areas. Cohorts of milkvetch seedlings drowned, and 2002 and 2004 founders did not survive the inundation events, which typically lasted at least two weeks. Following the 2005 flood events, milkvetch appeared following dry down at new locations on the driest margin of the flooding zone, where we believe seed was carried during the flooding events (Meyer, 2007). These new areas were labeled MSB 3E (ie. refers to the extention of plot 3) and MSB 4E.

Since that time, the MSB 3 and 4 plot areas have exhibited a substantial increase in cover in the shrub and herb layers, and the overall biomass has increased dramatically. There are new arroyo willows which are overtopping and shading the original MSB 3. Sandbar willow expanded and a willow thicket now dominates the MSB 5 location. A large expansion of coyote brush has occurred throughout the eastern lake margin and there are many more young willows growing in previously herb-dominated wetland margins.

All three original plots have exhibited a marked increase in cover and dominance by wetland indicators since the initial 2002 installation of founders. Total shrub cover has increased at all three sites (Table 3, 4 and 5).

MSB 3	**Descrip-tion**	**Plant Community**	**Dominant Veg Cover**	**Dominant Veg Wetland Status**	**Total Veg Cover**
2003 status	Coastal dune swale	Baccharis, Artemisia and Salix scrub	*Baccharis pilularis* (5%) *Ambrosia psilostachya* (20%)	phreatophyte FAC	30% Shrub Cover 5%
2011 status	Dune swale transition to margin of McGrath Lake	*Baccharis pilularis-Toxicodendron diversilobum* Association with emergent willow	*Salix lasiolepis* (40%) *Baccharis pilularis* (20%) *Toxicodendron* (5%)	FACW phreatophyte phreatophyte	95% Shrub cover 65%

Table 3. Comparison of associated vegetation at the original MSB 3 introduction area, February 2003 and August 2011.

Milkvetch no longer can grow in the original MSB 3 plot area. As of 2012, the original area is underneath four meter tall arroyo willows, with considerable expansion of poison oak, a phreatophyte common in dune hollows, and western goldenrod, a wetland obligate (Table 3).

The adjoining MSB 3E area exhibits the least change in associated vegetation and milkvetch continue to come up in this location. The low dry dune to the immediate north appears to limit establishment of both milkvetch and additional wetland margin vegetation (Photo 7). Milkvetch occasionally emerge on the low dunes in late winter, but

dessicate and fail to establish. The western ragweed common in the MSB 3E plot area is usually short and open, and I believe this may be due, in part, to intense rabbit herbivory pressure.

The most striking difference in wetland margin vegetation in the vicinity of the MSB 3/3E is the lack of rushes, salt grass and slender carex which have otherwise exhibited a dramatic expansion along the eastern margins of McGrath Lake. The absence of this suite of rhizomatous weteland herbs may be associated with a small wildfire which occurred in this vicinity several years prior to the 2002 milkvetch introduction. Black ash was visible on the dry sand in the area at the time VMMV were installed. The exact date of this fire and extent is not currently known, but I hypothesize that the fire may have eliminated this suite of plants and could have burned fairly hot if dense thatch was present and conditions were somewhat dry.

Photo 7, MSB 3E August 13, 2012: An expanding patch of slender carex, Mexican rush and salt grass (right) is moving over the crest of a low dune, through the iceplant and is likely to eventually reach the MSB 3E area (left). McGrath Lake is in the background behind a band of tules.

A patch of these rhizomatous, thatch-producing herbs is located to the north of MSB 3E in a dune swale near the lake, and has been continually expanding. In 2012, the expanding patch dominated by slender carex had reached the crest of the low dunes,

was coming up through the iceplant, and sending out runners (Photo 9). As of August 2012, slender carex was within 9 meters of the north edge of the MSB 3E plot area. This troubling change suggests that the suitability of this limited area near McGrath Lake for milkvetch may decline in the future.

The lack of annual grasses at the MSB 3E location may be attributed to high rabbit herbivory, as only *Schismus barbatus* is typically seen here, and exhibits the symptoms of being continuously herbivorized (appressed to the ground surface). In my opinion, this cespitose form of schismus is a response to repeated cropping by herbivores, as I have found unherbivorized individuals nearby, protected by woody debris that are entirely erect. Annual bromes are common about 9 meters away on the open low dunes, but do not seem to establish or persist in the 3E plot area. Gopher turbation appears high in the nearby dune where annual bromes grow. Gopher levels and disturbance has been generally low at the MSB 3E location, probably due to high soil moisture below the ground surface.

MSB 3 and 3E have not exhibited visible evidence of occupation by meadow voles. In contrast, locations with continuous thatch from rhizomatous perennials and/or continuous cover of annual grasses exhibit visible runways and surface tunnel entrances typical of meadow vole activity. There is potential for meadow voles to occupy the MSB 3E plot area, should these annual and perennial herbs expand here in the future. This would likely further contribute to adverse effects on milkvetch persistence.

MSB 4	**Description**	**Plant Community**	**Dominant Veg Cover**	**Dominant Veg Wetland Status**	**Total Veg Cover**
2003 status	Low area of coastal dunes (swale)	Semi-salt marsh w/*Baccharis*	*Baccharis pilularis* (15%) *Ambrosia psilostachya* (95%) *Distichlis* (20%)	phreatophyte FAC FACW	95% Shrub Cover 15%
2011 status	Alkaline meadow-dune hollow with emergent coyote brush and arroyo willow	*Baccharis pilularis*/*Juncus mexicanus*-*Carex praegracilis* tentative association	*Salix lasiolepis* and *Baccharis* (50%) *Juncus*/*Carex*/*Distichlis* blend (40%) *Anemopsis* (20%) *Ambrosia* (20%)	FACW phreatophyte FACW Obligate FAC	100% Shrub Cover 50%

Table 4. Comparison of associated vegetation at the original MSB 4 introduction area, in February 2003 and August 2011.

The herb layer at MSB 4 where milkvetch have not been seen to emerge since after the 2005 flooding, has exhibited a general shift toward dominance by FACW and obligate wetland indicators, suggesting this area has become moister (Table 4). In 2003, the planting area was primarily western ragweed with localized herbivory zones creating canopy gaps, and a few short coyote brush (Photo 8). This condition shifted to dominance by the suite of rhizomatous perennials that include Mexican and Baltic rush, slender carex, and salt grass, with inclusions of yerba mansa and patches of silverweed

(*Potentilla anserina*) (Photo 7). The latter two species are both wetland obligates. Shrub cover has substantially increased.

At MSB 4E, milkvetch established after the floods in a new area in a narrow linear band along the driest edge abutting low dunes and persisted for a few years. However, Mexican rush, slender carex and salt grass from nearby continued to expand vegetatively into the MSB 4E zone, while arroyo willows and coyote brush have overtopped most of the plot. No milkvetch have been observed here since 2010.

Photo 8, MSB 4- July 2002. Original outplants are in tree tubes and much of the area is western ragweed with a few small coyote brush and canopy gaps. The lowest spot in the photo (see red line) supported a small patch of Mexican rush, slender carex and salt grass, which expanded and now occupies much of this area as of 2012. Photo from Soza, et al., 2003.

