Central Coast Watershed Studies

CCoWS

Re-Vegetation Study Final Report

Small Arms Ranges 18 and 19 Former Fort Ord, Monterey, CA

Jon Detka

Report No. WI-2005-13
15 OCTOBER 2005

The Watershed Institute
Division of Science and Environmental Policy
California State University Monterey http://watershed.csumb.edu
100 Campus Center, Seaside, CA, 93955-831 582 4452 / 4431

All authors reside at:
Watershed Institute, California State University
Monterey Bay

TABLE OF CONTENTS

I. ACRONYMS AND TERMS

bgs		below ground surface
CSUMB		California State University, Monterey Bay
Cu		Copper
ECC		Environmental Chemical Corporation
ft		foot, feet
GPS		global positioning system
ITSI		Innovative Technical Solutions, Inc.
m		meter(s)
Mg/kg		milligrams per kilogram
%		percent
Pb		Lead
PRAC		Pre-Placed Remedial Action Contract
SAFR		small arms firing range
Sb		Antimony
TCLP		Toxicity Characteristic Leaching Procedure
USACE		U.S. Army Corps of Engineers
WAAS		Wide Area Augmentation System
WI		Watershed Institute
$\overline{X}$		mean value of a data set

II. LISTING OF FIGURES

III. LISTING OF TABLES

1.0 PROJECT OVERVIEW

This report is a final summary of results for the duration of the re-vegetation study within the recently remediated portions of two small arms firing ranges (SAFR) at the former Fort Ord, Monterey, California.

Two parallel SAFR demonstration projects were performed on Small Arms Ranges 18 and 19 during 2003. A “dry separation” demonstration and a "soil washing" demonstration were performed by Innovative Technical Solutions, Inc. (ITSI), and Environmental Chemical Corporation (ECC), respectively. The demonstrations were designed to assess the cleanup of lead (Pb), copper (Cu), and antimony (Sb) associated with SAFR bullets and associated byproducts. Cleanup criteria included achieving Pb, Cu and Sb levels of 400, 100, and 5 mg/kg, respectively, in processed soils, and having these same soils meet metal solubility criteria described in Work Plan, Treatment of Lead Contaminated Soil, Small Arms Range 18, Former Fort Ord, Monterey, California (ITSI, 2002).

On both Range 18 and Range 19, bullet-contaminated soils were excavated to approximately one foot below ground surface (bgs) and transported to a staging area. Soils were remediated at the staging areas and then retuned back to the ranges. Because the excavation and subsequent remediation of these soils may remove nutrients and other essential components (e.g., pH, organic contents) required for the growth of vegetation in these areas (whether or not soils are replaced in the excavated areas of the ranges), this re-vegetation project was implemented to determine what types of native plants will grow on these soils and how effectively.

ITSI was contracted to conduct this re-vegetation study by the U.S. Army Corps of Engineers (USACE) under Pre-Placed Remedial Action Contract (PRAC) DACA05-99-D-0014, Task Order CM11. The California State University, Monterey Bay (CSUMB) Watershed Institute (WI) was contracted by ITSI to conduct planting, baseline assessments, and quarterly evaluations for the study. This report is the final summary report that will be provided to the Sacramento District, USACE.

1.1. Former Fort Ord

After the closure of Fort Ord in 1994, the USACE was charged with returning the former base to habitat and non-habitat (development) settings within prescribed soil and biological parameters.

In order to transfer the property to other uses, the USACE is required to identify and remediate contaminated areas on the installation. The USACE has collected data that indicate many small arms firing ranges at the former Fort Ord are contaminated by lead (in the form of bullets and bullet fragments), with lesser concentrations of copper and antimony. The range soils need to be remediated to levels that meet human health and ecological criteria (current and future risks) prior to transfer of property.

Remediation of small arms ranges located in the development area (residential and mixed use) has been completed. Lead contaminated soil from these small arms ranges were excavated and transported to the Operable Unit 2 (OU2) Landfill for disposal. The OU2 Landfill was permanently closed in December 2002 and a new approach has to be developed to continue and complete the remediation within the habitat area.

1.2. Project Objectives

The objective of this project was to evaluate relevant data from three test soil remediation sites to determine re-vegetation requirements subsequent to future range remediation activities within habitat areas where the seed bank has been depleted, either by excavation and disposal of soil off-site or by processing and treatment of excavated soil which is subsequently returned to the site.

Quarterly monitoring events were performed for the period between Feburary 3rd, 2004 and August 16th, 2005 to examine the survivability of a variety of individual native species planted in the test plots and the repopulation of volunteer cover plants. This final report includes an evaluation of study results and recommendations for future re-vegetation projects. The report also includes a cost estimate to conduct future restoration and monitoring on a per acre basis based on mortality data and associated costs for this project and an exploration of uncertainties that should be considered before engaging in future restoration projects.

The CSUMB Watershed Institute, and Return of the Natives Restoration Education Project in particular, is familiar and experienced with re-vegetation projects in Ft. Ord's maritime chaparral ecosystem. We provided specific native plants grown in their greenhouse that strictly adhered to the seed source and plant stock requirements outlined in the Installation Wide Multi-Species Habitat Management Plan for Fort Ord, California.

1.3. Location of Study Area

Re-vegetation was evaluated from results obtained at one plot in Range 18 and two separate plots in Range 19. These plots together encompass approximately one-half acre. The corners of each plot were identified using a hand-held Wide Area Augmentation System (WAAS) differentially corrected global positioning survey (GPS) unit within three-meter accuracy. (See Images 1-3)

2.0. METHODOLOGY

2.1. Small Arms Ranges 18 and 19 Treatments

In September 2001, ITSI and Environmental Chemical Corporation (ECC) were tasked to develop a cost-effective treatment method to continue the remediation of small arms firing ranges in the Multi-use Range Area (MRA). The selected treatment method should reduce contaminant concentrations in soil to below both Land Disposal Restrictions (LDR) and proposed target cleanup goals for lead, copper, and antimony, to allow processed soil to be returned to the site (ITSI, 2002).

Three sites within Ranges 18 and 19 were selected for this project. The planting medium for Range 18 Site 1 and Range 19 Site 1 was processed soils. The planting medium for Range 19 Site 2 was exposed sub-surface native soil.

ITSI conducted dry separation soil treatment at Range 18 Site 1 and ECC conducted wet separation at Range 19 Site 1. Dry and wet separation techniques separate particles on the basis of differences in size and density (specific gravity).

The study areas at Ranges 18 and 19 were selected based on the following criteria:

- The presence of greater than 10 percent (%) surface coverage of spent ammunition,
- Considerable areas of the range exceeded the 400 milligrams/kilogram (mg/kg) lead treatment criteria for the project.

2.1.1. ITSI - Dry Separation

ITSI conducted dry separation in the field using a variety of soil from Ranges 18 and 19 to test the limitations of the equipment and method. Detailed discussions of the field demonstration approach and results are presented in the *Range Remediation Pilot Study Completion Report, Former Fort Ord, California* (ITSI, 2004).

Soil returned to the Range 18 revegetation study area was processed following the procedure below:

- Pre-screened to remove large pieces of organic material and debris using 4-inch grizzly and ½-inch screen. Large material is stockpiled.
- Screened soil is dried in a heated rotary trommel. Trommel was under vacuum from attached baghouse to control dust and remove fine lead-containing fragment and organics.
- Dry soil is screened through a 14-mesh vibratory sieve to remove bullets and other metallic debris. Screen was also under vacuum. This soil was returned to site.
- The soil returned to the Range 18 study area contains lead averaging 156 mg/kg which is below the 400 mg/kg action level.

2.1.2. ECC – Wet Separation

ECC conducted wet separation in the field using a variety of soil from Range 19. Detailed discussions of the field demonstration approach and results are presented in the *Final Report for Soil Washing Treatment of Lead Contaminated Soil, Small Arms Range 19, Former Fort Ord* (ECC, 2003).

- Soil returned to the Range 19 revegetation study area was processed following the procedure below:
- Wet screened with triple deck vibratory sieve to separate material into 3 fractions: large (> 1 inch), coarse (< 1inch and >10 mesh), and < 10 mesh material. Large material is stockpiled.
- Coarse material is conveyed to mineral jigs to separate bullets, fragments, and large particulates.
- Resulting fractions from coarse material and < 10 mesh soil is dewatered to separate sand from fines so that water can be used
- All < 10 mesh material is sent to pug mill where apatite is added at 3% weight to weight. This soil was returned to the site.
- The soil returned to the Range 19 study area contains lead averaging 271 mg/kg which is below the 400 mg/kg action level.

2.1.3. Excavation

The planting medium for Range 19 Site 2 is surface disturbed native soil in an area where the top 9 to 12 inches of bullet-rich soil was excavated, but cleaned soils were not returned to the site after processing. Range 19 Site 2 was selected so that the re-vegetation success rate in excavated soil conditions could be compared with the success rate of plants placed in wet separation soil treatments. Any comparisons of these two sites should be interpreted with a large degree of uncertainty. Treatment methods lacked the designation and monitoring of a suitable control site, where no soil treatment was conducted. This makes it impossible to quantitatively conclude with any degree of certainty if the observed difference is a product of the treatments.

