

561660
Bibkey
G06A

GGNRA REVEGETATION SITE EVALUATIONS 1991-1999

Golden Gate National Recreation Area
National Park Service
Department of Interior

March 2000

Prepared by:

Maria Alvarez
GGNRA Natural Resources Specialist

Katrina Strathmann
GGNRA Contractor

GGNRA Revegetation Site Evaluations

Table of Contents

Introduction	i
Site locator map	iii
Dune Restoration	1
Feral Dunes (Presidio)	1
Fort Funston Bank Swallow Site ... (Fort Funston)	7
North Baker Beach (Presidio)	12
Coastal Scrub and Grassland Restoration	17
✓ Baker Barry Tunnel (Rodeo Valley)	17
✓ Bolinas-Fairfax Region (Bollnas Ridge)	24
✓ Chaparral Trail Obliteration (Tennessee Valley)	31
Frank Valley Eucalyptus Site (Redwood Creek)	36
Rock Garden (Presidio)	41
Riparian Restoration	47
Muir Woods Fern Creek (Redwood Creek)	47
✓ Frank Valley Eucalyptus Site (Redwood Creek)	36
✓ Tennessee Valley Dam (Tennessee Valley)	52
Quarry/Dam Restoration	52
Tennessee Valley Dam (Tennessee Valley)	52
Tennessee Valley Quarry (Tennessee Valley)	57
Redwood Forest Restoration	47
Muir Woods Fern Creek (Redwood Creek)	47
Appendices	65
Species Revegetated by Site	65
Author Index	69
Index	71

Introduction

A primary mission of the Golden Gate National Recreation Area is the preservation and protection of a rich flora and fauna and the maintenance of natural processes, a tall order carried out through monitoring, inventorying and habitat restoration. One critical aspect of habitat restoration is revegetation. Overall goals of revegetation projects are to increase native species richness and diversity and accelerate native species establishment. This report focuses on the revegetation component of recent habitat restoration projects in the GGNRA.

The purpose of this report is to review methods and results of 12 revegetation efforts conducted from 1991-1998, in order to provide insight for everyone currently involved in planning, propagating, planting and monitoring of revegetation projects. This report does not attempt to provide a complete assessment of all revegetation projects in the GGNRA, since during this period well over 125 sites were planted. In addition, projects that included broadcast seed are underrepresented in this report because of the difficulty in monitoring such efforts. Projects were selected from as broad as possible a representation of site types (coastal scrub and grassland, dune, riparian and redwood forest) given the availability of revegetation data. Reporters made every effort to provide reliable results from existing data.

Each evaluation includes descriptive information such as site name, site type, plant community type (Keeler and Wolf 1996), soil type (Marin and S.F. Soil Surveys), aspect, site manager and reporter. Results are then summarized for that specific restoration site and are compared to the general restoration plan objectives such as "plant natives to speed recovery of native plant community" or "introduce rare plants". For sites that included study plots using container plants or broadcast seeding, specific summaries for are included within respective site evaluations.

The descriptive category of site type refers to one of three possible states: natural, disturbed or re-creation. Although nearly all restoration sites have natural features, in this document we are defining a "natural site" as the site type that is least disturbed by obvious human activity in terms of soils, grade and the deposition of soil or refuse. Natural sites are also located among apparently intact plant communities and require revegetation to establish a native community where non-native plants have been removed. "Disturbed sites" are those whose soils or grade have been significantly altered in the past (pre-1990) and include former rock quarries, existing dams, fill and dump sites where vegetation has already become re-established. A re-creation site is one that has been extremely altered or completely covered by artificial materials such as asphalt, cement, buildings, or fill, and has no established vegetation. Re-creation sites have recently undergone a transformation to restore them back to a native community through the removal of the artificial materials, re-contouring, and revegetation efforts.

The descriptive category of site size is restricted to the revegetated portion of the entire restoration site as cited in each site restoration plan. The author of each restoration plan is noted at the beginning of each evaluation and a copy of the plan can be obtained by the author or from the GGNRA Restoration Database. A hardcopy will also be stored at the Habitat Restoration Team office in the Marin Headlands at Fort Cronkhite.

While each revegetation project evolves individually as managers learn more about site-specific challenges, revegetation follows a general process. This process is outlined roughly

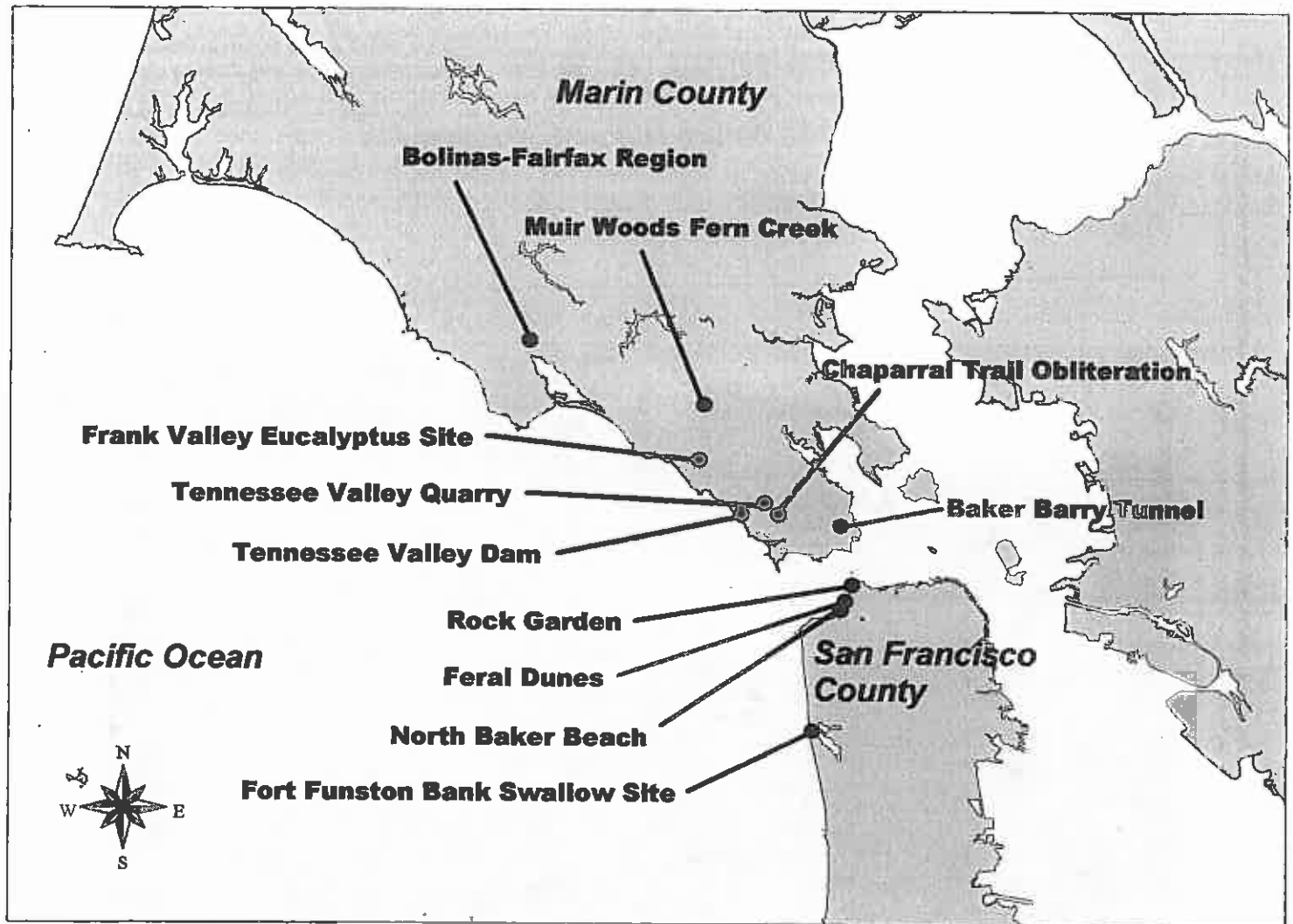
within each site evaluation: planning; initial monitoring prior to revegetation; invasive species control, or reclamation and reconstruction of a severely damaged or disturbed site; propagule collection and propagation; outplanting; and monitoring. The methodologies reported may serve as a resource for discussion and refinement of each of these project components. Comments for improving these project components are included in "Revegetation Recommendations" section of the evaluations.