Photo 9: MSB 4, central plot area, August 2011. The herb layer is continuous and dominated by wetland indicators. Non-native snails are common. Skeletal coyote brush and new recruitment is visible in the plot area. Arroyo willow thickets are now present and expanding on the perimeter of the original MSB 4 planting area. Milkvetch have not been seen here since summer of 2005.

At MSB 5, we observed no evidence of milkvetch dispersing to new areas from seed following the 2005 flooding. Low dry dune edges were distant from the plot. The introduction area was confined, with the lake to the immediate west, a low wet drainage swale to the south, and a dense horsetail meadow to the east. Milkvetch established after flooding in the same vicinity, but the plot area rapidly became shaded by expanding willows and growing conditions are no longer suitable (Table 5).

MSB 5	**Description**	**Plant Community**	**Dominant Veg Cover**	**Dominant Veg Wetland Status**	**Total Veg Cover**
2003 status	Adjacent to marshy area	Salix and Baccharis scrub/marshy area	*Salix exigua* (35%) *Baccharis* (25%)	Obligate phreatophyte	65% Shrub cover 60%
2011 status	Dune hollow and swale adjacent to McGrath Lake	*Salix exigua* Alliance	*Salix exigua*(50%) *Salix lasiolepis* (20%)	Obligate FACW	Shrub Cover 100%

Table 5. Comparison of associated vegetation at the original MSB 5 introduction area, in February 2003 and August 2011.

Carpinteria Salt Marsh Reserve

The following section examines changes in vegetation at five 2002 VMMV introduction plots located in various microsites at the Carpinteria Salt Marsh Reserve (CSMR), in the northeast corner of Basin 2. CSMR 1-4 represent failed plots, which was attributed primarily to high salinity in areas of high salt marsh.

CSMR 1

Ventura marsh milkvetch failed to establish at this plot in 2002. Plants experienced severe snail damage despite snail control, while holes were eaten in the tree tubes and above-ground milkvetch biomass was consumed (attributed to pocket gophers). By spring of 2003, the remaining five plants potentially succumbed to high soil salinity. Topographic elevation is around 5.5 feet msl (Santa Barbara County Flood Control and Water Conservation District, Feb. 2003).

Soza, et al. 2003, indicates that annual grasses (primarily *Polypogon* and *Lolium*) dominated the planting area in 2003, and the upland shrub, coastal goldenbush (*Isocoma menziesii* var. *vernonioides*) was common (Table 6). Coastal goldenbush is not listed as a wetland plant in California (Reed, 1988). Smith (1998) identifies this species as being commonly scattered in salt marshes, low ground and saline situations, decreasing in the interior of the county.

CSMR 1	Description	Plant Community	Dominant Veg Cover	Dominant Veg Wetland Status	Total Veg Cover
2003 status	Mixed *Polypogon* and *Lolium depression*	Estuarine Emergent Wetland- High Marsh	Grasses (80%) *Isocoma menziesii* var. *vernonioides* (45%)	FACW+ (*Polypogon*) Upland (*Lolium*) Upland	85%
2012 status	High marsh/tidal marsh	*Arthrocnemum subterminalis* Alliance *Salicornia pacifica* Alliance in depression	*Arthrocnemum* (40%) *Salicornia* (25%)	Obligate Obligate	95%

Table 6. Comparison of associated vegetation for CSMR 1, comparing February 2003 observations with August 2012.

By 2012, coastal goldenbush and annual grasses were replaced by high marsh wetland obligates (Table 6). Parish's glasswort (*Arthrocnemum subterminalis*) dominates the CSMR 1, along with *Limonium californica* and *Frankenia salina*, both high marsh wetland obligates. A low area within the plot, at the outer margin of the marsh floor, previously supporting *Polypogon monspeliensis* in 2002, was replaced by *Salicornia pacifica* (Pacific pickleweed) and salt grass (*Distichlis spicata*) in 2012. These changes indicate

that the CSMR 1 is wetter and salinity has likely increased over the last decade, as evidenced by the expansion of halophytes.

CSMR 2

Table 7 summarizes key vegetation data for the CSMR 2 failed introduction plot. Three founder VMMV persisted through August 2003 on the driest, northern edge of the plot, but failed to reshoot the following growing season. High salinity, large numbers of snails, and gopher damage contributed to loss of plants here (Soza, et al. 2003). Topographic elevation at CSMR 2 is close to 5 feet msl (Santa Barbara County Flood Control and Water Conservation District, Feb. 2003).

CSMR 2	**Description**	**Plant Community**	**Dominant Veg Cover**	**Dominant Veg Wetland Status**	**Total Veg Cover**
2003 status	*Polypogon* depression	High marsh transition to upland	Grasses (annual) 80% *Ambrosia* 20%	FACW+ (*Polypogon*) FAC (*Ambrosia*)	90%
2012 status	High marsh	*Arthrocnemum subterminalis* Alliance	*Arthrocnemum*:90% *Limonium californicum*: 5%	Obligate Obligate	100%

Table 7. Comparison of vegetation data for CSMR 2, comparing February 2003 observations with August 2012.

In 2002, the planting area in summer was primarily covered in dry annual grasses, with *Polypogon monspeliensis* in the lowest and wettest areas, and brome grasses, including *Bromus diandrus*, on the northern edge and transition up the berm adjacent to the access roadway. Western ragweed was scattered throughout. Patches of Parish's glasswort are visible in the surrounding marsh (Photo 10). Western goldenrod (*Euthemia occidentalis*) was present in extensive patches in 2002 along the outer margin of the marsh floor adjacent to the road berm.

Photo 10. CSMR 2, July 2002. CSMR 3 in background. View south. A stand of taller western goldenrod stems is on the left, and dry annual grasses are visible throughout much of the plot.

By 2012, the planting area is almost entirely occupied by *A. subterminalis* (Photo 11). *Limonium californica* occupies small canopy gaps in the glasswort stand. This indicates a general shift has occurred from dominance by FAC or FACW species in 2002, to dominance by wetland obligates in 2012.

Western goldenrod is typically observed at locations with subsurface freshwater input and lower salinity. Increases in salinity may have reduced the extent of this species in transitional areas along the northern edge of Basin 2. The area which supported western goldenrod in 2002 is now dominated by Parish's glasswort and salt grass (*Distichlis spicata*). A shift to dominance by halophytes suggests increased tidal influence in this vicinity, when compared with conditions in 2002.

Photo 11, CSMR 2 September 20, 2012. View south. Three rebar correspond with three VMMV that persisted through fall 2003. Plot area is now dominated by Parish's glasswort.

CSMR 3

VMMV were originally installed in 2002 primarily in the *Polypogon*-dominated area (described as a depression) associated with localized canopy gaps in the Parish's glasswort stand (Soza et al. 2003). Plants failed to establish at this location, which had the highest soil salinity of all the CSMR introduction plots (Soza et al. 2003). By 2012, Parish's glasswort dominates the entire planting area to the exclusion of other species (Table 8).