2.2 Site Descriptions

2.2.1 Range 18 Site 1

Range 18 Site 1 is composed of soil that was cleaned by ITSI using dry separation. Soil was excavated to an approximate depth of one foot bgs, lead was removed using screening and density separation methods, and the cleaned soils were retuned to Range 18 Site 1. Range 18 Site 1 dimensions form a rectangular array approximately 30 meters by 10 meters and contain 300 one-meter square quadrats for plant installation. The site resides on a 17% slope with an aspect of 319 degrees. The habitat consists of an intermediate oak woodland and maritime chaparral transition with severe levels of disturbance and invasion by non-native *C. edulis*. (See Image 1)

Image 1. Range 18 Site 1, Post Soil Treatment, December 2003

2.2.2 Range 19 Site 1

Range 19 Site 1 is composed of soil that was cleaned by ECC using their soil washing technology. Using wet separation techniques, bullet particulates were first removed from the excavated soils. A phosphate-based chemical stabilizer was then applied to selected soil fractions so that they would meet Toxicity Characteristic Leaching Procedure (TCLP) solubility testing specifications[1] requirements in addition to total metal requirements. After soil washing was completed, all cleaned soils were retuned to this Range 19 site. Range 19 Site 1 dimensions form a rectangular array approximately 27 meters by 10 meters and containing 270 one-meter square quadrats for plant installation. The site resides on a 3% slope with an aspect of 212 degrees. The habitat is predominately undisturbed maritime chaparral habitat dominated by mature stands of recently burned *Arctostaphylos tomentosa*. (See Image 2)

Image 2. Range 19 Site 1, Post Soil Treatment, December 2003

[1] The maximum allowable toxicity characteristic concentration for lead is 5.0 mg/L (40 CFR 261).

2.2.3. Range 19 Site 2

Range 19 Site 2 is composed of pre-existing soils exposed by near-surface excavation of contaminated soil. Contaminated soil at this site was excavated by ITSI, processed, and spread out over the staging area following treatment instead of being replaced at the point of excavation. Range 19 Site 2 consists of a two-meter wide, 67-meter long array of one-meter square quadrats in along a variable 3-7% South facing meandering trench approximately 9-12" in depth. The site consists of loose disturbed sandy soil in the same habitat type as Range 19 Site 1. Prior to installation of plants erosion preventative sandbag burms were installed at the northern head of the site to reduce the potential effects of downhill sheet erosion from adjoining roads.

Image 3. Range 19 Site 2, Post Soil Excavation, December 2003

2.3. Potted Plant Installation

704 one-gallon plants indigenous to the Fort Ord ecosystem were installed on the sites within Small Arms Ranges 18 and 19 on January 19, 2004. A single 1-gallon potted greenhouse plant was placed in the center of each quadrat. The randomly selected plant established in each quadrat is identified on the plant arrays included with the corresponding figures. (See Image 4)

Image 4. Installed plants were planted on 1 meter centers throughout the sites.

The following 11 species were planted in a predetermined pattern at each of the three sites in roughly equal quantities:

- Blue Wild Rye (*Elymus glaucus*)
- Black Sage (*Salvia mellifera*)
- California Coffeeberry (*Rhamnus californica*)
- Mock Heather (*Ericameria ericoides*)
- Purple Needlegrass (*Nasella pulchra*)
- Sandmat Manzanita (*Arctostaphylos pumila*)
- Shaggy Bark Manzanita (*A. tomentosa*)
- Bush Lupine (*Lupinus arborius*)
- California sagebrush (*Artemesia californica*)
- Coyote Brush (*Baccharis pilularis*)
- Wedge-leaf Horkelia (*Horkelia cuneata*)

A single randomly designated species from the above species palate was installed in each quadrat contains one plant. Details including the species planted in each quadrat and physical attributes of the plots were noted during the out-planting event.

Range 18 Site 1 was planted with 300 plants, Range 19 Site 1 was planted with 270 plants, and Range 19 Site 2 was planted with 134 plants. Within each plot, 10% of the quadrats were also randomly selected (prior to planting) as locations to be monitored throughout the study for volunteer plant establishment. Volunteer plants are classified as either native or non-native. Volunteer plant counts were made during each quarterly monitoring event for non-planted species growing within the selected quadrats.

2.4. Site Monitoring

To date, seven monitoring events have occurred for installed plants and volunteer species counts at all three of the sites. The first baseline monitoring event was conducted on February 3, 2004, and consisted of: (1) evaluating plant "health" and "coverage" at all three sites; (2) assessing whether any volunteer plants had emerged within the randomly-selected quadrats since the planting event (January 19, 2004) and; (3) continuing the collection of photographic records of site activities and plant conditions. Volunteer species were not evident at any of the sites prior to the February 3rd, 2004 monitoring event. Similar monitoring events were conducted on March 26, 2004, July 29th, 2004, November 23rd 2004, February 23, 2005, June 4th, 2005, and August 16, 2005. The addition of non-native invasive plant species eradiation tasks were added to each monitoring event following the March, 26, 2004 monitoring event.

2.4.1. Installed Plant Monitoring

Monitoring installed species consists of assessing the "health" and the "cover" of the installed plants in each of the designated quadrats established within the three sites. "Health" is a qualitative assessment of the color green, expressed as an integer value, for the following ranges:

- 0: 0 to <10% green
- 1: 10% to 25%
- 2: >25% to 50% green
- 3: >50% to 75% green
- 4: >75 to 100% green.

For instance, on a given plot if the average health of a species were determined to be 2.4 on February 3 and 3.8 on March 26, then the calculated health difference of 1.4 would suggest a significant improvement. This health difference is tallied for each of the 10 species and a mean health difference ($\overline{X}_{health}$) is determined for the overall plant population. A negative value for health difference suggests that a particular species is not thriving or that the entire site is experiencing difficulties. "Cover" is a measurement of how much of the quadrat is covered by the leafing plant. A rubric similar to the health analysis is performed for coverage (mean cover difference = $\overline{X}_{cover}$), with the focus being on the percentage of the quadrat that is covered as the plant grows over time. (See Image 5)

Final analysis consisted of summarizing the health and cover for each site. Final overall site health was calculated by determining the mean of all health differences for all planted species during each monitoring event. A positive or negative value for health difference suggests a gain or loss in overall site health through time. Overall site mortality was determined by summing all individuals per species with greater than 25% green cover and categorizing them as alive. Individuals from each species with less than 25% green cover were categorized as dead.
Species mortality was determined based on the quotient of total dead in population / total planted population. Total site mortality was determined based on the quotient of total dead plants / total site planted individuals.

2.4.2. Volunteer Species Counts

Monitoring of volunteer species emergence was conducted using an inventory count method of individual volunteer plant species emergence in randomly selected quadrats. 10% of each sites' quadrats were randomly selected and identified for observational counts of volunteer plant species that have emerged and grown during the course of the project. Total number of species and counts of individual species over the course of the project are reported in the Volunteer Species Tables in Appendix 1. On all treatment sites no volunteers were evident at the time of the initial potted plant installation.

3.0. RESULTS

3.1. Range 18 Site 1 Analysis

Final analysis of overall site health for Range 18 Site 1 planted species indicates a small decrease in mean site health from Feburary 2004 – August 2005 ($\overline{X}$ Site Health difference= -0.75). In total 194 of the 300 plants (65%) survived into August 2005 with greater than 25% green biomass. The largest losses of individuals per species were observed in *E. glaucus, R. californicus, N. pulchra, L. arborius, Arctostaphylos species,* and *H. cuneata.* In contrast *S. mellifera*, *A. californica*, and *B. pilularis* had much lower mortality rates. (See Table 1) Images 8-13 at the end of this section provide a visual log of the sites progress.

Table 1 .Mortality Summary for Ranges 18 Site 1, Range 19 Site 1, and Range 19 Site 2

Site Mortality Summary	**Range 18 Site 1** (Dry Separation)			**Range 19 Site 1** (Wet Separation)			**Range 19 Site 2** (Excavation)		
Genus species	**Plant Count**	**# Surviving >25% Green**	**Mortality Deaths/Pop**	**Plant Count**	**# Surviving >25% Green**	**Mortality Deaths/Pop**	**Plant Count**	**# Surviving >25% Green**	**Mortality Deaths/Pop**
Elymus glaucus	28	16	0.43	21	1	0.95	10	3	0.70
Salvia mellifera	21	19	0.10	21	2	0.90	9	7	0.22
Rhamnus californicus	35	13	0.63	32	3	0.91	18	9	0.50
Baccharis pilularis	25	23	0.08	34	9	0.74	12	9	0.25
Ericameria ericoides	33	25	0.24	21	3	0.86	14	4	0.71
Nasella pulchra	36	21	0.42	22	3	0.86	15	10	0.33
Horkelia cuneata	30	20	0.33	32	2	0.94	12	6	0.50
Lupinus arborius	35	18	0.49	39	0	1.00	19	3	0.84
Artemesia californica	31	28	0.10	30	13	0.57	18	17	0.06
Arctostaphylos species	26	11	0.58	18	1	0.94	7	3	0.57
Total Plant Count	**300**	**194**		**270**	**37**		**134**	**71**	
		Site Mortality	**0.34**		**Site Mortality**	**0.87**		**Site Mortality**	**0.47**

The most significant losses in surviving individuals per species were observed in the first year following plant installation. Beyond January 2005 the majority of species mortality rates decreased with the exception of *E. glaucus* and *N. pulchra* (See. Figure 1). The noted fluctuations in these perennial bunchgrass species and the observed fluctuation in green cover is more indicative of the cyclical patterns of senescence and green-up rather than increased mortality.