It would be impossible to produce such a report without noting the many volunteers and interns who made such projects possible. These individuals worked in all aspects of the revegetation process, from propagation, outplanting and invasive species control, to the more complex components of monitoring, planning and reporting results. The restoration programs of the GGNRA are very grateful to the commitment of these volunteers and interns, who contribute their time, knowledge and labor to these projects and many, many others.

It is our sincere hope that this report will assist the valiant efforts of all habitat restorationists by demonstrating the importance of planning projects carefully, collecting meaningful data, and sharing results. Armed with information, we also hope that it will help to inspire all to take on new challenges with ever greater success.

Sincerely,
Maria Alvarez

Revegetation Site Locator Map 1991-1998



**All restoration sites in this document are located
in the Golden Gate National Recreation Area,
within Marin and San Francisco Counties.**

Feral Dunes

Site Location: North side of Lincoln Blvd. at intersection with Pershing Dr., next to the Wherry Housing development

Site Type: Re-creation

Plant Community: Dune lupine-goldenbush

Soil Type: Sand

Average Aspect: SW

Average Slope: 12 degrees

Size: 1.79 acres

Restoration Plan: Wherry Housing Demolition Proposal; Revegetation of the Presidio Wherry Dunes and Water Treatment Plant Areas by Monica Wadsworth, May 1997; no formal Site Management Plan exists.

Site Manager: Jean Koch and Marc Albert, current managers; Sharon Farrell and Monica Wadsworth, former site managers

Reporter: Jean Koch

Reporting Date: January 1999

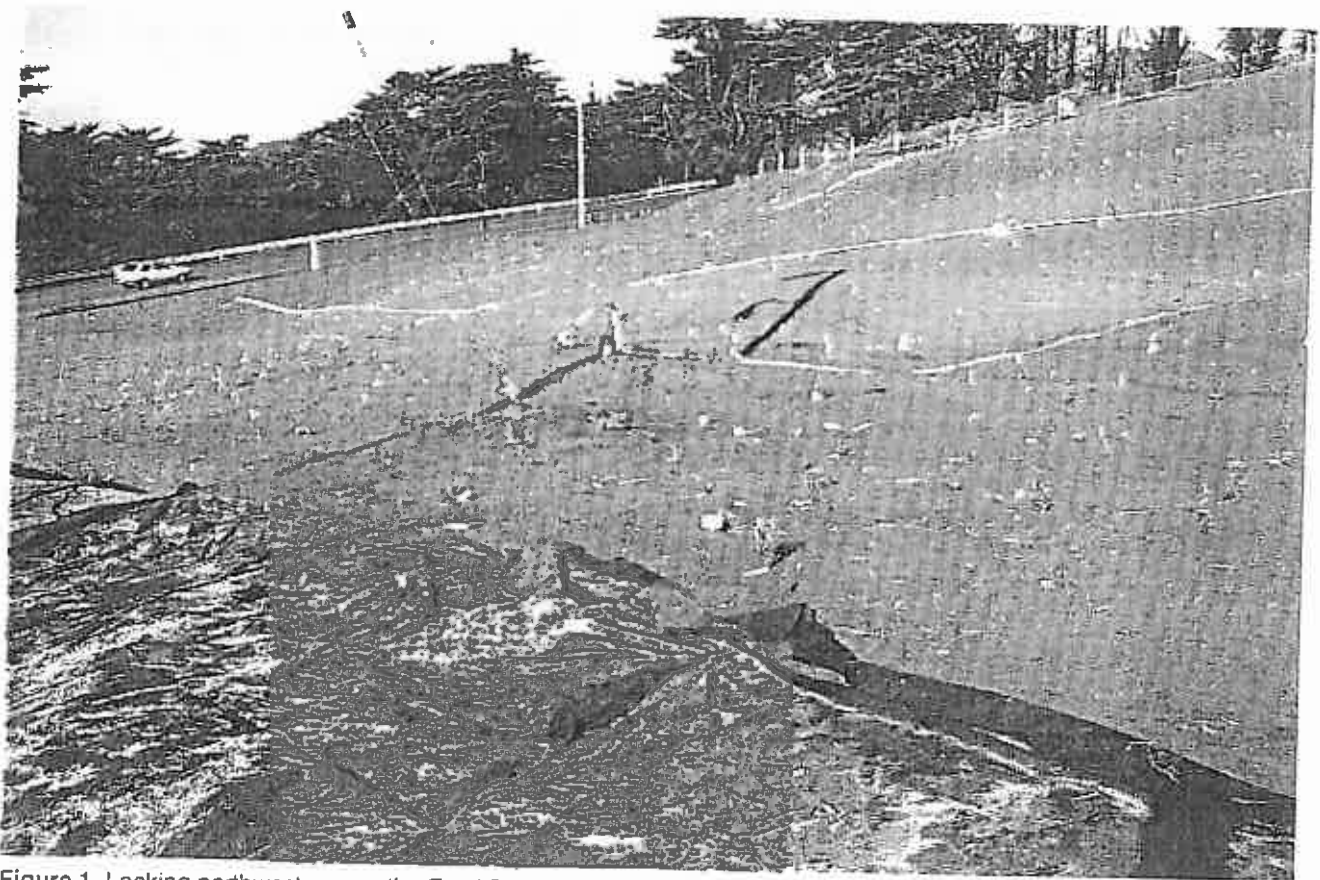


Figure 1. Looking northwest across the Feral Dunes site prior to revegetation. Lincoln Boulevard runs roughly north-south in the background. Photo taken in 1996 by S. Farrell.