CSMR 3	Description	Plant Community	Dominant Veg Cover	Dominant Veg Wetland Status	Total Veg Cover
2003 status	*Polypogon* depression	High Marsh transition	*Arthrocnemum* (45%) Grasses (35%)	Obligate FACW+ (*Polypogon*)	80%
2012 status	High Marsh	*Arthrocnemum subterminalis* Herbaceous alliance	*Arthrocnemum* (95%+)	Obligate	95%+

Table 8. Comparison of vegetation data at CSMR 3 for 2002 and 2012.

CSMR 4

The CSMR 4 planting area in 2002 supported a dense patch of *Lolium multiflorum*, a non-wetland invasive annual grass. Milkvetch introduced to this area in 2002 failed to establish. Twenty-two of the 31 founders installed here were reshooting in February 2003, but by early summer, surface salt deposits were observed and the milkvetch abruptly died, with subsequent removal by pocket gophers as the galvanized chicken wire cages had disintegrated in the moist saline soil. Elevation here is around 4.5 feet msl (Santa Barbara County Flood Control and Water Conservation District, 2003).

Parish's glasswort was present in 2002 and small plants were scattered throughout the plot co-mingled with the *Lolium*. By 2012, *A. subterminalis* had expanded but still appears to be competing with *Lolium*. *Lolium multiflorum* produces a dense thatch that tends to exclude other species, and is potentially allelopathic (Smith, 1998). Competition with the dense *Lolium* stand and its heavy thatch may be slowing the rate of expansion of Parish's glasswort and other high marsh species in this location.

CSMR 4	**Description**	**Plant Community**	**Dominant Veg Cover**	**Dominant Veg Wetland Status**	**Total Veg Cover**
2003 status	*Lolium* zone	High Marsh grassland transition zone	*Lolium multiflorum* (90%)	Upland	100%
2012 status	High marsh	*Arthrocnemum subterminalis* Herbaceous alliance	*Arthrocnemum* (60%) *Lolium multiflorum* (35%)	Obligate Upland	95%+

Table 9: Comparison of vegetation changes at the CSMR 4 introduction plot

CSMR 5

CSMR 5 and vicinity represents the most successful introduction plot at the Carpinteria Salt Marsh Reserve. Introductions in 2002 were followed by additional planting in 2004 in adjoining areas to the immediate northwest and east. Observations summarized in Table 10 focus on conditions in the original CSMR 5 area. The original 2002 founders were installed in an herb-dominate area adjoining a dense stand of coyote brush occurring on a remnant deltaic formation associated with the deboucher of Santa Monica Creek at the northern margin of the salt marsh. Santa Monica Creek is now confined to a deeper channel with periodic sediment removal to maintain capacity, and deltaic deposition no longer occurs. This plot location represents the highest elevation in the northeast corner of Basin 2, estimated to be around 5-5.5 feet msl (Santa Barbara County Flood Control and Water Conservation District, 2003), and abuts the access roadway/road berm.

CSMR 5	Description	Plant Community	Dominant Veg Cover	Dominant Veg Wetland Status	Total Veg Cover
2003 status	Delta scrub	Palustrine wetland transition-disturbed coastal habitat	*Baccharis pilularis* and *Isocoma* (shrubs) 30% Grasses 70% (mostly *Bromus diandrus*) *Ambrosia* (30%)	Upland Upland	75%
2012 status	Coastal scrub transitional to high marsh	*Baccharis pilularis* Alliance	*Baccharis pilularis* (25%) *Heliotropium curassavicum* (45%) *Distichlis spicata* (10%)	Upland Obligate FACW	85%

Table 10. Comparison of vegetation changes at the original CSMR 5 introduction plot

The localized area experiences intense rabbit herbivory as the coyote brush stand provides protective cover. This is the only site where we have been able to observe the brush rabbits, which are often foraging on the dirt roadway or in the plot area when we drive in, and then flee into the adjacent coyote brush. In 2011 and 2012, the plot area exhibited very high levels of rabbit herbivory with annual grasses and palatable herbs largely removed entirely from the Plot 5 area.

Removal of herbaceous species (including milkvetch) by pocket gophers occurs periodically, primarily during years of low rainfall. In fall of 2010, very high levels of gopher activity removed many of the naturally recruited VMMV along the southern margin of the plot area. The raised dirt road berm likely serves as a refuge for pocket gophers during episodes of high water or years when the ground water table is higher.

Several noteworthy changes have occurred in the general CSMR 5 area across the period of observation. Coastal goldenbush are no longer present in the plot, and as of 2012, they are observed mostly along the margins of the road berm at the highest elevations above the floor of the marsh. The northwestern patch of western goldenrod is still generally present in the same area in 2012, but has contracted northward. Localized patches of mugwort (*Artemisia douglasiana*) have changed little across the observation period. Establishment of new individuals of mugwort has not been observed, and is likely due to removal of new juveniles by rabbits. Western ragweed was present in the CSMR Plot 5 area in 2002, but by 2012, it had been largely eliminated from the entire area. Loss of western ragweed was attributed to high levels of rabbit herbivory.

Heliotrope (*Heliotropium curassavicum*), an obligate wetland plant, exhibits high cover in summer across the plot area and seems to be largely left alone by rabbit herbivores. Heliotrope is visible across the plot area in the July 2002 base photographs but was underrepresented in the cover data estimates shown in Table 10 as these were winter

observations. Heliotrope was likely still dormant or just starting to emerge from below ground rhizomes in February 2003. Annual grass cover was extremely low in the summer of both 2011 and 2012, and removal over the growing season by herbivores was likely the contributing factor.

An increase in new coyote brush individuals was observed during the last few years with new plants establishing beyond the boundary of the original 2002 coyote brush patch. A few coyote brush were trimmed in 2010 and 2011 to maintain some open growing conditions in the milkvetch plot.

In 2010, we observed a small patch of salt grass in the southern portion of the CSMR planting area. By 2012, substantial spatial expansion of this salt grass patch was observed and includes alkali heath (*Frankenia salina*), a FACW+ halophyte, some *Polypogon*, and *Limonium californicum* (a wetland obligate) (Photo 12). A similar patch of salt grass and alkali heath is expanding on the west side of the original plot area, and the two patches are separated by only about 5 meters of open ground. If this expansion continues, the salt grass patches are likely to merge, eliminating low competition open ground favored by milkvetch in the southern portion of the plot area.

Photo 12, August 9, 2012: An expanding patch of halophytes (inside black line) dominated by salt grass in the vicinity of the southern exposed edge of CSMR 5. Rebar corresponds with locations of 2002 founders. View W X NW. Herbivorized area on the right is adjacent to hiding cover. The open salt marsh is on the left.

Recent observations suggest conditions are changing in the CSMR 5 area. The decline of the upland shrub, coastal goldenbush, combined with a potentially expanding patch of high marsh halophytes (salt grass and alkali heath) suggest a shift toward increased salinity and expansion of high marsh transitional habitat. Continued observation is warranted in order to confirm these trends and document any additional milkvetch germination at this location, as considerable seed is likely still present in the plot area.