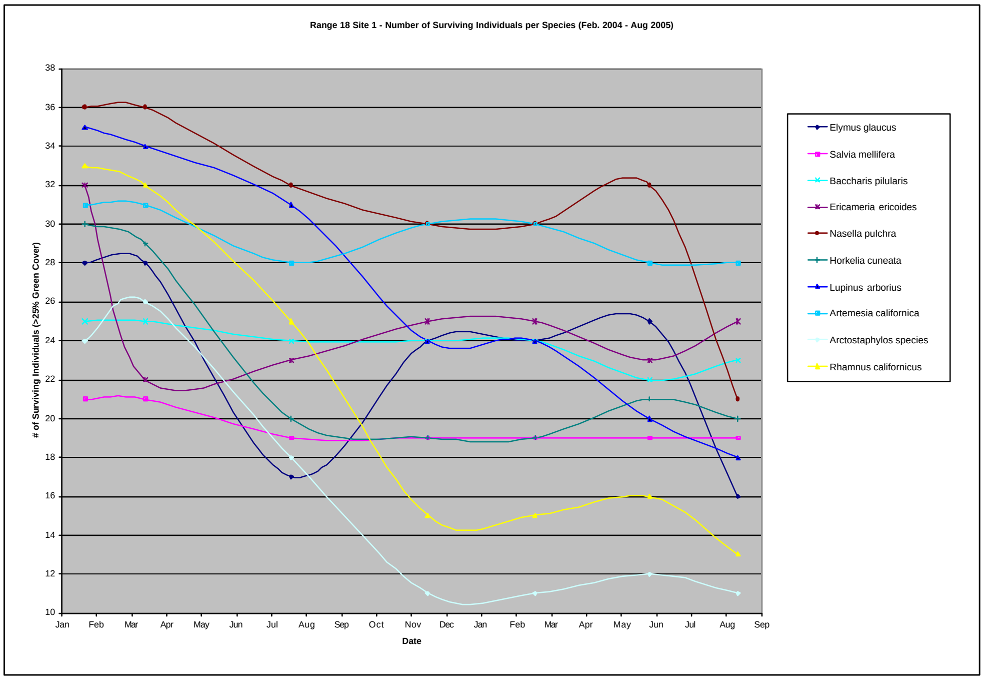

Figure 1. Range 18 Site 1 Number of Surviving Individuals per Species (Feb. 2004 – Aug. 2005)

An increasing trend in total percentage site cover, due to growth of installed plants, was observed throughout the course of the project with a small decrease in percent site cover occurring between the July 2004 and November 2004 monitoring events. (See Figure 2 and Figure 3)

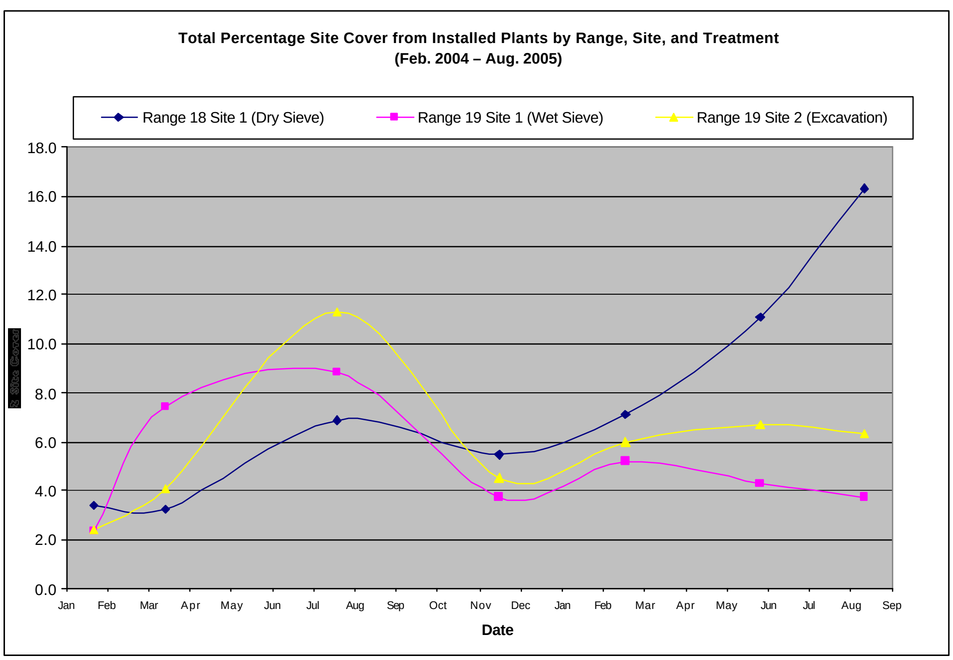

Figure 2. Total Percentage Site Cover from Installed Plants by Range, Site, and Treatment (Feb. 2004 – Aug. 2005)

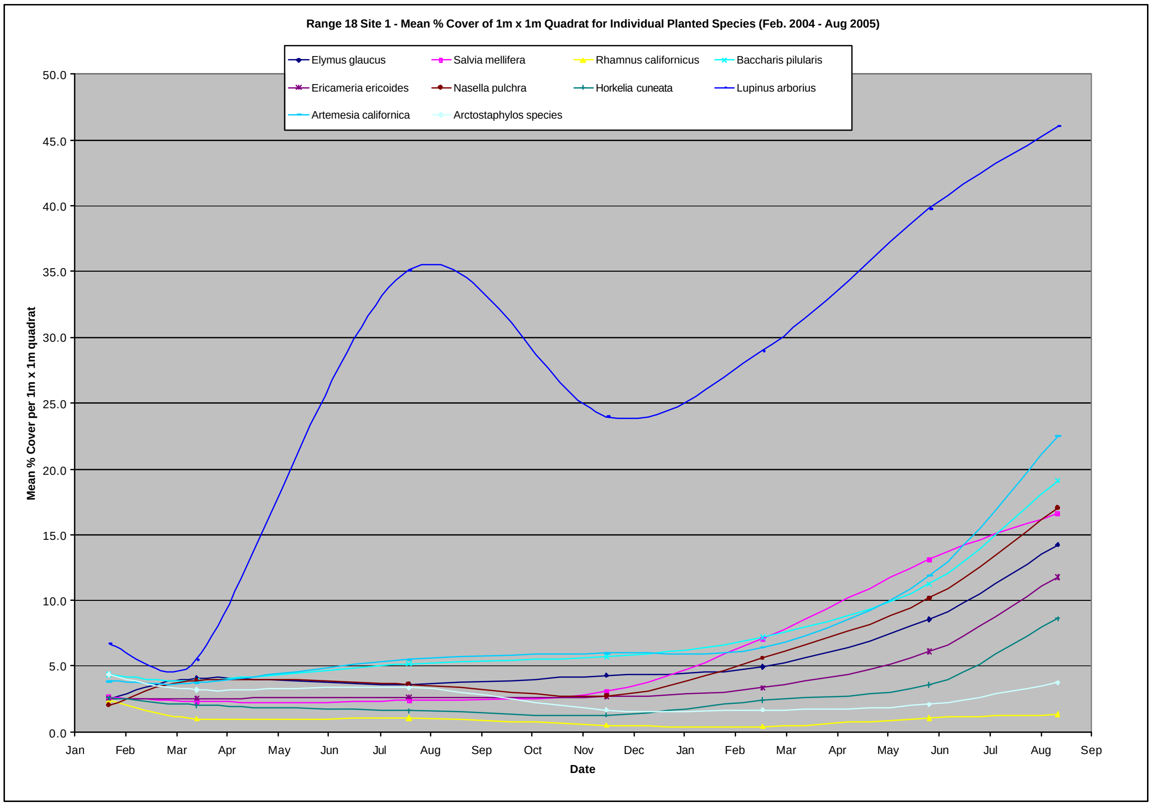

Figure 3. Range 18 Site 1 – Mean Percent Cover of 1mx1m Quadrate for Planted Species (Feb. 2004 – Aug. 2005)

Changes in mean percent cover of a 1m x 1m quadrat for each planted species support the observed loss of cover largely due to herbivore browsing on *L. arborius, R. californicus, and Elymus glaucus* between the July-November 2004 monitoring events. (See Image 5). During the Feburary 2005 monitoring visual evidence of herbivory suggested that Mule Deer (*Odocoileus hemionus*) continued to browse on *R. californicus* and *L. arborius* following the November 2004 monitoring event. The planted *R. californicus* that were not completely defoliated by browsing recovered with additional green cover and flowering present. *Elymus glaucus* that was heavily grazed prior to the July, 29th, 2004 monitoring was recovering quickly and showing signs of vigorous new green growth and viable seed production.

Image 5. Evidence of Deer Browsing on *L. aborius* – Range 18 Site 1

Arctostaphylos species experienced increased casualties over time, indicated by a loss of green cover, until November 2004 when many individuals on the site appeared to be resprouting vigorously from root and basal stems. Green leaf cover that was present when plants were installed completely desiccated between the July 2004 and November 2004 monitoring events. Final *Arctosophylos* species health values actually represent the near-complete regrowth of green cover from new stems since the last monitoring. (See Image 6)

Image 6. Installed *A. tomemtosa*. (left) pre-desiccation and (right) desiccated individual in foreground with resprout in background.

The total number of native volunteer species, both annual and perennial, followed a generally increasing trend over time with a peak in native species diversity by June 2005 monitoring event. Total number of non-native volunteer species increased rapidly between February 2004 and July 2004 largely due to annual non-native species. *Chorizanthe pungens var. pungens*, a Federally Threatened species of concern, was found in large patches throughout the site after the February 2005 monitoring. These established patches covered 75% of the site and remained for the duration of the project (See Image 7).

Image 7. Range 18 Site 1 supported extensive patches of *Chorizanthe pungens var. pungens*.