RESTORATION GOALS

To successfully restore this two acre revegetated dune into a functioning, self-sustaining system. Eventually to link it with the Feral Scrub restoration site to the east and to the North Baker Beach site to the north.

REVEGETATION CHRONOLOGY

- Summer 1996 – Housing units removed, site covered with landscape fabric, temporary irrigation system set up.
- Winter 1996-97 – First outplanting of 5,000 nursery plants plus estimated 24,000 plants from broadcast seeding.
- December 1996 – Baseline monitoring.
- November 1997 – Broadcast seeding.
- November-December 1997 – First year monitoring for nursery survivorship (see Figures 3A and 3B).
- Winter 1997-98 – Second outplanting of 10 m swath along edge of site (1,500 plants).
- January 1999 – Broadcast seeding and second year monitoring (see Figure 3).
- Ongoing weeding, seed gathering, photomonitoring.



Figure 2. Looking northwest across the site. One year following initial planting and broadcast seeding. Photo taken in 1997 by M. Chasse.

REVEGETATION METHODS

- The site was divided into scrub and sub-shrub areas.
- The entire site was covered with landscape fabric following initial contouring in summer 1996. It remained covered until the day of outplanting, at which point patches were removed as planting progressed. The landscape fabric was used to reduce erosion and to serve as a barrier to weed seeds.
- A 10 m swath along the edge was left covered with landscape fabric for the first year to protect perimeter from erosion and weeds.
- Nursery-propagated plants and broadcast seed were used. Seeds were collected locally and grown at the Presidio Native Plant Nursery.
- Irrigation was used immediately following planting and during the dry season of the first year.
- Exotic species were weeded ongoing.

Species planted:

Abronia latifolia
Achillea millefolium
Baccharis pilularis
Bromus carinatus
Cardionema ramosissimum
Castilleja wightii
Cirsium occidentale var. *venustum*
Croton californicus
Ericameria ericoides
Erysimum franciscanum
Erigeron glaucus
Eriogonum latifolium
Eriophyllum staechadifolium

Fragaria chiloensis
Heteromeles arbutifolia
Lotus scoparius
Lupinus chamissonis
Mimulus aurantiacus
Polygonum paronchia
Pteridium aquilinum var. *pubescens*
Rhamnus californica
Scrophularia californica
Silene verecunda ssp. *verecunda*
Tanacetum camphoratum

Species seeded:

Agoseris apargioides var. *apargioides*
Amsinckia spectabilis var. *spectabilis*
Camissonia cheiranthifolia
Camissonia contorta
Camissonia micrantha
Cardionema ramosissimum
Chorizanthe cuspidata
Cryptantha leiocarpa
Eschscholzia californica

Gilia capitata ssp. *chamissonis*
Lupinus arboreus
Marah fabaceus
Phacelia distans
Plantago erecta
Quercus agrifolia
Scrophularia californica
Uropappus lindleyi

Outplant Success Monitoring Methods

- Five 10 x 10 m plots were randomly placed within the scrub and subshrub areas for a total of 10 plots. Plastic 10" stakes were used to mark the corners and the boundaries were mapped using GPS.
- All outplants in each plot were counted initially for the first and second year after outplanting. Nursery propagules were not consistently distinguishable from volunteers. For

some species, individuals were considered surviving nursery propagules if they exceeded a determined size.

- Many plants were difficult to count due to their spreading or clumping growth forms.
- Species that are naturally establishing inside plots, and which were not planted, are not included in survivorship numbers. For example, 23 *Lupinus chamissonis* were counted in sub-shrub plots in 1999 where none were planted.
- *Silene verecunda* numbers are not accurate because survivorship monitoring was done at a time of year when this species is difficult to locate.
- *Bromus carinatus* was not flowering during monitoring and is difficult to distinguish from non-native grasses based on vegetative characteristics. These numbers are also not accurate.

WHAT WORKED

- *Lupinus chamissonis* recolonized the site naturally from a remnant population.
- Species observed to be most vigorous and spreading three years after outplanting are:
 - Baccharis pilularis*
 - Cardionema ramosissimum*
 - Fragaria chilensis*
 - Lotus scoparius*
 - Lupinus chamissonis*
- Annuals reseeded themselves in the years following the original broadcast seeding.
- Two plant assemblages were established: scrub on the periphery and sub-shrub on the interior. Some of everything we planted survived and overall the restoration was successful.
- Irrigation occurred during plant establishment.

WHAT DID NOT WORK

- *Lupinus arboreus* succumbed to insect pests and died, leaving plant skeletons scattered around this highly visible site. Previously it was noted that they were shading out outplants (especially *Ericameria ericoides*).
- *Pteridium aquilinum* did not establish from field divisions.
- *Silene verecunda* did not do well when outplanted onto site, although it is establishing in a *Silene* subsite.
- *Phacelia distans* is taking over in places.
- Plastic tags used to mark nursery plants were often missing or lost by year two.

REVEGETATION CHALLENGES

- Some erosion occurred; heavy rains created gulleys.
- Extremely large exotic seed source from "control" dune across the street (basically a weed field).
- Relatively small area bordered by roads, housing units, and Monterey cypress and pine. No link to other restoration sites yet.
- As surrounding housing units are occupied, the impact from people and domestic animals may increase dramatically.

GENERAL SITE OBSERVATIONS

- Annual seedlings were numerous and varied from year to year.
- In doing nursery outplant success monitoring, we are faced with some critical questions such as, what defines success? It is also important to consider whether survival of many individuals with reduced vigor, or a smaller number of individuals in excellent health, may be more successful.
- There are a variety of microsites influencing success, even in an apparently homogenous site such as Feral Dunes.

REVEGETATION RECOMMENDATIONS

- Broadcast seed annual species.
- Create a scrub zone on site perimeter to reduce weed flow and trampling. We have no quantitative data to support this, but from observations it seems to be working well.
- Plant in assemblages rather than a random mix of species.