Coal Oil Point Reserve

COPR Lagoon

Table 11 summarizes key vegetation observations for the COPR Lagoon introduction area. The area was first planted in 2003 with eight founders and a single successful direct seeding plot. This was followed by outplanting 54 nursery raised milkvetch in 2004. The plot area was very open, with a depauperate herb layer and large amounts of residual litter associated with several non-native *Melaleuca* trees that had been previously removed. Established arroyo willows are adjacent to the planting area on the east side. Bands of coyote brush surround the planting area. Adjacent topographic low spots supported dense patches of fleshy jaumea (*Jaumea carnosa*), a wetland obligate and halophyte.

COPR Lagoon	**Description**	**Plant Community**	**Dominant Veg Cover**	**Dominant Veg Wetland Status**	**Total Veg Cover**
2004 status	Coyote brush with western ragweed transitional to arroyo willow stands and fleshy jaumea patches	*Baccharis pilularis/Ambrosia psilostachya*	*Baccharis pilularis* 8% *Ambrosia psilostachya* 20%	Phreatophyte FAC	40%
2012 status	Coyote brush with alkali rye grass, transitional to wetlands	*Baccharis pilularis/Leymus triticoides*	*Baccharis pilularis* 20% *Leymus triticoides* 80%	Phreatophyte FAC+	100%

Table 11. Comparison of vegetation changes at the COPR-Lagoon introduction site.

The Lagoon planting area exhibited a steady expansion of cover in the herb layer, which had likely been suppressed by the *Melaleuca* trees that once occurred there. *Melaleuca* mulch exhibits allelopathic effects and contains hydroxylated aromatic compounds (Duryeah, et al., 1999). By 2005, western ragweed had expanded across the south and east portion of the plot area and patches of dense rabbitsfoot grass were now occupied by meadow voles. Adult milkvetch were unable to reshoot in these areas and seedling recruitment was low. By 2010, alkali rye, a FAC+ robust rhizomatous thatch producing

grass, was dominating the herb layer, local patches of salt grass had expanded, and the last milkvetch to survive here was in a very small remnant area with annual grasses. As of 2012, the entire plot area was dominated by alkali rye grass and is no longer suitable for milkvetch. The overall plot area is potentially more mesic and both soil moisture and soil salinity may be increasing.

COPR Pond

Table 12 summarizes key vegetation changes for the COPR Pond A introduction site. Eight founders and two small direct seeding plots were introduced here in winter 2003. Naturally recruited Ventura marsh milkvetch have persisted in this area for the last nine years and new plants occur at the feral location about 30 m (100 feet) south.

COPR POND-A	**Description**	**Plant Community**	**Dominant Veg Cover**	**Dominant Veg Wetland Status**	**Total Veg Cover**
2003 status	Rabbits foot grass dominated herbaceous meadow adjacent to brackish sag pond in backdunes	Southern dune scrub/alkali meadow/palustrine vernal marsh	*Polypogon monspeliensis* 30% *Gnaphalium palustre* 10% *Distichlis spicata* 10%	FACW-+ FAC-W FAC-W	60 %
2004 status	Western ragweed/lowland cudweed herbaceous meadow	same	*Gnaphalium palustre 20%* *Ambrosia psilostachya* 15% *Distichlis spicata* 5%	FAC-W FAC FAC-W	50%
2005 status	Rabbits foot grass herbaceous meadow	same	*Polypogon monspeliensis 50%* *Gnaphalium palustre 20%* *Distichlis spicata 5%*	FACW-+ FAC-W FAC-W	90%
2012 status	Salt grass meadow in dune hollow	Same, *Distichlis spicata* alliance	*Distichlis spicata* 80% *Ambrosia psilostachya* 5% *Gnaphalium palustre* 5%	FAC-W FAC FAC-W	97%

Table 12. Comparison of vegetation changes for the COPR Pond A introduction area.

The planting area is an herb-dominated dune hollow adjacent to a 1 ½ acre brackish sag pond. The general area experiences large fluctuations in soil moisture and soils are sandy, with some fines. The dune hollow is inundated for various amounts of time (days/weeks/months) in years of average to above-average rainfall. The pond basin dries out entirely in years of low rainfall, and soil moisture in the adjacent dune hollow appears very low during drought years. The pond basin appears to sustain an adjacent near-surface perched aquifer beneath the dune hollow, but this moist area either dries out entirely or drops to a greater subsurface depth in years of drought, stressing a variety of plants occupying the dune hollow.

Across the observation period of 2003-2012, herbaceous vegetation associated with the COPR Pond A planting area has expanded and canopy gaps in the herb layer were scarce in 2012 (Figure 17). Dominance by largely annual herbs observed in 2003 has shifted to dominance by perennial salt grass (Table 12; Photos 13 and 14). Salt grass has expanded since the wet winter of 2005 and has become denser with more residual thatch. Annuals, which, like milkvetch, seem to establish in localized canopy gaps, were also scarce by 2012. Salt grass typically occurs in poorly drained sites that are alkaline or saline, while rabbits foot grass favors moist areas in a variety of habitat types. Expanded cover of salt grass indicates the area is potentially getting wetter and potentially more saline.

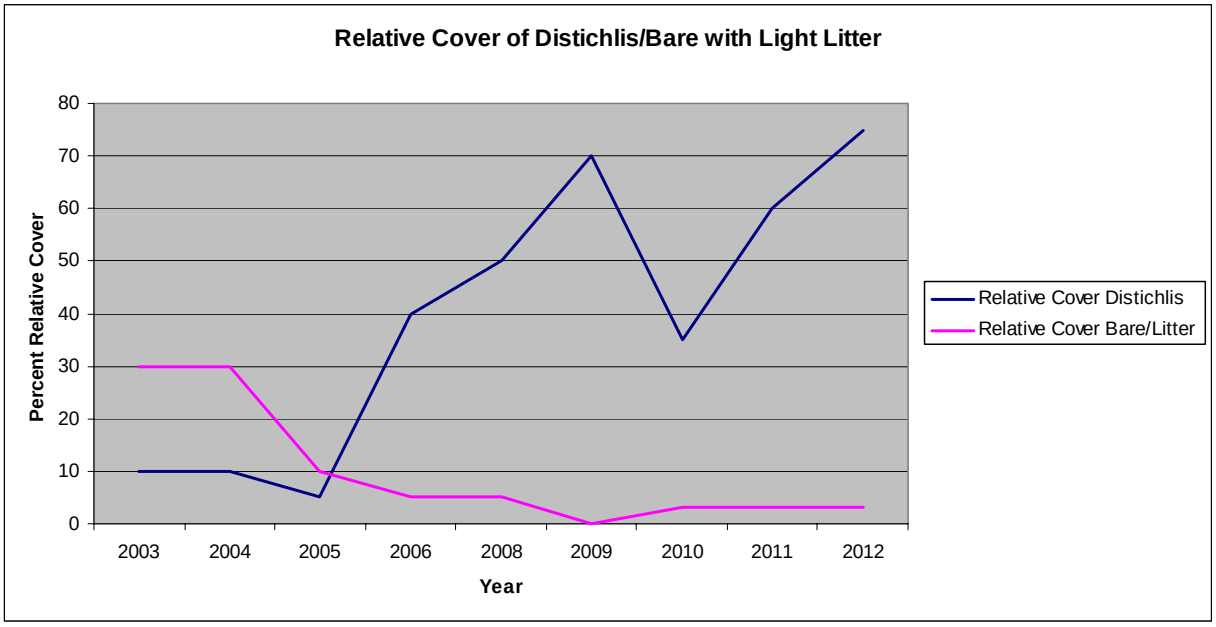


Figure 17. Changes in relative cover of a) salt grass and b) bare areas with light litter, across the observation period in the vicinity of the COPR Pond A planting area.