Non-Native species diversity increased again between November 2004 and June 2005 with species composition consisting of annuals. Perennial non-native species (*C. edulis* and *R. acetosella*) were completely eradicated from the site by November 2004. Several non-native species and known invasive weed species were found early in the project and required continual maintenance over the course of the project. Invasive weed management focused on eradication of Carpobrotus edulis, Centaurea solstitialis, Rumex acetosella, and Conyza Canadensis on Range 18 Site 1. Early detection and nominal follow-up labor (< 2 hours total for project) resulted in excellent control for these species. In total, non-native volunteers decreased over time but a suspected invasion of non-native annual grasses was observed. Technicians were not able to positively identify many of these annual monocots but speculated that they may be non-native in origin. This suggests that the data may be underestimating the total number of annual non-native species actually occurring on the site. (See Figure 4 and Table 2)

Table 2. Range 18 Site 1 – Volunteer Species Count Summary

Range 18 Site 1 - Volunteer Species Count Summary

Species Name	Origin	Ann./ Pern.	04-Feb-03	04-Mar-26	04-Jul-29	04-Nov-23	05-Feb-23	05-Jun-01	05-Aug-16
Baccharis pilularis	Native	Perennial	0	0	0	0	4	2	3
Cardionema ramosissimum	Native	Annual	0	17	3	1	14	5	0
Cammisonina Species	Native	Perennial	0	0	0	0	0	2	0
*Chorizanthe pungens var. pungens***	Native	Annual	0	0	21	0	10230	300	0
Circium occidentale var. californicum	Native	Annual	0	1	1	0	0	0	0
Claytonia perfoliata	Native	Annual	12	13	0	4	173	0	0
Crassula connata	Native	Annual	0	9	0	380	800	0	0
Deschampsia caespitosa	Native	Perennial	0	0	0	0	0	130	555
Elymus glaucus	Native	Perennial	0	0	0	0	0	1	0
Eriophyllum confertiflorum	Native	Perennial	0	0	0	0	0	1	2
Eschscholzia californica	Native	Perennial	0	1	0	0	1	0	0
Gilia Species	Native	Annual	0	0	0	0	0	256	207
Gnaphalium Species	Native	Annual	0	16	19	15	10770	691	1166
Helianthemum scoparium	Native	Perennial	0	0	0	0	0	1	2
Horkelia cuneata	Native	Perennial	0	1	0	4	0	0	0
Lotus scoparius	Native	Perennial	34	65	14	12	15	42	13
Marah fabaceus	Native	Perennial	0	1	1	1	0	0	0
Mimulus aurantiacus	Native	Annual	17	48	26	17	13	16	13
Navarretia atractyloides	Native	Annual	0	0	0	0	0	183	0
Quercus Agrifolia	Native	Perennial	0	2	0	0	0	1	0
Toxidendron diversilobuun	Native	Perennial	0	1	2	0	1	0	0
Bromus Species	Non-Native	Annual	0	0	0	0	2612	169	0
*Carpobrotus edulis**	Non-Native	Perennial	0	1	1	1	0	0	0
*Centaurea solstitialis**	Non-Native	Annual	0	0	2	0	0	0	0
*Conyza canadensis**	Non-Native	Annual	0	0	447	314	0	132	116
Erodium Species	Non-Native	Annual	4	12	3	3	92	3	0
Fescue Species	Non-Native	Annual	0	0	0	0	0	785	0
Linaria canadensis	Non-Native	Annual	0	0	4	0	0	0	0
Medicago polymorpha	Non-Native	Annual	0	0	0	0	0	6	0
Plantago Species	Non-Native	Annual	0	0	24	20	11	125	79
Rumex acetosella	Non-Native	Perennial	1	1	1	0	0	0	0
Sonchus oleraceus	Non-Native	Annual	0	2	1	0	0	0	0
Unknown Annual Monocot			0	0	106	102	0	11	1090
Unknown Brassicaceae			0	0	0	0	0	37	0
Unknown Dicots			660	430	39	205	218	21	5

* Special Status Native
* Listed Invasive Non-Native Species

Summary Counts	Feb, 03,2004	Mar. 26,2004	Jul. 29, 2004	Nov. 23, 2004	Feb. 23, 2005	Jun. 1, 2005	Aug. 16, 2005
Tot. # Native Species	3	12	8	8	10	14	8
Tot. # Native Annual Species	2	6	5	5	6	6	3
Tot. # Native Perennial Species	1	6	3	3	4	8	5
Tot. Non-Native	2	4	8	4	3	6	2
Tot. # Non-Native Annual Species	1	2	6	3	3	6	2
Tot. # Non-Native Perennial Species	1	2	2	1	0	0	0

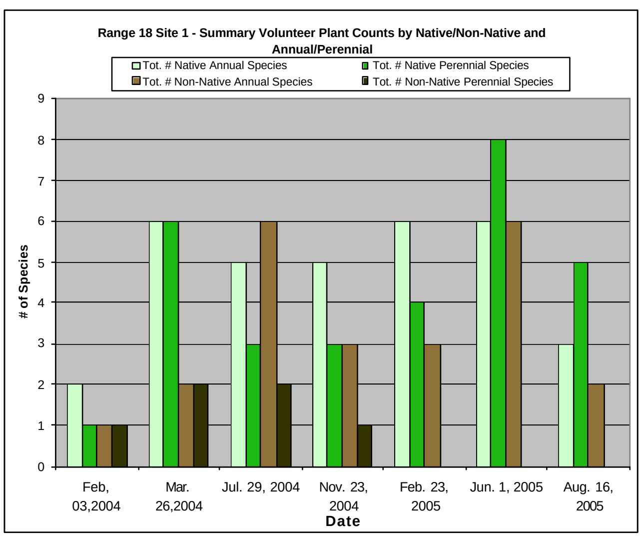

Figure 4. Range 18 Site 1 – Summary Volunteer Plant Counts by Native/Non-Native and Annual/Perennial Categories.

Image 8. Range 18 Site 1, March 2004.

Image 9. Range 18 Site 1, July 2004.

Image 10. Range 18 Site 1, November 2004

Image 11. Range 18 Site 1, Feburary 2004

Image 12. Range 18 Site 1, June 2005

Image 13. Range 18 Site 1, August 2005

3.2. Range 19 Site 1 Analysis

Final analysis of overall site health for Range 19 Site 1 planted species indicates an overall catastrophic decrease in mean site health from Feburary 2004 – August 2005 ($\overline{X}$ Site Health difference Feb. 2004 – Aug 2005 = -2.43). In total 37 of the 270 plants (14%) survived into August 2005 with greater than 25% green biomass. Comparison of Feburary 2004 and March 2004 monitoring event results indicated extraordinary growth rates in all of the individual installed plants. During this initial period all planted species experienced increased mean green cover and increased mean percent cover of their respective 1m x 1m quadrats. Subsequent monitoring events detected a rapid and catastrophic decline in installed plant survivorship, greenness, and mean percent cover of a 1m x 1m quadrat. (See Figure 5 and Figure 6)

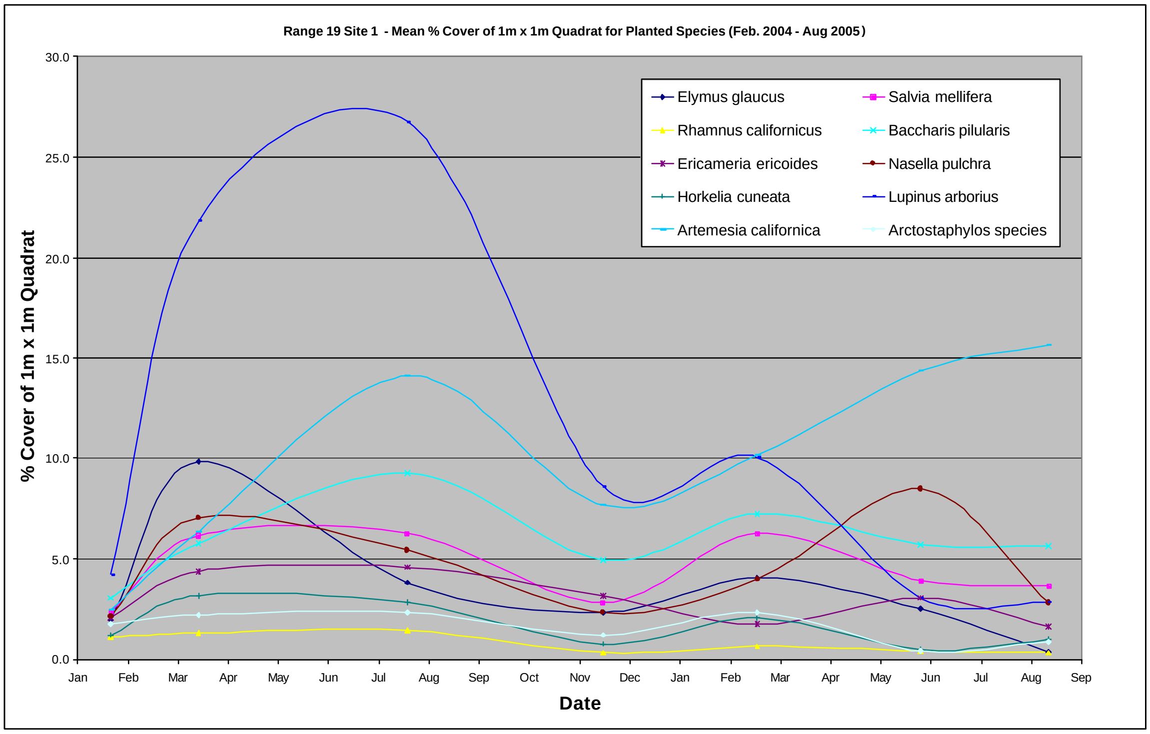

Figure 5. Range 19 Site 1 – Mean Percent Cover of 1mx1m Quadrate for Planted Species (Feb. 2004 – Aug. 2005)