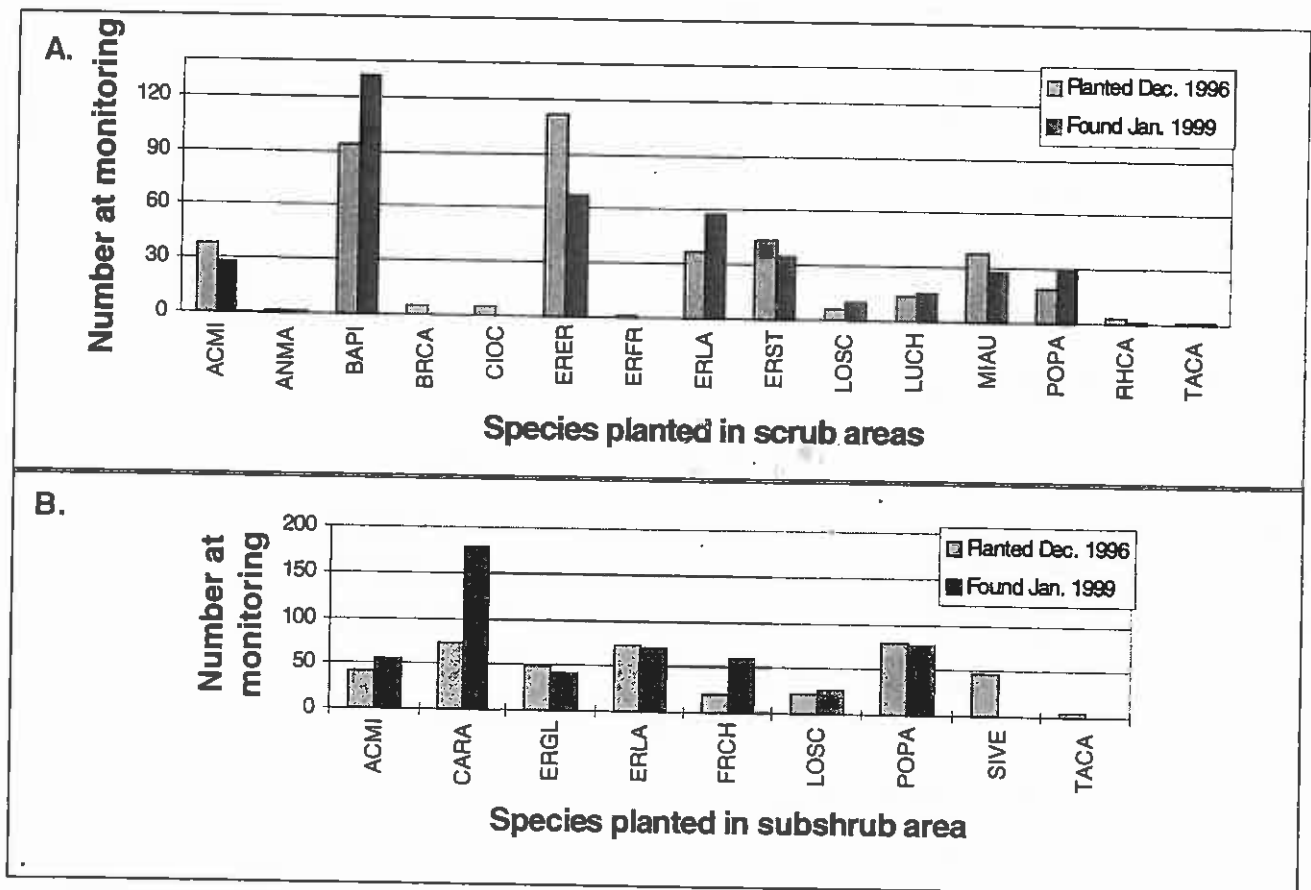


Figure 3. Number of each species planted in December 1996 and number counted in January 1999 in (A) scrub areas and (B) subshrub areas of Feral Dunes. See monitoring methods for discussion of plants counted in January 1999. Genus and species codes are listed; see plant lists on previous page for full names. Monitoring results for *Abronia latifolia*, *Castilleja wightii*, *Croton californicus*, *Heteromeles arbutifolia* and *Pteridium aquilinum* are not shown.

- Improve plant monitoring methods for quantifying both nursery propagule survivorship and revegetation success (the latter would include both nursery propagules and naturally establishing individuals). This would include improving tagging techniques for dune species, so that tagging is visible for the full duration of monitoring which allows outplanted individuals to be monitored for more than one season. In addition, standardized methods should be developed for monitoring the survivorship of outplanted species that reproduce vegetatively, such as *Fragaria chiloensis*.

ESTIMATED LABOR AND COST (FIRST YEAR OF PROJECT):

	<u>LABOR</u>	<u>COST</u>
Planning	500 hrs	\$18,000
Invasive plant control	500 hrs	\$7,500
Native plant propagation		\$44,600
Outplanting	1,000 hrs	\$1,500
Installing fencing/signs	10 hrs	\$200
Importation of sand/ dune installation*		\$38,000
Annual monitoring (1997)		\$1,500
Landscape fabric/ weed suppression		\$5,700

* This project component was funded by the Presidio Project Office.

Fort Funston Bank Swallow Site

Site Location: Dunes and foredunes near bank swallow nesting site in the northern tip of Fort Funston bluffs. South of Ocean Beach near the intersection of Sloat Blvd. and the Great Highway.

Site Type: Natural

Plant Community: Dune scrub

Soil Type: Dune sand on top of impervious clay layers (Colma formation)

Average Aspect: NW, NE

Average Slope: Level to 20 degrees on east side, to 45 degrees on west side

Size: Total site size is 4 acres

Restoration plan: Bank Swallow Habitat Restoration, Just a Swallow Habitat Restoration Project, J.M. Milestone, June 1992

Site Manager: Mary Petrilli, Jim Milestone

Reporter: Ingrid Cabada

Reporting Date: 1997-1998



Figure 1. View south from Bankswallow Site along the Sunset Trail, following iceplant and cypress removal (1993). 24 mature cypress trees were removed, with the single tree pictured remaining to interpret the historic scene. The density of iceplant as seen east of the Sunset Trail fence (left side) is similar to cover on site prior to tree removal. Photo by M. Petrilli.

RESTORATION GOALS

Protect bank swallow nesting habitat and flyway by installing fencing; to remove iceplant and other exotic invasive species; and to restore coastal scrub and dune communities to attract locally extirpated wildlife such as quail and rabbits.

REVEGETATION CHRONOLOGY

- Iceplant and Monterey cypress removal began in 1991.
- Revegetation began in winter 1992-93 and continued until 1996-97.
- Species composition monitoring performed in 1997.
- Restoration goals were completed in 1997.
- Project is ongoing to the south with iceplant removal and native planting.

REVEGETATION METHODS

- 28,000 native plants were outplanted from leach tubes, 4" and one-gallon pots. Plants were grown at the Fort Funston Nursery using locally collected seeds and cuttings (Figure 4).
- Post-revegetation monitoring for species composition consisted of two line transects and nine 2 m² plots, performed in 1997 (Figure 5).
- No survivorship monitoring data was collected; success of outplantings and seedlings was assessed by observation.