The interplay between wet years and dry years appears to strongly influence the composition of herb and shrub vegetation in the dune hollow at the COPR-pond introduction area. Shrubs such as coyote brush, arroyo willow, and dune lupine are present around the perimeter of the herbaceous meadow as it transitions into dune scrub and coastal scrub in areas less subject to prolonged inundation. Prolonged inundation of the dune hollow seems to reduce the presence of dune lupine and coyote

brush. Following inundation events, evidence of pocket gophers (fresh turbation mounds) and meadow voles (runways, seed caches and cleared feeding areas) at the COPR Pond plot area typically declines.

Photo 13, COPR Pond: July 18, 2003. Area is dominated by annual herbs and grasses with abundant canopy gaps. Founder milkvetch by orange pin flags are growing well and show no moisture stress (rainfall was above average). Direct seeding plot 3 is marked by wooden stakes.
Photo 14, below, August 2012. The area is now dominated by salt grass. A single VMMV at arrow.

Potential Causes for Decline at Introduction Sites

Six introduction plots in four habitat areas still support milkvetch in 2012, but the numbers of adults has dropped to low levels and few new recruits established in 2012 (Table 1). Seven introduction areas supported no plants in 2012 although seedbank is likely still present (Table 2). These seven sites have all exhibited substantial expansion of associated vegetation in the herb and shrub layer, and loss of low competition growing sites suitable for milkvetch.

Of the six introduction sites supporting milkvetch in 2012, Mandalay 1B has exhibited the least change in associated vegetation since the initial 2004 plantings, but adjoining willows and coyote brush have grown in stature and are reducing the size of the opening where a few milkvetch persist. Associated vegetation at MSB 3E is relatively stable for now, but it is likely the expanding patch of rhizomatous perennial wetland herbs nearby will reach and overtake this location in the next few years. Expansion of associated vegetation at COPR Pond is also occurring, with COPR Pond A experiencing the greatest loss of low competition growing sites as salt grass cover expands.

The CSMR 5 location is potentially experiencing increased salinity and high salt marsh plants are expanding into the narrow upland fringe at Basin 2 and now dominate the CSMR 1-4 plot areas where 2002 introductions failed to establish.

All introduction sites support small mammal herbivores who also respond to shifts in vegetation and increased cover in the herb and shrub layer. Herbivory remains a serious threat to establishment and persistence of VMMV at sites where abiotic growing conditions are otherwise suitable.

Loss of Canopy Gaps in the Herb and Shrub Layer

All of the failed locations and declining plots have exhibited a general increase in vegetative cover and loss of canopy gaps favored for milkvetch recruitment. Most of the expanded vegetation in the herb and shrub layer represents various wetland indicators and phreatophytes. Even the driest site where milkvetch established (Mandalay 1) has exhibited an increase in FACW herbs and the canopy and biomass of phreatophytes has increased. Increased cover and biomass of wetland indicators and phreatophytes suggests that soil moisture available for plant growth has increased over the observation period.

Increases in soil moisture could be tied to annual rainfall patterns or broad rainfall patterns over recent decades. Subsurface soil moisture at COPR Pond appears most closely tied to annual rainfall patterns, suggesting the semi-perched aquifer here, if it exists, is weak, or drops to greater depth in droughts.

Most of the wetland ecotones where introductions occurred have subsurface soil moisture associated with perched aquifers, areas of subsurface tidal influence, or adjoin brackish water bodies like lagoons or ponds. The presence of subsurface soil moisture within reach of the root zones of these plants suggests that processes affiliated with hydraulic lift and hydraulic redistribution could be involved in driving vegetation expansion (Liste and White, 2008). Increased biomass associated with expanding

vegetation also likely increases fog drip at these coastal sites and may further contribute moisture to the air and ground, benefiting plant growth.

Sea-level rise could also be increasing subsurface soil moisture at locations proximate to the immediate coast. The evident shift toward increased cover of halophytes and wetland obligates in the CSMR 2002 introduction plots provides indirect evidence that sea levels are rising.

Longer term weather patterns would be interesting to further examine. For instance, it is possible that episodes of consecutive years of drought could set back phreatophyte vigor leading to a loss or reduction in hydraulic lift. The mid to late 1980's represents an example of a multi year drought cycle. A contraction in neighboring rhizomatous wetland herbs benefiting from hydraulically lifted water could occur under prolonged drought scenarios. Establishment of new phreatophytes from seed following flood events, which was observed after 2005, could have re-invigorated hydraulic lift and redistribution processes, fueling the observed recent vegetation expansion seen around McGrath Lake, for example.

At COPR Lagoon, a less noticeable shift toward higher cover of wetland species has occurred. This site supported an artificially open herb layer in 2003, which first became overtaken by expansion of western ragweed (FAC) and which was then replaced by FACW+ alkali ryegrass which produces tall dense thatch. At this plot, loss of canopy gaps in the herb layer directly corresponds with declining suitable area for milkvetch to occupy.

Increased Soil Salinity

Vegetation shifts at the five CSMR plots indicate increased soil salinity as evidence by increased cover and dominance of halophytes (salt grass, alkali heath, and others). This location is the only tidal salt marsh where plants were introduced into fringe areas of high marsh and upland transition. COPR Lagoon is tidal only when the mouth is breeched, which occurs in winter, or after heavy rains break through the spit which forms there.

Herbivory on Milkvetch

Direct herbivory on milkvetch remains another confounding dilemma and is an important factor influencing whether or not milkvetch establish and persist in given area. Small mammal herbivores such as cottontail rabbits, meadow voles and pocket gophers interface with their environment and have their own complex population cycles.

The overall expansion of the herb layer, seen here, and increased hiding cover in neighboring shrub layers may account for expanded populations of herbivores who feed directly on this vegetation. At a variety of sites in coastal Ventura and Santa Barbara Counties, pocket gopher and meadow vole activity appears to have increased in the last several years.

Open ground at the CSMR 5 location the last two years, and low cover of herbs generally, may be attributed to high levels of rabbit herbivory, but we cannot rule out that salinity shifts are affecting milkvetch recruitment rather than removal by rabbit herbivores. We have not seen evidence of meadow voles at this location, and pocket

gopher turbation and holes were rare in the plot area in 2011 and 2012, suggesting gophers do not account for the recent observed low cover of herbs and lack of milkvetch recruitment.

Implications of Climate Change

Sea level rise and elevation issues

Sea level rise associated with climate change poses a new and overarching threat to coastal milkvetch introduction sites. Topographic elevation of milkvetch sites can be used to interface with sea level rise elevation models, in order to determine potential vulnerability at these sites.