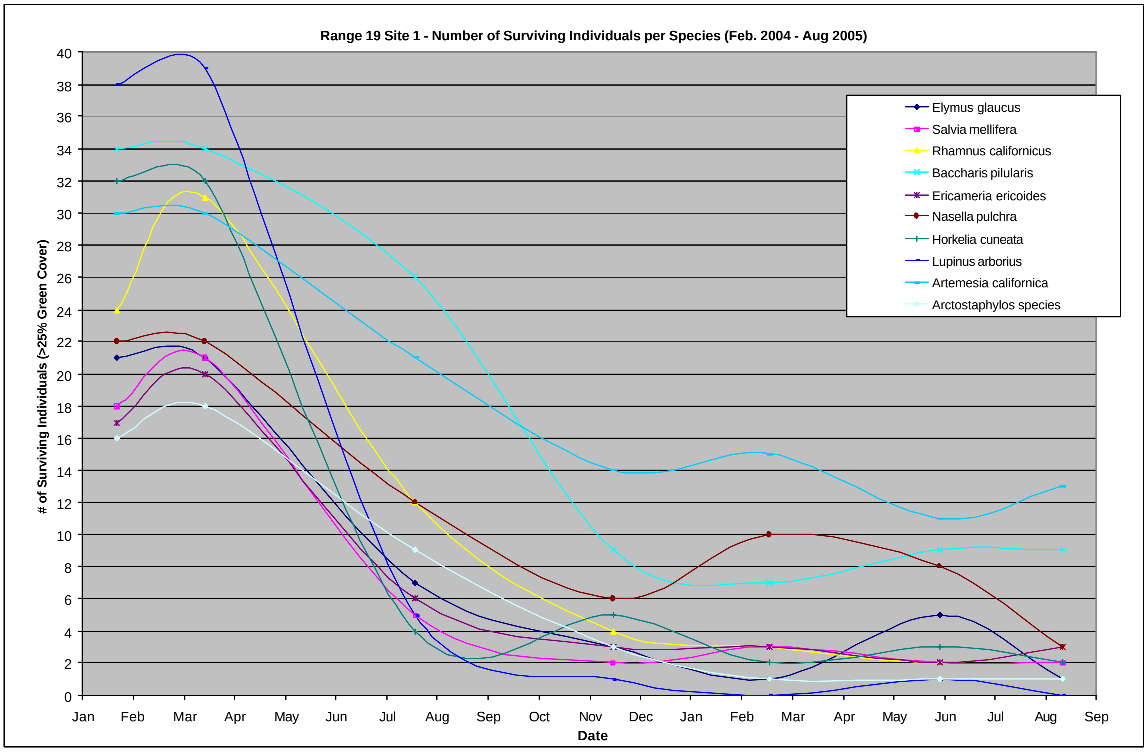

Figure 6. Range 19 Site 1 - Number of Surviving Individuals per Species (Feb. 2004 – Aug. 2005)

Comparison between July 2004 and March 2004 mean health and mean cover data support the field observation of a rapid die-off in all planted species except *B. pilularis* and *A. californica*. Field observation in Febuary 2005 noted that each of the installed species had a particularly small number of individuals that were thriving in green cover and size. Field observations also noted that these same individuals had growth patterns that we would consider atypical. Refer to Images 18-23 at the end of this section for a visual of the field observed trends in growth and decline.

For example, *H. cuneata* and *S. mellifera* were noted as both remaining relatively small in foliage stature but having prolific, or abnormally large, flowering segments. Another anomaly was observed in the few surviving individual *A. californica*. *A. californica is* typically a relatively slower growing shrub species during its early development, yet surviving *A. californica* in the treated soil had experienced an enormous growth rate that resulted in a 60% increase in total quadrat cover between samplings.

Image 14. Large rapid growing *A. californica* (foreground) Note: 10cm ruler in plant for scale.

In July, it was suspected that the observed site die-off might be the result of normal water stress associated with the summer months. Additional comparison of overall health for the first three site rows, where treated soil appeared to be applied in a thinner layer, was compared against the remaining portion of the site suggest that mortality rates are significantly different. The upper three rows of the site experienced a mortality rate of 17% and the remaining portion of the site has a catastrophic 78% mortality rate. This tends to support the hypothesis that the treated soil may have a negative impact on the productivity of native plant species. Continued comparison of overall health for the first three site rows, where treated soil was applied in a thinner layer, against the remaining portion of the site suggest that mortality rates remain drastically different. By Feburary, the upper three rows of the site suffered from a 27% mortality rate and the remaining portion of the site continues to experience a catastrophic 79% mortality rate. Final comparison of mortality between rows 1-3 and rows 4-27 continued to support the hypothesis that the treated soil may have a negative effect on the productivity of native plant species. Final analysis of installed plants and this phenomenon failed to locate a species that was particularly resilient to the soil treatment (See Table 3). The only exception to this observation was found in native *N. pulchra* volunteers, which were noted throughout rows 4-27 during the June 2005 monitoring event. This would suggest that *N. pulchra* may be able to establish itself in the wet treatment soils. (See Image 15) *N. pulchra* that was established as volunteers appeared to be producing seed at a relatively immature stage in its growth development. It is suspected that these individuals may suffer the same fate as planted individuals who exhibited the same growth abnormal growth pattern. Several species may have preferred the conditions in rows 1-3 over conditions in rows 4-27. These species include *S. mellifera, E. ericoides, H. cuneata, and A. californica.* It was not possible to conduct the same comparison for Arctostaphylos species installed on the site because no individuals were present in the first three rows of the site.

Table 3. Range 19 Site 1 - Mortality Comparison (Rows 1-3 and Rows 4-27)

Range 19 Site 1 - Mortality Comparison (Rows 1-3 / Rows 4-27)

Planted Genus species	Rows 1-3 Mortality Deaths/Pop	Rows 4-27 Mortality Deaths/Pop
Elymus glaucus	1.00	1.00
Salvia mellifera	0.50	0.95
Rhamnus californicus	0.00	0.93
Baccharis pilularis	0.00	0.93
Ericameria ericoides	0.33	1.00
Nasella pulchra	1.00	0.84
Horkelia cuneata	0.75	0.89
Lupinus arborius	1.00	0.89
Artemesia californica	0.25	0.86
Arctostaphylos species	N/A	0.83
	0.54	0.92

* Note: Rows 1-3 Consist of a thin layer of treated soil and n < 20 for all species.

**Note: No Arctostaphylos Speices present in rows 1-3

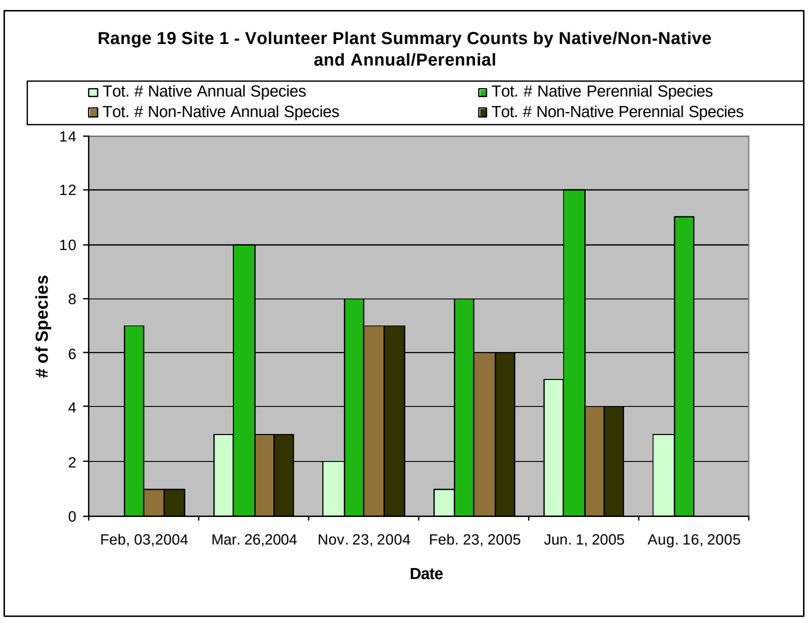

Figure 7. Range 19 Site 1 - Volunteer Plant Summar y Counts by Native / Non-Navie and Annual / Perennial

Image 15. Range 19 Site 1. Volunteer and planted *N. pulchra* surviving in background.

Volunteer species abundance and distribution varied greatly between the first 5 rows of the site and the remaining rows over time. Several trends were observed in the field and are evident in the volunteer monitoring data. First, the upper 5 rows consisted of predominately volunteer annual and perennial natives. The remainder of the site consisted largely of bare compacted soil for the duration of the project. The only exceptions to this were the establishment of non-native *Soncus oleraceus*, non-native *Conyza Canadensis,* and native *Nasella pulchra.* (See Table 4)

Conyza canadensis (Horseweed) invasion occurred only on the treated soil and not in the first five rows where treated soil was distributed in a relatively thinner layer. In the previous samplings two common non-native weeds *Sonchus oleraceus* (Common Sow Thistle) and *Sonchus asper* (Prickly Sow Thistle) invaded in a similar distribution. This has lead to the hypothesis that the treated soil may have properties that are more supportive of these weed species. (See Images 16 and 17)

Image 16. *Sonchus oleraceus* Invades in proximity to installed plants.

Image 17. *S. oleraceus* invades and competes with installed plant. Also, Note: Presences of low quality fill gravel and asphalt.