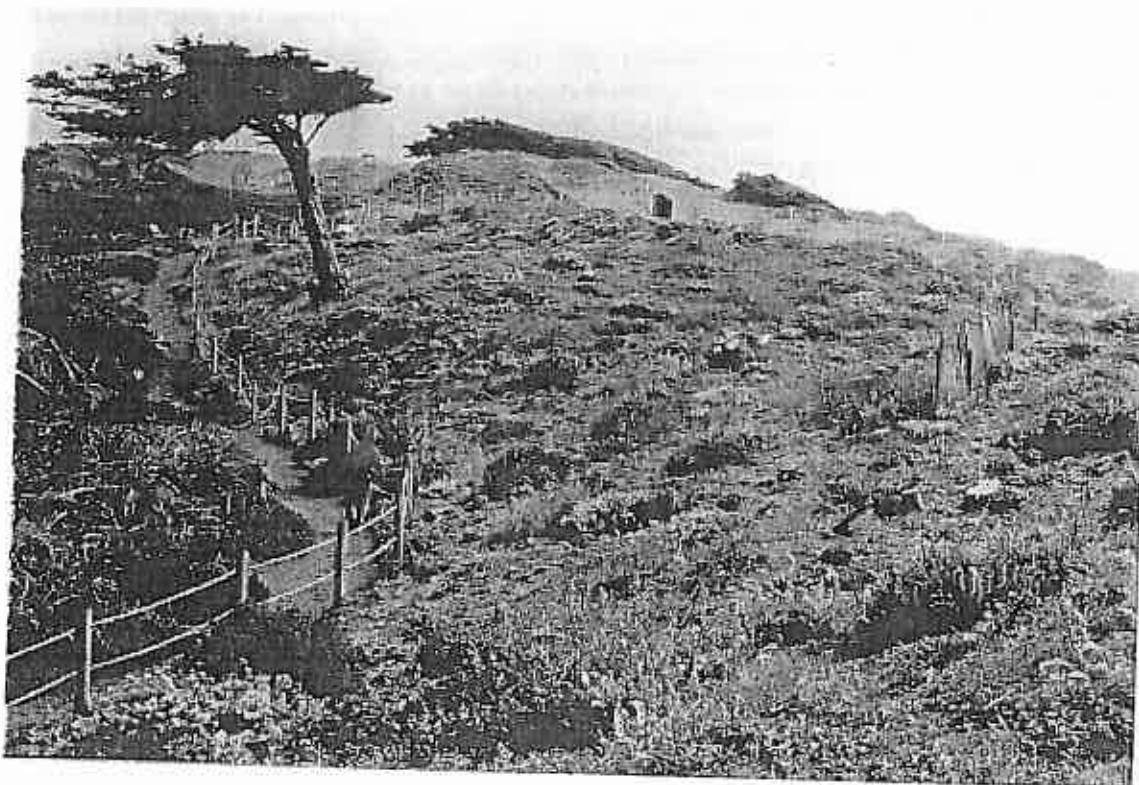


Figure 2. View south in 1997, five years following the beginning of outplanting. Photo by M. Petrilli.

- Fencing was erected to assist establishment of plants on the windward side of dunes. Additional fencing was erected to prevent trampling by Park visitors.

WHAT WORKED

- Species observed to be most vigorous and spreading 5 years after outplanting:
Artemisia pycnocephala
Baccharis pilularis
Eriogonum latifolium
Eriophyllum staechadifolium
Fragaria chilensis
- Species observed to establish but did not form natural populations or spread within 5 years after outplanting:

<i>Achillea millefolium</i>	<i>Erigeron glaucus</i>
<i>Ambrosia chamissonis</i>	<i>Leymus mollis</i>
<i>Armeria maritima</i>	<i>Lupinus arboreus</i>
<i>Astragalus nuttallii</i>	<i>Lupinus chamissonis</i>
<i>Castilleja sp.</i>	<i>Polygonum paronychia</i>
<i>Dudleya sp.</i>	<i>Rumex sp.</i>
<i>Ericameria ericoides</i>	<i>Tanacetum camphoratum</i>
- *Abronia* and *Camissonia* observed to reestablish naturally following removal of iceplant.

Outplanting Success in Primary Dunes:

- Planting in leeward and protected sites, primarily the north side of the site.
- Two kinds of fencing ("post and cable" and "dune fence") created sheltered areas for planting as well as adequate protection from trampling. (See Figure 3).
- Planting pioneer species such as *Lupinus arboreus*, *Lupinus chamissonis*, *Eriophyllum staechadifolium*, *Artemisia pycnocephala*, *Ambrosia chamissonis*, *Leymus mollis* and *Camissonia cheranthefolia*.

Outplanting Success in Secondary Dunes:

- *Artemisia pycnocephala*, *Eriophyllum staechadifolium*, *Eriogonum latifolium*, *Fragaria chilensis* and *Baccharis pilularis* were planted in higher volumes and were most successful in establishing.
- By 1997 there was 65.5% native and 1% non-native plant cover in former iceplant and Monterey cypress habitat in secondary dunes. (See Figure 5.)

WHAT DID NOT WORK

- In the primary dunes, the following species did not establish or established poorly:
Heteromeles arbutifolia
Lathyrus littoralis
- On the windward side of dunes, straw mulch buried upright in the sand next to plantings was used as a wind barrier for one season, however the barriers did not adequately protect the plants and was discontinued.
- *Rhamnus californicus*, *Ceanothus sp.*, *Mimulus aurantiacus*, *Anaphalis margaritacea*, *Artemisia californica*, *Heteromeles arbutifolia* and *Lathyrus littoralis* were introduced into

windy, unprotected areas and did not establish.

- Planting was conducted under the lone Monterey cypress on the site over several years, and natives were unable to establish, with the exception of sparse *Artemisia pycnocephala*. The cypress also appeared to enhance the establishment of weedy species, such as *Chenopodium sp.* and exotic annual grasses.