Approximate elevations for the wild site and various introduction sites are shown in Table 13. The exact topographic elevations of the introduction sites and topographic control points vulnerable to sea level rise should be measured in the field with accurate global positioning unit systems, or through physical surveys.

Location	**Elevation in Feet Introduction Plots**
Wild Site- Oxnard	**28-29**
Mandalay 1	9
Mandalay 1B	10
McGrath 3 and 3E	10 (9.5)
McGrath 4 and 4E	10 (9)
McGrath 4 2002 juncus patch	9 (8-9)
McGrath 5	10 (8-9)
Carpinteria Salt Marsh 5	**5-5.5**
Coal Oil Point Reserve Pond A	10
COPR Pond D	11
COPR feral	11
COPR Lagoon	9

Table 13. Approximate elevation of milkvetch introduction plots. Elevation for the wild site (bold) is from accurate survey data (Arcadis, 2012) and was consistent with Google Earth elevations. Elevations for Carpinteria Salt Marsh (bold) also relied upon accurate survey maps from 2003 (Santa Barbara County FCD, 2003). Google Earth elevations were used for other locations and accuracy may vary. Numbers in parentheses are estimates for MSB, where the three plots are likely slightly below the elevation of 10.

The introduction sites examined to date are likely all vulnerable to adverse effects from sea level rise associated with topographic elevation. The CSMR 5 is most vulnerable, followed by the at COPR Lagoon plot, as both are directly connected to tides either daily or seasonally.

Milkvetch locations in dune systems protected only by foredunes are likely next in vulnerability, as storm surges during extreme weather events could break through sand deposits and capture interior wetlands like COPR Pond or McGrath Lake. Topographic

low spots (blow outs) in foredunes are likely the weak point, and the sea could get behind taller dunes at such locations, capturing dune hollows and entering the deflation plain that sometimes forms behind the foredune system. Beach sand would offer little resistance and continued erosion of adjoining taller foredunes is likely.

The vegetation shifts at CSMR marsh suggest that gradual creep of rising seas is potentially observable even over a period less than ten years. From 1950 to 2009, measurements show an average annual rise in sea level of 1.7 ± 0.3 mm with satellite data showing a rise of 3.3 ± 0.4 mm from 1993 to 2009 (Nicholls and Cazenave, 2010). Using the 3.3 mm value, sea levels potentially rose 33 millimeters (3.3 cm, or 1.3 inches) over the ten year period of observation since milkvetch were installed. The rate of sea level rise has the potential to continue to accelerate.

Plants associated with salt marshes have specific tolerances relative to tidal inundation patterns and soil salinity. Salt marshes exhibit evident zonation patterns associated primarily with flooding, soil salinity and interspecies competition (Pennings and Callaway, 1992). Gradients can often be observed indirectly by observing the distribution of key plant species sensitive to changing salinity and inundation patterns.

Assuming that trends observed at the CSMR 5 location are a response to sea level rise and associated increased salinity, milkvetch will only be able to complete about 3-4 recruitment cycles before conditions shift enough to require rescue or re-establishment elsewhere. There are a few areas near Ash Avenue and Basin 1 at Carpinteria Salt Marsh with elevations ranging from 7-9 feet, but these areas are limited in extent. Non-native snails were problematic near Ash Avenue and invasion from adjoining residences is a problem.

This information suggests that any effort to recover milkvetch will be challenged by continued shifting abiotic and biotic conditions at any given location. Under ideal conditions, where habitat areas are contiguous and unconfined, common and rare vegetation has some ability to shift spatially as conditions change, without substantial human intervention. Intensive development on the south coast of California has confined and fragmented the majority of coastal salt marsh, lagoon and dune systems. The Carpinteria Salt Marsh Reserve and adjoining marsh lands on private and city property are severely confined, and the future does not look promising.

Other Climate Change Issues

VMMV appears sensitive to air temperatures and humidity. Vigor is best on the immediate coast where hotspells are infrequent and episodes of summer fog are common. Increasing temperatures or humidity reductions could be detrimental to milkvetch. Should more persistent summer fog occur, this could reduce vigor and flower production.

Milkvetch recruitment may be lower during episodes of prolonged drought, or when rainfall is low in late winter and spring. Changing weather patterns favoring greater growth of ruderal weedy competitors could adversely affect persistence or cause increased herbivory pressure. Prolonged or repeated drought could could also influence perched aquifers.

Recommendations for Future Management and Recovery

Our effort to establish experimental milkvetch introductions was primarily aimed at expanding our understanding of VMMV's poorly understood habitat requirements. Through this effort, we have generated considerably more knowledge about this species relative to the types of habitats examined to date. However, a secondary objective was that these introductions, if successful, would be the first stage in establishing self perpetuating "populations" which could kick start species recovery. It was anticipated that additional plantings would be necessary to build up population numbers and genetic diversity at successful sites. Declines in abundance and extent of milkvetch observed in the last several years associated with shifting habitat conditions on the near coast suggest that there is still a long way to go before any introduction to new areas can be viewed as successful.

Milkvetch Propagules for Future Projects

One positive aspect of the current effort to propagate and outplant milkvetch to natural locations has been that we have built up a considerable bank of seeds. In the 1980's VMMV was still thought to be extinct, and was one of about 30 presumed-extinct plants in California where consideration was being given to take seed from herbarium specimens and attempt to resurrect living plants (called Project Phoenix). That project was never initiated.

Fortunately, VMMV was given another chance. Several collections were made associated with "maternal lines" at the wild site from 1998-2000. Santa Barbara Botanic Garden has around 3950 seeds stored there, from varied sources including the wild site, several of our introduction sites, and from VMMV growing at the SBB Garden (SBBG 2011). An additional 50,788 seeds collected from introduction sites between 2003 and 2008 are now stored at RSABG (representing 14-17 maternal lines) and are available for recovery projects. Preliminary germination trials indicate these seeds exhibited 100% germination (60 seeds tested, ten each from six collection years). In December 2011 an additional 6406 seeds were collected along 28 maternal lines at the "wild" Oxnard population and represented less than 5% of the overall seed produced that year. These seeds are in a permanent, funded conservation collection at RSABG.

It is recommended that a new seed bulking effort be undertaken in order to expand the potential number of maternal lines utilizing some propagules obtained from the wild Oxnard population in 2012. Soza et al. 2003 describes the original bulking effort that yielded seeds, some of which were used for the current introductions. RSABG has established protocols for germination and propagation and have an excellent track record for producing healthy vigorous young juveniles. Transfer of plants to a facility or location on the immediate coast is recommended to produce abundant flowering and maximize fruit production and viability.

Direct seeding into test plots at new experimental sites could be used for initial assessments at locations favorable for germination.