Table 4. Range 19 Site 1 - Volunteer Species Count Summary

Range 19 Site 1 - Volunteer Species Count Summary

Species Name	Origin	Ann./Pern.	**04-Feb-03**	**04-Mar-26**	**04-Nov-23**	**05-Feb-23**	**05-Jun-01**	**05-Aug-16**
Adenostoma fasiculatum (5)	Native	Perennial	0	0	0	0	3	2
Amsinckia menziesii	Native	Annual	0	0	0	0	3	0
Artemesia californica	Native	Perennial	0	6	4	1	1	1
Arctostaphylos sp.	Native	Perennial	2	18	2	1	1	1
Baccharis pilularis	Native	Perennial	0	2	0	0	0	0
Cardionema ramosissimum	Native	Annual	0	3	0	0	1	0
Ceanothus species (5)	Native	Perennial	5	5	0	3	2	2
Chorizanthe angustifolia	Native	Annual	0	0	0	0	2	0
*Chorizanthe pungens var. pungens***	Native	Annual	0	0	0	0	0	2
Crassula connata	Native	Annual	0	6	153	0	0	0
Elymus glaucus	Native	Perennial	0	0	0	0	66	66
Eriophyllum confertiflorum (5)	Native	Perennial	15	15	17	0	10	4
Gnaphalium Species	Native	Annual	0	1	12	226	67	61
Helianthemum scoparium	Native	Perennial	8	8	12	13	17	6
Lotus heermanii var. orbicularis	Native	Perennial	0	2	2	2	3	0
Lotus scoparius (5)	Native	Perennial	34	21	5	16	12	5
Nasella pulchra (6-27)	Native	Perennial	0	0	0	0	47	26
Navarretia atractyloides	Native	Annual	0	0	0	0	0	11
Phlox gracilis	Native	Annual	0	0	0	0	12	0
Salvia mellifera	Native	Perennial	4	4	1	1	3	1
Toxidendron diversilobum (6-27)	Native	Perennial	2	5	3	4	3	2
Bromus Species (6-27)	Non-Native	Annual	0	0	0	901	10	0
*Carpobrotus edulis** (6-27)	Non-Native	Perennial	0	3	0	1	3	3
Circium vulgare (6-27)	Non-Native	Annual	0	0	0	5	0	0
*Conyza canadensis** (6-27)	Non-Native	Annual	0	0	4	210	74	19
Erodium Species	Non-Native	Annual	0	0	60	54	28	17
Fescue Species	Non-Native	Annual	0	6	0	1302	170	0
Medicago polymorpha	Non-Native	Annual	1	2	5	1	0	0
Sonchus oleraceus (6-27)	Non-Native	Annual	0	1	9	105	1	0
Unknown Annual								139
Unknown Dicots			62	50	30	1	4	19

(5) Majority of individuals located in Treatment Rows 1-5.
(6-27) Majority of indivudals located in Treatment Rows 6-27.
* Special Status Native
* Listed Invasive Non-Native Species

Summary Counts	Feb, 03,2004	Mar. 26,2004	Nov. 23, 2004	Feb. 23, 2005	Jun. 1, 2005	Aug. 16, 2005
Tot. # Native Species	7	13	10	9	17	14
Tot. # Native Annual Species	0	3	2	1	5	3
Tot. # Native Perennial Species	7	10	8	8	12	11
Tot. Non-Native	3	6	10	8	6	0
Tot. # Non-Native Annual Species	1	3	7	6	4	0
Tot. # Non-Native Perennial Species	1	3	7	6	4	0

Several field observations tend to support the hypothesis that there may also be a correlation between the soil treatment and the occurrence of this *Sonchus* invasion. First, *Sonchus* was not observed in the nearby vicinity of Range 19 Site 1 in undisturbed or disturbed soils. *Sonchus* is a common windborne weed that invades disturbed soils and waste sites. It would be expected to find plants of this genus on disturbed road cuts, gullies and lots in the vicinity of Range 19 Site 1. *Sonchus* was observed at the entrance gates to Range 19 and this may have provided a seed source. *Sonchus* was not observed on the Range 19 Site 2 with the excavated soil treatment. This would suggest that disturbance coupled with available nutrients from the soil treatment on Range 19 Site 1 might be providing suitable conditions for *Sonchus.* If soil was moved off of Range 19 Site 1 to an area proximal to the entrance to Range 19 soil may have become contaminated with the nearby *Sonchus* seed source. Many of the *Sonchus* invaded directly into the planted vegetation depressions and the lower rows of the site further down-slope. *Sonchus* may have colonized these locations based on water availability and soil disturbance during planting. The proposal that *Sonchus* invaded via introduced potted plant soil was considered, but field observations suggest this was not a potential seed source because neither of the other planted sites experienced an invasion by this genus. It is possible that viable *Sonchus* seed was introduced via fecal deposits by mammals although no evidence of browsing, footprints, or fecal material was found on site. Interestingly, the suppression of invasive weeds, absence of nearly any native species, and hard dry compacted soils may have created conditions capable of supporting *N. pulchra*.

Image 18. Range 19 Site 1, March 2004.

Image 19. Range 19 Site 1, July 2004 – Note Cover difference in rows 1-4 (Right)

Image 20. Range 19 Site 1, November 2004 – Note extreme desiccation of installed plants.

Image 21. Range 19 Site 1, Feburary 2005. Note Weed Infestation.

Image 22. Range 19 Site 1, June 2005. Note Light brown is *N. pulchra* volunteers.

Image 23. Range 19 Site 1, August 2005. Technicians are in upper 4 rows. Note cover difference.

3.3. Range 19 Site 2 Analysis

Final analysis of overall site health for Range 19 Site 2 planted species indicated a small fluctuating decrease in mean site health from Feburary 2004 – August 2005 with slightly lower health values for all species except *B. pilularis* ($\overline{X}$ Site Health difference Feb. 2004 – Aug 2005 = -0.69). In total 71 of the 134 plants (~ 53%) survived into August 2005 with greater than 25% green biomass (See Figure 8).

All of the species experienced a decline in health following the July monitoring event with the exception of *B. pilularis.* Although the number of surviving individuals decreased over time analysis of trends in mean cover indicate that growth rates of surviving species was excellent. Positive changes in mean cover of 1m x 1m quadrats were noted for virtually all individual installed species. Between February 2004 and July 2004 the majority of installed plants increased their amount of green cover in their respective 1m x 1m quadrats (See Figure 9).

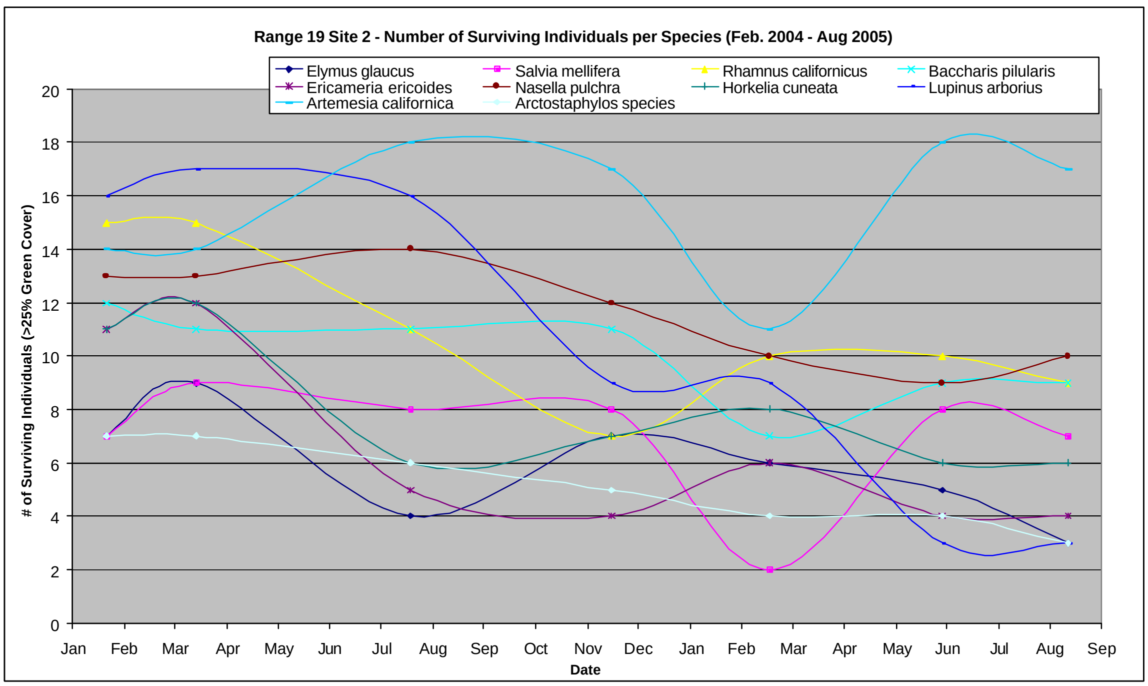

Figure 8. Range 19 Site 2 - Number of Surviving Individuals per Species (Feb. 2004 – Aug. 2005)

Subsequent monitoring events detected a large loss in installed mean percent cover of a 1m x 1m quadrat for many species prior to the November 2004 monitoring event. (See Figure 9). This loss in cover can be attributed to two events. First, scouring and deposition from sheet and gully erosion during the rainy season resulted in the burial and or excavation of several plants and/or their identification tags (See Image 24).

Image 24. Range 19 Site 2. Scouring gully erosion (Left) and Vehicle Trampling (Right).

Secondly, evidence of human traffic via treaded vehicle through the site potentially destroyed ~ 6-9 individual plants on the site (See Image 24). These conditions made it difficult to locate and identify individual plants. If a plant could not be identified with a tag it was recorded as a null value for health and cover. Many of the plants were later found resprouting vigorously in the loose sediments and their tags were generally found intact upon moderate hand-excavation. Even with these factors effecting mortality final analysis suggests that species in Range 19 Site 2 retained relatively higher health values than plants in Range 19 Site 1. *L. arborius* was the only species with a large mean cover fluctuation and can be attributed to extensive herbivory on the site from September 2004 to Feburary 2005 (See Figure 9). Deer browsing also denuded green leaf cover almost completely on several *L. arborius* individuals.