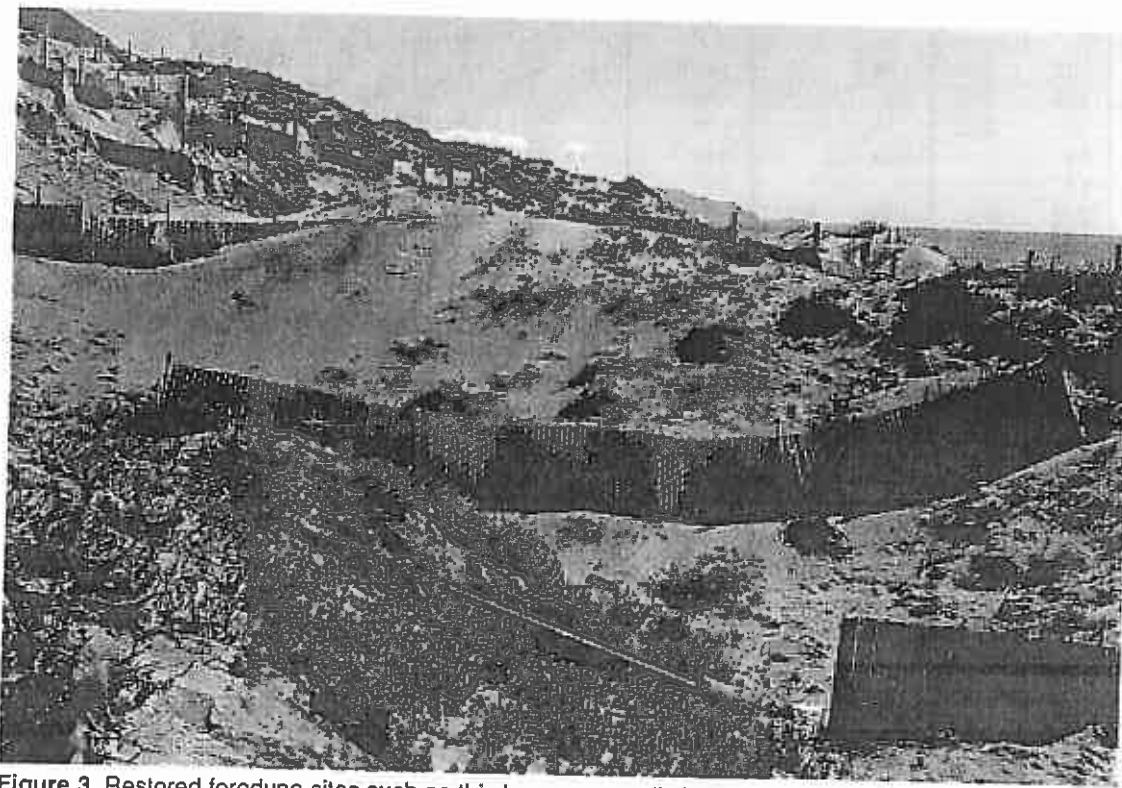


Figure 3. Restored foredune sites such as this have a naturally low proportion of plant cover to bare sand. Photo taken in December 1997 by Ingrid Cabada.

REVEGETATION CHALLENGES

- Wind direction and wind velocity make it difficult for plants to establish because they must withstand movement of sand as well as dessication.
- Cliff erosion occurs on the south-facing side of the site.
- Recreational impact from Park visitors and dogs off leash trampled outplanted plants and disturbed wildlife.
- The subsoil in some subsites is compacted clay, making both planting and plant establishment difficult.

REVEGETATION RECOMMENDATIONS

- In the active dune areas, plant mainly in wind-protected sites and let the active dune plant community establish itself. Also, wait to interplant these areas with smaller native species until after pioneer species (such as *Lupinus arboreus*, *Lupinus chamissonis*, *Eriophyllum staechadifolium*, *Artemisia pycnocephala*, *Ambrosia chamissonis*, *Leymus mollis* and *Camissonia cherranthefolia*) have established.
- Before beginning revegetation projects, determine the amount of natural reestablishment on the site and subsequent need for revegetation. Following removal of exotic species, select sample areas that will not be revegetated and monitor natural reestablishment.

SPECIES	FOREDUNE		SECOND DUNE		TOTAL
	1 GAL	LT	1 GAL	LT	
ABLA	51				51
ACMI	45	100	114	198	457
AMCH	242		36		278
ANMA				38	38
ARMA	11	300	38		349
ARPY	296	3550	128	400	4374
ARCA	50				50
ASNU	3				3
BAPI	932	373	154		1459
CACH	269	892	50	100	1311
CAsp	73	100			173
CETH	64		254		318
DUFA	17				17
ERER	382	500	16	147	1045
ERGL	395	450		300	1145
ERLA	10	1962		500	2472
ERST	377	1165		250	1792
ESCA	7	230	4	95	336
FRCH*	598	420	100		1118
HEAR	54	100			154
LALI	77				77
LEMO***	6000		600		6600
LUAR**	38	234	49		321
LUCH	467	746	40	153	1436
MIAU	92		75		167
PLMA	40				40
PODO		416			416
POPA	95	156	18		269
RHCA	59	98			157
RUsp	3				3
SCCA	18				18
TACA	160		3		163
Total	22717		3890		26607
* Add 22 flats at 900 plants					
** Seeds were also scattered					
*** Culms					

Figure 4. Species planted from 1992-1996. Genus and species codes are listed. See plant lists for full species names.

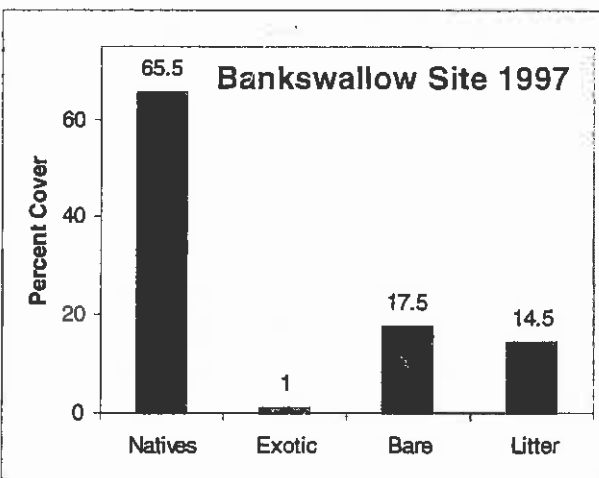


Figure 5. Composition of secondary dunes five years after planting based on nine 2 m² plots.

- If the project manager is unsure if a species will establish, outplant 10 plants of that species and monitor their survivorship.
- Weed planting area during the first year. (Suggested calendar for invasive dune species: April/May - *Bromus diandrus*, *Vulpia*; June/July/August - Sow thistle, *Gnaphaleum*, *Solanum*, *Conium maculatum*, mustard, *Conicosia*.)
- Ongoing removal of iceplant and other exotic species.
- Investigate removal of the single Monterey cypress tree and its cultural significance status in the Park since it encourages exotic weedy species and is an ongoing source of cypress seedlings.

ESTIMATED LABOR AND COST

1992-1997

Planning

Project review: 1 FTE for 3 months

Plant Control

1 day/week year-round

Native Plant Propagation

3 days/week year-round

Outplanting

1 crew: 8 weeks/year for 4 years

Installing Fencing/Signs

1 crew: 1 month/year for 2 years

North Baker Beach

Site Location: Serpentine grassland and sand terrace community listed as a Special Ecological Area. Bordered by Battery Crosby Road to the north, a stand of cypress trees to the south and Lincoln Boulevard to the east.

Site Type: Natural

Plant Community: Dune lupine-goldenbush

Soil Type: Sand

Average Aspect: SW

Average Slope: 7%

Size: Total site is 6 acres; revegetation area is 12,500 square feet.

Restoration Plan: Vegetation Restoration Plan for North Baker Beach by Maria Alvarez, 1992

Site Manager: Maria Alvarez from 1991-1994; Sharon Farrell and Marc Albert from 1994-1999.