Augmentation of Current Introductions

MSB and COPR Pond: Outcomes at various sites observed here suggest that COPR Pond and MSB 3E remain the most viable sites still supporting vegetative conditions

suitable for milkvetch. Both sites are near brackish interior water bodies, experience episodes of flooding within a contained basin, and adjoin drier dune habitat areas with relatively gentle topographic relief. Adjacency to open habitats without topographic confinement, with lower herb and shrub cover and lacking rhizomatous wetland margin plants, provides a future opportunity for milkvetch to disperse to these adjoining areas following episodes of flooding, establish for a period of time, and drop seed. We observed this response at MSB 3 and 4 in 2005 and likely at COPR Pond. When another large scale flood event occurs and McGrath Lake exceeds its banks, new opportunities for milkvetch dispersal and germination may occur. Teams of volunteers could be assembled and trained to search for new milkvetch in post-flood terrain at MSB, especially at locations distant from the introduction plot(s) or founders. In the last two decades, flooding and temporary inundation has occurred on at least two occasions at MSB (water year 1997/98 and water year 2004/05).

Since flooding sometimes causes mortality in small mammal herbivores, or spatially displaces them for a period of time, herbivory affects on milkvetch may be temporarily lower on recently flooded exposed fringe areas. Post-flooding conditions in years of high rainfall also result in more germination and growth of associated plant species preferred by herbivores. This window may represent a short term temporary reduction in herbivory pressure, allowing milkvetch an opportunity to establish and produce flowers and fruits, before conditions change.

At COPR Pond, the single surviving 2004 founder at the relatively dry Pond D location (dominated by coyote brush and western ragweed) produced abundant seed after the 2005 flooding ended. It took five years (2011) for a new milkvetch to establish and mature in the same location, when high rainfall returned and soil moisture in the vicinity temporarily improved. Absence of establishment in the intervening years did not mean milkvetch no longer occupied the area, nor that it was somehow unsuitable.

Additional introduction of milkvetch to both the east margins of McGrath Lake and COPR Pond dune hollow appears worthwhile. At McGrath, a very carefully planned intensive introduction along the entire drier fringe associated with western ragweed stands could be implemented. Single founders, planted in wide hardware cloth cages, watered, weeded and sung to, could be installed in large numbers during a single year. I would recommend that several hundred plants be installed, and broadly distributed around the eastern margin areas. Those which survive to a second year could potentially produce millions of seeds. Some portion of those seeds could then reside as seed bank and respond to the next flood event.

Iceplant mats throughout the east McGrath Lake wetland margin and adjoining dunes should be removed before an intensified planting effort is undertaken. In localized areas with low cover of weeds or annual grasses, the iceplant and surface thatch should be lifted and removed entirely, so only low levels remain on the dune surface. Iceplant dominates much of the low dunes on the state park property, but is being controlled and eliminated on the adjoining private parcel. Surface roughness of iceplant mats could interfere with surface sheet flow around fringe areas and potentially intercept floating detritus containing milkvetch seeds or fruits. Seeds landing in dense iceplant are unlikely to establish.

Under these possible future scenarios, the expectation that VMMV should persist as an above ground population, year after year, in the same general area, appears misguided.

It is far more likely that milkvetch experiences frequent colonization and extirpation events within dynamic coastal systems. To respond to these changing conditions, it is likely that much larger numbers of seeds, and substantial seed bank, needs to be built up to enhance persistence.

COPR Lagoon: Much of the lagoon margin consists of abrupt topographic rises leading to coastal terraces currently dominated by mostly non-native grasslands, including tall perennial Harding grass (*Phalaris aquatica*) and *Bromus diadrus* (ripgut brome) Both produce heavy thatch and considerable hiding cover on the ground surface for herbivores. These locations are highly competitive, and loaded with gophers, rabbits and voles. More careful examination for future introduction areas around Devereux Slough (at COPR) may be warranted, but could prove difficult to locate. To date, there is no evidence that seed residing in the Lagoon plot has any ability to disperse to a more favorable environment nearby. Arroyo willow thickets and dense fleshy jaumea stands adjoin the plot.

CSMR 5: Continued observation of the plot area is necessary to further determine if the declining trend here is permanent. Laboratory study could serve to better identify and bracket milkvetch soil salinity tolerances, and it is recommended that both seeds and young juveniles be tested.

Mandalay: Although this represents the driest location for milkvetch with low levels of infrequent natural recruitment, there are still areas near Mandalay 1B that could be augmented with new founders or seeds. Additional reconnaissance of the habitat area here may be worthwhile, as conditions are changing. Soil moisture probe sampling would be helpful in locating appropriate sites for future test outplantings.

Restoration Strategies for New Sites

Efforts to date initially focused on installations in wetland margin habitats in dunes and near salt marshes and lagoons. It remains critically important that we also explore other types of planting situations (Meyer, 2007). Coastal terraces may contain suitable areas for milkvetch in situations that do not support wetland species. Areas along the edges of walking paths and dirt roads or trails may be potentially suitable, although milkvetch stature and vigor would likely be reduced. VMMV's closest relative, the northern brine milkvetch (*Astragalus pycnostachyus* var. *pycnostachyus*), occurs in such locations south of the San Francisco Bay area (Meyer, 2007; Wilken and Wardlaw, 2001).

Where subsurface hardpans, clay layers, or rock layers occur on coastal terraces, there is sometimes additional soil moisture accumulating above those layers, which millkvetch may be able to tap into. Soil moisture testing and sampling along gradients should be undertaken before outplanting trials.

Interdisciplinary Team Approach: Future planning for introductions would benefit from engaged participation by experts in local geology, soils, hydrology and herbivores. Technical teams of botanists have been convened periodically by the California Department of Fish and Game, United States Fish and Wildlife Service; the North Shore at Mandalay Bay development project, associated with the wild site in Oxnard, has also sponsored periodic coordination with local botanists. These efforts should continue, and more frequent coordination would be beneficial.

Ongoing and Future Habitat Restoration: There is considerable interest in introducing VMMV into new sites which have been recently restored, or where new habitat restorations projects are being planned. New projects provide an opportunity to design physical and biological conditions more favorable for milkvetch. We are still in the early stages of understanding: what might those conditions be?

Past restoration of coastal scrub and terrace habitats has occurred in limited areas, including the Carpinteria Bluffs, Carpinteria Salt Marsh Ash Avenue and Basin 1, localized areas at Coal Oil Point Reserve, and the Goleta Slough Ecological Reserve.

Factors to consider in evaluating restoration potential could include whether or not the restoration area has intact soils, or represents graded areas, relocated fill or other conditions that have changed the soil structure and texture. A restoration site with intact native soils provides an opportunity to work in an area that is more stable and with more predictable abiotic and biotic conditions.

Newly created habitat areas are inherently unstable and could change over time from a favorable milkvetch response initially, to an unfavorable one. At COPR for instance, soils were relatively undisturbed but invasives (ie. *Melaleuca* and *Cortaderia*) had just been removed, leaving unstable conditions in the herb and shrub layers, which changed dramatically over the 8-9 years we observed the area. Herbivore activity also intensified as associated vegetation changed.

Outplanting opportunities associated with more compacted soil areas, supporting more fines, could be explored. Artificially compacting areas during a restoration project could provide opportunities for establishing compaction gradients along which milkvetch might establish in suitable conditions. Soil compaction sometimes favors plant species which are poor competitors, or need additional moisture that can be obtained by residing on the edge of a compacted trail, for instance, or road shoulder (eg. Hwy 1 near San Gregorio Creek, where northern brine milkvetch grows).