Analysis of volunteer species counts on Range 19 Site 2 reveal increased numbers of native annual and perennial species. Non-native species were present in much smaller populations compared to Range 19 Site 1. Non-native invaders consisted of *C. edulis*, *Erodium*, and several unidentifiable *Fescue* genera. Minimal hand-pulling (< 10 minutes labor) was conducted for control of *C. edulis* during the July 2004 and Feburary 2005 monitoring events (See Figure 10).

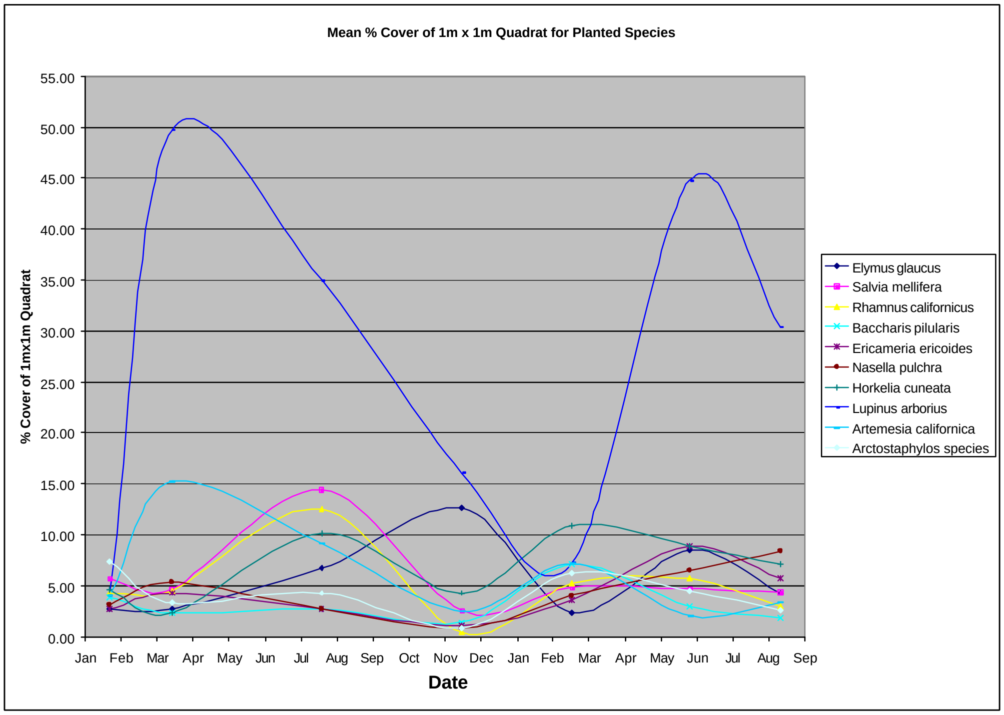

Figure 9. Range 19 Site 2 – Mean Percent Cover of 1mx1m Quadrate for Planted Species (Feb. 2004 – Aug. 2005)

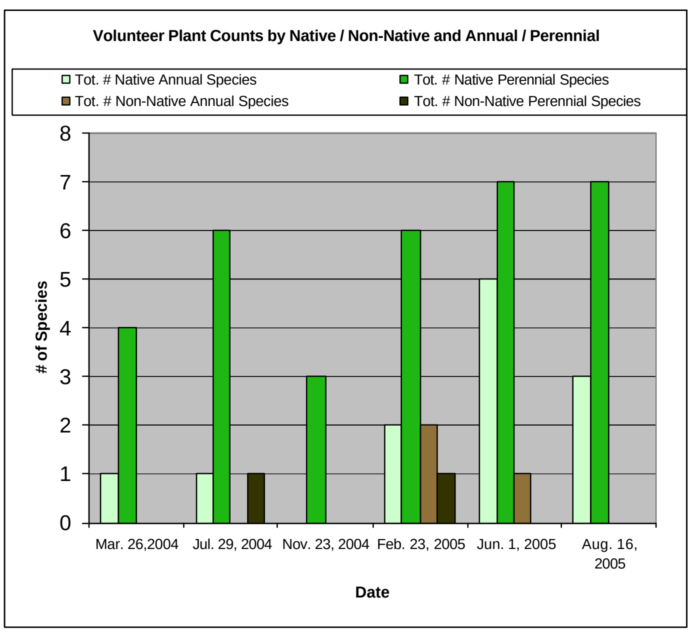

Figure 10. Site 2 - Volunteer Plant Counts by Native / Non-Native and Annual / Perennial. Note: Non-Native Perennial is *C. edulis.*

Table 5. Range 19 Site 2 – Volunteer Species Count Summary

Range 19 Site 1 - Volunteer Species Count Summary

Species Name	Origin	Ann./ Pern.	04-Mar-26	04-Jul-29	04-Nov-23	05-Feb-23	05-Jun-01	05-Aug-16
Adenostoma fasiculatum	Native	Perennial	0	0	0	0	1	1
Arctostaphylos sp.	Native	Perennial	0	24	2	5	5	6
Baccharis pilularis	Native	Perennial	0	1	0	0	0	0
Ceanothus species	Native	Perennial	1	2	0	2	2	3
Chorizanthe angustifolia	Native	Annual	0	0	0	0	11	0
*Chorizanthe pungens var. pungens***	Native	Annual	0	1	0	1	4	0
Eriophyllum confertiflorum	Native	Perennial	0	3	1	1	3	4
Gilia species	Native	Annual	0	0	0	0	13	17
Gnaphalium Species	Native	Annual	1	0	0	9	9	5
Helianthemum scoparium	Native	Perennial	3	36	24	31	12	28
Lotus scoparius	Native	Perennial	1	0	0	2	1	1
Lupinus albifrons var. albifrons	Native	Perennial	0	1	0	0	0	0
Navarretia atractyloides	Native	Annual	0	0	0	0	1	13
Salvia mellifera	Native	Perennial	1	0	0	1	1	1
*Carpobrotus edulis**	Non-Native	Perennial	0	4	0	2	0	0
Erodium Species	Non-Native	Annual	0	0	0	1	0	0
Fescue Species	Non-Native	Annual	0	0	0	302	24	0
Unknown Annual			0	3	18	0	2	54
Unknown Dicots			34	22	0	22	0	0

* Special Status Native
* Listed Invasive Non-Native Species

Summary Counts	Mar. 26,2004	Jul. 29, 2004	Nov. 23, 2004	Feb. 23, 2005	Jun. 1, 2005	Aug. 16, 2005
Tot. # Native Species	5	7	3	8	12	10
Tot. # Native Annual Species	1	1	0	2	5	3
Tot. # Native Perennial Species	4	6	3	6	7	7
Tot. Non-Native	0	1	0	3	1	0
Tot. # Non-Native Annual Species	0	0	0	2	1	0
Tot. # Non-Native Perennial Species	0	1	0	1	0	0

Image 25. Range 19 Site2 - March 2004.

Image 26. Range 19 Site 2, July 2004.

Image 27. Range 19 Site 2 - November 2004 (Right)
Image 28. Range 19 Site 2 - Feburary 2005 (Left)


Image 29. Range 19 Site 2 August 2005. (Right)

Image 30. Range 19 Site 2. June 2005. (Left)

4.0. SUMMARY

Range 18 Site 1 had the lowest site mortality rates and greatest growth in green cover for installed plants when compared to the Range 19 treatment sites. Range 18 Site 1 also had comparably higher diversity in volunteer species throughout the site. These findings come with a large degree of uncertainty due to the nature of the project. The goal of this project was to demonstrate that installed plants survive through their first year in soils that have been undergone a variety of lead remediation treatments. The absence of paired treatments and control sites make it impossible to ascertain if the observed treads for installed plants and volunteer cover at Ranges 18 and 19 are the direct result of soil treatments, or the combined affect of differences in abiotic and biotic site characteristics. It can be ascertained from this project that potted plants grown in greenhouses from local seed stock will survive, with extremely varying degrees of success, under a variety of localized conditions that include soil treatment such as excavation or dry separation. It cannot be concluded that excavation treatment will result in greater losses to volunteer diversity and survivorship of installed plants. It can however be hypothesized that wet sieve soil treatment may adversely impact the survival and productivity of installed plants and volunteer species establishment. The following summary elaborates on the critical uncertainties that need to be explored further before we can conclusively determining which soil treatments are capable of better supporting installed plants and volunteer plant recruitment.

Range 18 Site 1 is on a predominantly North-facing slope shaded on all sides by established *Q. agrifolia* and living stands of associated chaparral. The northern aspect alone could have provided conditions that might be more supportive for potted plants compared to conditions on Range 19. Range 18 Site 1 orientation may have resulted in less direct sunlight exposure and soils that retained surface moisture for longer than burned South-facing sites on Range 19 Site 1 & 2. The live vegetation on Range 18 may have acted as a windbreak for potted plants sheltering them from desiccation. Living vegetation bordering the Range 18 Site 1 may have also facilitated volunteer colonization, accounting for the higher levels of native volunteer species. In contrast, Range 19 sites were on south-facing slopes in an area recently burned. Sunlight exposure for plants on Range 19 was conceivably higher and burned vegetation would not provide as much buffeting protection from wind. Range 19 Site 2 had dimensions that created more edge relative to site area. These dimensions may have facilitated invasion from the neighboring untreated burned soils.