Reporter: Ingrid Cabada

Reporting Date: 1997-1998

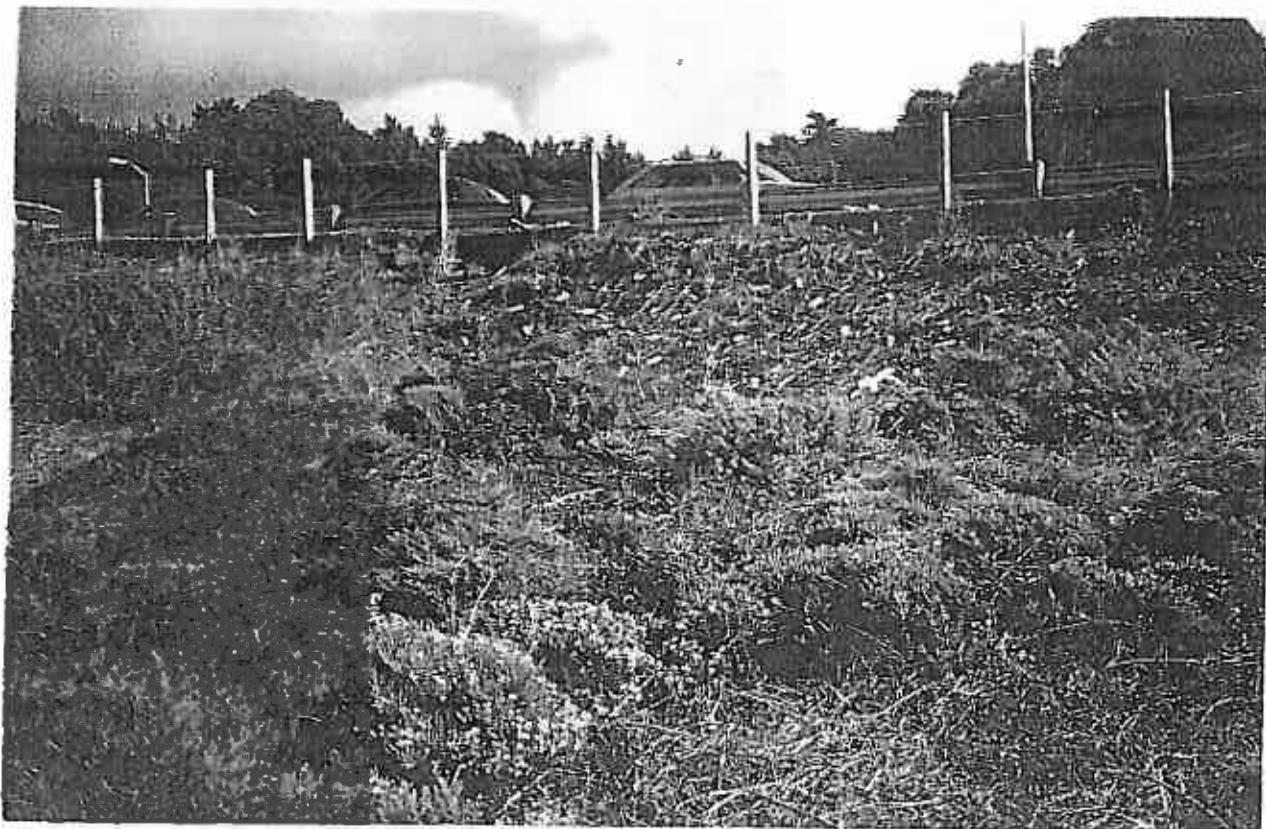


Figure 1. Portion of outplanted area from which Iceplant was removed. Leach tubes indicate outplanting density. The mature shrubs in the foreground (*Baccharis pilularis*, *Eriophyllum staechadifolium*, *Lupinus chamissonis*) are typical of this community type. The fenceposts pictured border Lincoln Avenue. Photo taken in 1993 by M. Alvarez.

RESTORATION GOALS

- Remove 4 acres of iceplant and accelerate revegetation by outplanting native plants.
- Revegetate a conifer tree removal site along the sand ladder.
- Accelerate revegetation of a 10 m wide strip adjacent to the inner guardrail along the length of Lincoln Boulevard by planting native plants.
- Reintroduce native plants that formerly occurred in this area, and increase those that are rare:

Arabis glabra

Lathyrus littoralis

Astragalus nuttallii

Layia carnososa

Calystegia soldanella

Lessingia germanorum

Cirsium occidentale

Silene verecunda ssp. *verecunda*

Erysimum franciscanum

Solidago spathulifolia

- Ongoing removal of weedy annual and perennial species after meeting original goals.

REVEGETATION CHRONOLOGY

- 1990 – Iceplant removal began and continued through 1995.
- November, 1991 – Planted north of the sand ladder next to the fence along Lincoln Blvd.
- February, 1992 – Planted in iceplant removal area south of the sand ladder, midway to the sea strand.
- November, 1992 – Planted along the perimeter fence of Lincoln Boulevard north and south of the sand ladder.
- July, 1993 – Gathered transect data in adjacent intact community.
- November, 1993 – Planted south of the sand ladder. Monitored outplants plants for survivorship.
- December, 1994 and March, 1995 – the Habitat Restoration Team planted south of the sand ladder.

Figure 2. View of North Baker Beach rear dune outplanting site, located north of Lincoln Avenue. Leach tubes indicate outplanting density. Photo taken in 1992 by M. Alvarez.



- 1995-1999 – Monthly visits by Presidio Park Stewards for weeding, primarily narrow-leaf iceplant.
- March, 1998 – Supplemental planting of *Silene veracunda* ssp. *veracunda* north of the sand ladder by Presidio Park Stewards.

REVEGETATION METHODS

- Three sites were revegetated: north of the sand ladder, south of the sand ladder, and adjacent to the guardrail along the Lincoln Blvd.
- Two transects were established in July 1993 in adjacent intact community. The transect north of the sand ladder showed 70% cover of natives dominated by *Ericameria ericoides*, *Polypodium californicum*, *Eschscholzia californica*, *Rubus ursinus*, and *Chlorogallum pomeridum*. *Bromus diandrus*, *Vulpia bromoides* and *Conicosia pugioniformes* were dominant exotic species. The transect south of the sand ladder showed 87% native cover dominated by *Ericameria ericoides*, *Toxicodendron diversilobum*, *Lupinus chamissonis*, *Pteridium aquilinum*, *Eschscholzia californica* and *Marah fabaceus*. *Bromus diandrus* and *Vulpia bromoides* were the only exotic species present in transect two.
- Additional sampling along 8 transects was conducted in 1995 and 1997. The species list and percent cover are used in many dune scrub revegetation projects in the Presidio dunes, including Lobos Dunes.