We have not yet tried growing VMMV in locations that could be described as supporting heavy clays, and/or low areas. In the Santa Barbara area, such locations are often dominated by invasive Harding grass, Italian rye grass, or ruderal weeds like curly dock (*Rumex crispus*), or black mustard. If such areas were restored to native grassland, it might be possible for milkvetch to co-occur. Should such locations be restored to native herbs and native grasses, introduction of milkvetch could be tried. Herbivory issues will be challenging in such locations. An area near Ojai in Ventura County has clay soils and pocket gophers, at least, do not occupy the heavy low ground. Meadow voles are common, and cottontail rabbits have expanded because shrub hiding cover was created adjacent to herbaceous areas where they tend to feed.

Creation of a low stature coastal scrub: Should VMMV be able to grow outside wetland margins, its overall height and stature will likely be reduced. Northern brine milkvetch near Pescadero Creek occupies the shoulders of a walking path in dense low growing coastal scrub. Few milkvetch occur in the dense scrub. But they persist well along the trail edge, grow in relatively open sun, and are about the same height as the adjoining scrub. Northern brine milkvetch is less robust and shorter when growing on coastal terraces, compared with those growing on rack lines in wetlands at Drakes Estero, Point Reyes National Sea Shore.

It would be worthwhile to attempt to create a low growing dense coastal scrub palette, emphazing low stature shrubs (ie. under 1 meter). Low stature may be controlled to some degree by rooting depth on coastal terraces. Rooting depth above a denser compacted layer should be examined and sampled along gradients to better understand below ground soil moisture and factors influencing plant stature.

Most of the coastal scrub that I observe on the south coast in Santa Barbara County is potentially degraded. Many sites are largely dominated by coyote brush, whose seeds are wind dispersed, with disturbed understories often dominated by non natives. This may represent the climax vegetation for these locations, or it could represent the end result of several hundred years of human activity, including grazing, farming and oil exploration. Frequent burning by the native Chumash has been documented on the immediate coast, and the area between Gaviota and Carpinteria may have also been strongly influenced by these management practices with large populations and villages nearby.

Rabbit herbivores are particularly abundant in locations where coyote brush provides hiding cover, and adjoin areas with more herbaceous species. Cottontails will feed on stems of some of our native shrubs, including coyote brush and mule fat. It is possible that cottontail and brush rabbits, as well as pocket gophers and other herbivores, may exist in higher numbers currently than they did in the past, due to the expansion of fragmented habitats and invasion by Mediterranean weeds.

Establishment of a dense, low growing coastal scrub, distant from grasslands and herblands might be worth exploring. Milkvetch would then be introduced following establishment, along a trail or compacted surface created specifically within this dense stand. Species such as coastal encelia, (*Encelia californica*), sages (*Salvia mellifera* and *Salvia leucophylla*), or seaside buckwheat (*Eriogonum parvifolium*) are examples of lower statured common coastal shrubs that milkvetch might be able to co-occur with. Some coastal scrub species are potentially allelopathic (for instance, *Artemisia californica*) and compatibility with milkvetch should be investigated before such species are used.

Creation of an isolated pond: It might be feasible to create a fresh water isolated water body within a restored coastal terrace. Proposals to do restoration on the 69 acres "South Parcel" at Goleta, might entertain creating such a feature to benefit milkvetch. A created pond that captures surface runoff, with stop logs that would allow active management of ponding, might be feasible and could result in creating episodes of inundation of adjoining fringe areas, tied to both natural rainfall and milkvetch population cycles. This parcel also might be a good location to look at restoring a dense low growing coastal scrub palette with controlled rooting depths.

Intact soils versus disturbed soils: Soil texture and compaction are important factors influencing plant species distributions and should be fully evaluated at reference sites, which would help inform planning for new areas. It may be advisable to not introduce milkvetch into recently reconfigured areas until such a time as soils stabilize.

Avoidance of certain native species: It is common for restoration projects to sometimes emphasize achieving general native cover performance criteria with low weed cover. Some native plants used in restoration projects are likely strong competitors with

milkvetch. Where those species are introduced to a restoration site, cover criteria may be achieved for the overall project, but the result could prove unsuitable for milkvetch.

For example, Jenkins (2007) evaluated a recently restored berm in Carpinteria Salt Marsh Basin 1. He rated this location as a preferred, high quality potential introduction site for VMMV, but acknowledged that vegetation was still establishing and conditions there could change. Several years later, most of the open ground in between the shrubs was dominated by dense continuous cover of *Phacelia ramosissima*. Rabbits were residing underneath these dense stands and feeding in adjoining open areas. It does not appear likely that milkvetch would be able to compete with the rambling stems and abundant biomass of phacelia occupying the herb layer at this restored location.

Hooker's evening primrose is another species that appears to be highly competitive when co-occuring with VMMV. At MSB, primrose has expanded dramatically, and occupies the same open ground that milkvetch prefers. It is not favored by cottontail rabbits and is rarely herbivorized. It blooms prolifically. Primrose has expanded at COPR pond and last year, thousands of rosettes were occupying the post-inundation areas desirable for milkvetch. This plant is quite common along roadsides just beyond the shoulder, and I often imagine every one being a milkvetch, instead of a primrose. There is some potential that this subspecies has been contaminated with genes from non-native primroses introduced as ornamentals and it has become weedier (Wayne Ferren, pers. comm. Oct 2012).

I would be cautious in introducing quail bush (*Atriplex lentiformis* subsp. *Breweri*), or chaparral mallow (*Malacothamnus fasciculatus*) in a palette for a milkvetch restoration. Chaparral mallow was introduced on upland terraces at the Ash Avenue restoration at Carpinteria, and they've produced tall dense colonies. Quail bush often forms dense masses on bluffs and terraces on the immediate coast.

Herbivore Planning and Management: Any project intending to introduce milkvetch must fully evaluate the complex issues associated with herbivory by small mammals. As seen throughout the discussion here, and results reported in Meyer, 2007, herbivory can lead to complete failure at introduction sites. It has proven difficult to locate experts on this topic, despite the importance of such species to their environment.

As reported in Meyer, 2007, milkvetch palatability seems to vary between sites. At some locations they are left largely alone (Mandalay), while at others, reshooting on adults is consistently impaired (MSB 3). One hypothesis was that milkvetch may be uptaking selenium and this could be reducing herbivore palatability (Parker, 2006). A controlled study could still be undertaken by growing milkvetch with differing levels of selenium and exposing them to rabbit or meadow vole herbivores. If studies confirm that herbivory can be reduced, applying selenium in local areas to plants or soils around milkvetch areas might be a possible management tool.

Non-native snails including both common garden snails and European milk snails are persistent problems in moist areas when milkvetch was growing nearby. It seems that local areas where we have mostly hand removed these snails and disposed of them, do not have as many snails as they once did. This suggests that their numbers can at least be reduced with some hand labor, and weeding of restoration projects during maintenance periods should include snail removal.

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