It is also evident that herbivory is a major biotic factor in the survival and productivity of installed plants. All sites were impacted by varying degrees of browsing and grazing. It can be concluded that herbivory exclusion using caging may be necessary during the first year of plant installation if increased success in plant survivability is desired. Herbivory may also be dependent on the surrounding habitat mosaic and its ability to support deer and rabbit. Range 18 may have received more herbivory pressure due to its proximity to dense vegetative cover. Range 19 may have received the observed levels of herbivory pressure due to transient deer moving through the sites searching for new seedling growth. In either case, consideration for control against herbivory may need to be considered in future projects.

All sites experienced non-native weed invasions with varying degrees of intensity. It can be concluded that non-native species control should be factored into any future soil remediation. Erosion control measures were easily rectified with the installation of sandbags on Range 19 Site 2. Future revegetation efforts should consider the potentially higher costs of installing erosion control measures on sites. Given the small scale of this project, it was feasible to simply hand-pull invading non-native species but if the scale of soil treatment is increased this could quickly become a cumbersome undertaking. Trends observed in the wet sieve soil treatment suggest that this method is more conducive to supporting non-native weeds and has a negative impact on installed plants. Any future consideration of this method could assume potentially higher costs for non-native species eradication and higher casualties among installed native plants.

4.1. Discussion & Cost Analysis

The following section outlines the feasibility, potential production costs, and uncertainties associated with native plant restoration of Central Coast Maritime Chaparral habitat in the inland ranges of the former Fort Ord military reserve following vegetation removal and soil remediation for lead. Projections are based one the results of this study, namely the utilization of mortality rates for un-watered potted native plant survivability in areas where vegetation has been removed and soils have undergone lead remediation treatments, either excavation or dry separation. Such a broadly defined restoration goal is not recommended and the following provides elaboration on this critical point.

Return of the Natives, Watershed Institute; California State University Monterey Bay is capable of producing a maximum of 40,000 – 60,000 plants per year over our current project commitments. Assuming that plants will be planted on sites in a similar fashion as the pilot study, approximately 1-meter centers or 4075 plants/acre, this restricts our organization from projecting feasibility and costs beyond a 10-acre per year production estimate. See Table 6. Estimated Costs for 40,750 plants – Central Maritime Chaparral Revegetation for an estimate of production costs (See Table 6).

Several assumptions have been made in the establishment of a restoration goal related to the cost estimate. First, it has been assumed that the goal of this restoration is to establish native plant cover using site-specific species similar to those used in the pilot study (See Table 2). Secondly, it has been assumed that the goal of this restoration work would be to conduct monitoring aimed at assessing the restoration sites trajectory towards the species composition that exists in regionally specific transects
(See Table 1).

In order to reach these broad restoration goals, several site management goals and ecological considerations extend beyond the scope of this current project and will need to be clearly defined. The following discussion briefly explores the uncertainties that will require consideration in any future planning.

The cost estimate does not include costs associated with site preparation (E.g. lead remediation techniques, grading and/or erosion control, and invasive exotic control). It also assumes that the restoration sites will be actively managed to reduce the potential for excessive erosion and invasion of exotic species. Monitoring, Planning, and reporting costs are based on the need to collect information regarding reference ecological conditions, provide a proposed restoration plan, and conduct annual site monitoring with reporting. Planning costs also include preliminary field assessment of site characteristics such as physical soil conditions (E.g. permeability, nutrients (NPK), soil texture), on-site reference vegetation transects (pre-treatment), soil core extractions for baseline seedbank assessment, and general observational surveys for conditions and evidence of site fauna that may inhibit plant success. Preliminary soil analysis was not performed as part of this project and it is hypothesized that the wet separation and excavation methods may be radically altering the physical and biological characteristics of the soils. Preliminary definition of soil characteristics should also explore the biotic constituents in the soil as well (E.g. seedbank, and mychorrizal community).

Planning costs include determination of specific plant species to be propagated based on documented historical pre-existing conditions from previously documented plant transects in nearby regions. Propagation costs assume only costs associated with the growing of 40,750 plants consistent with the species outlined in *Table 1. Mortality Summary for Ranges 18 Site 1, Range 19 Site 1, and Range 19 Site 2* in equal proportions for a single planting event, on a single 10-acre site. This cost does not include the potential need for replanting dead plants due to mortality rates that may be higher than those listed. The mortality rates listed are based on first year survival of planted individuals. It is also critical to point out that mortality rates were estimated exclusively from data on plants in Range 18. The Range 18 site received the dry-sieve soil treatment and had the highest overall cover and survival rate over the other treatments. Final data analysis from the sites on Range 19 treated with either excavation or soil-wash treatments suggest that these treatments may have a potentially negative effect on the survival of planted species. It would be safe to conclude from these results that if these treatments are used in regions with similar characteristics (E.g. soil, facing slope, species composition) that costs associated with replanting would be higher due to higher rates of mortality. It is difficult to project the sustainability and success of a site into the following years but we suspect that if an individual is able to survive the first year on a site that its chances of survival may increase as time passes. I would also like to stress the importance of disturbance scale and the potential negative impact large scale disturbances may have on the survivorship of installed plants. Mortality rates determined from this project were on sites with area dimensions not exceeding 300 m^2. It can be hypothesized that larger scale disturbance dimensions could result in additional weed invasions and higher rates of erosion, which in turn could raise the site maintenance cost and reduce the success of installed plants.

Propagation costs do not include the potential risks associated with growing additional species of concern. Return of the Natives has prior experience propagating species of concern such as *Ericameria fasciculata* and *Ceanothus cuneatus var. ridgidus*.. However we have had more limited success in the propagation of *Arctostaphylos montereyensis,* and *Arctostaphylos hookeri ssp. hookeri,* and we are not prepared to estimate the costs associated with their propagation but we suspect that the expense per plant will be greater due to the potential difficulties involved in successfully germinating or propagating from cuttings, housing, and outplanting individuals. For example, many of these species of concern may have lower rates of success from cuttings-the preferred propagation method or from germination requiring increased seed and cutting collection costs. Also, many of these species may have slower growth rates and require more time in greenhouse conditions before out-planting, subsequently requiring more lead-time. Lastly, to the best of our knowledge no data exists that accurately estimates the mortality rates of outplanted nursery grown specimens of these species of concern and this information may have a bearing on species composition and propagation numbers required for a site.

All propagation costs also assume that at least a 1-year lead-time will be required for propagation of plants. The cost estimate also assumes that the existing Return of the Natives community-based school greenhouse system will be utilized. We are not prepared to speculate on the costs associated with contract growing outside of our existing infrastructure for the following reasons. First, this infrastructure exists because the primary goal of the Return of the Natives Restoration Education Project, Watershed Institute is "to bring people closer to nature and nature closer to people through hands-on restoration in their community". Excluding public involvement would be an exclusion of our primary goal of restoration education. This directive and the system that is currently in operation are capable of providing healthy potted native plants grown from local seed stock on Fort Ord. Given the uncertainties associated with the cost estimate we urge you to consider this estimate extremely preliminary with the absolute need for additional planning and risk assessment on a site specific / treatment specific basis.

Table 6. Estimated Costs for 40,750 plants.

Planning, Monitoring, Reporting	Year 1	Year 2	Year 3	Year 4
(Salaries + Benefits)				
RON Project Director (Jon Detka) 1 FTE $54000 .5FTE =$27,000 planning, monitoring, reporting	$27,000	$27,000	$27,000	$27,000
Science Advisor Dr. Suzanne Worcester $5,000/year	$5,000	$5,000	$5,000	$5,000
RON Director $33/hour x 150 hours/year (Laura Lee)	$5,000	$5,000	$5,000	$5,000
RON Restoration Coordinator 25%time, 1 FTE $54,000/year (Rami)	$13,500	$13,500	$13,500	$13,500
Monitoring / Reporting Totals	**$50,500**	**$50,500**	**$50,500**	**$50,500**
Seed Collection Plant Propagation (40,750 Plants ea. Dec)	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Salaries				
RON Schools and Community Outreach Coordinator 50%time, 1 FTE $54,000/year (Bree)	$27,000	$27,000	$27,000	$27,000
RON Greenhouse/Propagation Coordinator 75%time, 1 FTE $54,000/year	$40,500	$40,500	$40,500	$40,500
Ron Greenhouse Seed Collection and Propagation Assistant 50% time 11% benefits $17/hr	$19,624	$19,624	$19,624	$19,624
Student Assistants for schools, monitoring, and propagation	$15,000	$15,000	$15,000	$15,000
Contractual	**Year 1**	**Year 2**	**Year 3**	**Year 4**
CEC-greenhouse repair / maintain.	$4,000	$4,000	$4,000	$4,000
Materials / Supplies	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Soils $1000/truckload x 7 truckloads=$7000	$7,000	$7,000	$7,000	$7,000
Pots, hoses and other greenhouse supplies $3000	$3,000	$3,000	$3,000	$3,000
Cutting bench heating supplies $7000	$7,000			
Greenhouse repair $2000/year	$2,000	$2,000	$2,000	$2,000
Tools and equipment	$4,000	$3,000	$2,000	$1,000
Volunteer Supplies	$1,000	$1,000	$1,000	$1,000
Truck maintenance, gas, insurance	$4,000	$4,000	$4,000	$4,000
Propagation Total	**$184,624**	**$176,624**	**$175,624**	**$174,624**
FCSUMB Indirect 20% Salaries/benefits/contractual	$36,925	$35,325	$35,125	$34,925
Production + Monitoring Totals	**$221,549**	**$211,949**	**$210,749**	**$209,549**
Cost per Plant	$5.44	$5.20	$5.17	$5.14
Planting Estimate				
4,075 plants/acre / 120 plants/day/planter =34person days/acre x 8 hours/day x $17/hour = $4624/acre	$46,240	$46,240	$46,240	$46,240
Estimated Annual Cost / Acre	**$26,779**	**$25,819**	**$25,699**	**$25,579**