Species planted:

<i>Anaphalis margaritaceae</i>	<i>Erysimum franciscanum</i>
<i>Artemisia californica</i>	<i>Grindelia hirsutula</i> var. <i>hirsutula</i>
<i>Astragalus nuttallii</i>	<i>Koeleria macrantha</i>
<i>Baccharis pilularis</i>	<i>Lathyrus littoralis</i>
<i>Camissonia cheiranthifolia</i>	<i>Lupinus chamissonis</i>
<i>Castilleja wightii</i>	<i>Mimulus aurantiacus</i>
<i>Cirsium occidentale</i>	<i>Phacelia californica</i>
<i>Danthonia californica</i>	<i>Polygonum paronychia</i>
<i>Dudleya farinosa</i>	<i>Rhamnus californica</i>
<i>Ericameria ericoides</i>	<i>Rumex</i> sp.
<i>Eriogonum latifolium</i>	<i>Scrophularia californica</i>
<i>Eriophyllum staechadifolium</i>	

- Weeding was conducted by the HRT, Presidio Park Stewards and Ingrid Cabada following revegetation.

WHAT WORKED

- There is very little survivorship data for the majority of outplantings, with the exception of one 1993 monitoring and observation for other plantings.
- Reintroduction of *Silene veracunda* ssp. *veracunda*. Three years following outplanting 98 individuals were located. Four years following outplanting, 275 individuals were located (280% increase).
- *Leymus pacificus* colonized naturally in areas cleared of iceplant.
- Woody species, such as *Rhamnus californica*, were planted along Lincoln Boulevard fared better when outplanted from one-gallon pots (75% survivorship) than from leach tubes (33% survivorship).

- *Cirsium occidentale*, *Dudleya farinosa* and *Grindelia hirsutula* var. *hirsutula* survived on the site, based on observations and 1993 monitoring.

WHAT DID NOT WORK

- The following native plants did not survive 1-2 years following outplanting, based on observation of its existence in the planted area:

Anaphalis margaritacea
Artemisia californica
Astragalus nuttallii
Camissonia cheiranthifolia
Castilleja wightii

Danthonia californica
Erysimum franciscanum
Koeleria macrantha
Lathyrus littoralis
Rhamnus californica

- Annual iceplant *Conicosia pugioniformis* and other annual exotics, such as *Senecio elegans*, radish and mustard increased in numbers in former perennial iceplant locations.
- Outplanting of prostrate, sun-loving perennials like *Phacelia elegans*, *Astragalus nuttallii* and *Lathyrus littoralis* was not successful due to shading caused by expansion of both planted and naturally-occurring native woody species.
- Non-native weeds also over-topped and shaded out planted prostrate, sun-loving perennials.

GENERAL SITE OBSERVATIONS

- Prevent cape-ivy expansion into the site from draw on northern edges between Battery Crosby and Battery Crosby Road.
- There is expansion and increase of weedy exotic species such as *Oxalis* ssp. and *Senecio elegans*, but reduction in weeds such as *Carpobrotis edulis* and *Raphanus sativa*.
- Continue weeding annual exotic species by May 1, before they set seed, particularly along Lincoln Boulevard and in open sandy areas.

REVEGETATION RECOMMENDATIONS

- Do not outplant woody species from leach tubes.
- Consider the target plant community structure in the outplanting design. In coastal scrub community revegetation such as North Baker Beach, avoid planting prostrate, sun-loving species near woody species as the prostrate species will be eventually over-topped and shaded out.
- With plant community structure in mind, attempt another reintroduction of rare and endangered species.
- Expand the weed-reduced buffer zone around the planting site to reduce potential for reinfestation.
- Consider effects of fill soils from road building, etc., as hardy native scrub may not be able to tolerate these soils.

ESTIMATED LABOR AND COST (1991-1995)

Planning (1991-1992)

Writing/meetings/review

Resource Management, South District and CNPS 120 hrs

Plant control (1991-1995) 320 hrs/yr

Native plant propagation

Tennessee Valley and Fort Funston

Native Plant Nurseries 80 hrs/yr

Outplanting

Habitat Restoration Team and

Fort Funston ranger staff 60 hrs/yr

Installing fencing/Signs

Sand ladder repairs requires continual maintenance, approximately 25 hrs per year.

Baker-Barry Tunnel

Site Location:	Marin Headlands entrance on both the east and west sides of the Baker-Barry Tunnel
Site Type:	Re-creation of perennial grassland and <i>Baccharis</i> scrub
Plant Community:	Creation of grassland and coastal <i>Baccharis</i>
Soil Type:	East side: Rodeo clay loam West side: Tamalpais-Barnabe Variant, very gravelly loam.
Average Aspect:	East side: NE aspect West side: S and SW
Average Slope:	2-15% slope
Size:	61,500 sq. ft.
Restoration plan:	Baker/Barry Tunnel Revegetation, by Terri Thomas 1992
Site Manager:	Laura Nelson, from 1993-1997
Reporter:	Laura Nelson and Maria Alvarez
Reporting Date:	May 1997-1999

RESTORATION GOALS

- To restore 2.7 acres of native plant vegetation removed by 1993 repair of the tunnel that connects Fort Baker with Fort Barry (Baker-Barry Tunnel) to grassland and scrub habitat.
- Restore east side median strips to 80% cover of native prairie vegetation.
- Restore west tunnel top to 50% cover coastal native vegetation.

TUNNEL REPAIR AND REVEGETATION CHRONOLOGY

Tunnel Repair Overview

- 1995 - Tunnel repairs were completed a year late. Vegetation at five subsites were completely removed by construction activities. East portal tunnel repairs were completed by Fall, 1994 and outplanting began at two subsites in Spring, 1995. Construction on the west side was completed by Fall, 1995.
- *East Side:* A parking lot, bus stop and new median were constructed from a gravel lot and a former median strip. Stored topsoil, native to the site, was imported and recontoured to form vegetation medians around the 45,425 sq. ft. parking lot between the east portal entrance road and Alexander Avenue. The two revegetation subsites are: the bus stop median and the road median.
- *West Side:* Three different areas were impacted creating the following three revegetation subsites: "Tunnel top" refers to a 700 ft. temporary access road was constructed from the west portal entrance to the top of the tunnel consisting of 8,000 sq. ft. "Side berm" refers to the north side of Bunker Road consisting of (16,342 sq. ft.). "Culvert" refers to the south side of the West Portal Entrance consisting of (10,481 sq. ft.).
- Although the original plan called for cutting back the slope (the sharp natural curve) on the southwest side of Bunker Road to improve safety, this was not done.
- Soil was removed during construction and stored off Bunker Road at a temporary storage



Figure 1. West portal of Baker-Barry Tunnel showing berm and tunnel top subsites following repair and recontouring of soil. Photo taken in 1995 prior to revegetation. Photo by L. Nelson.

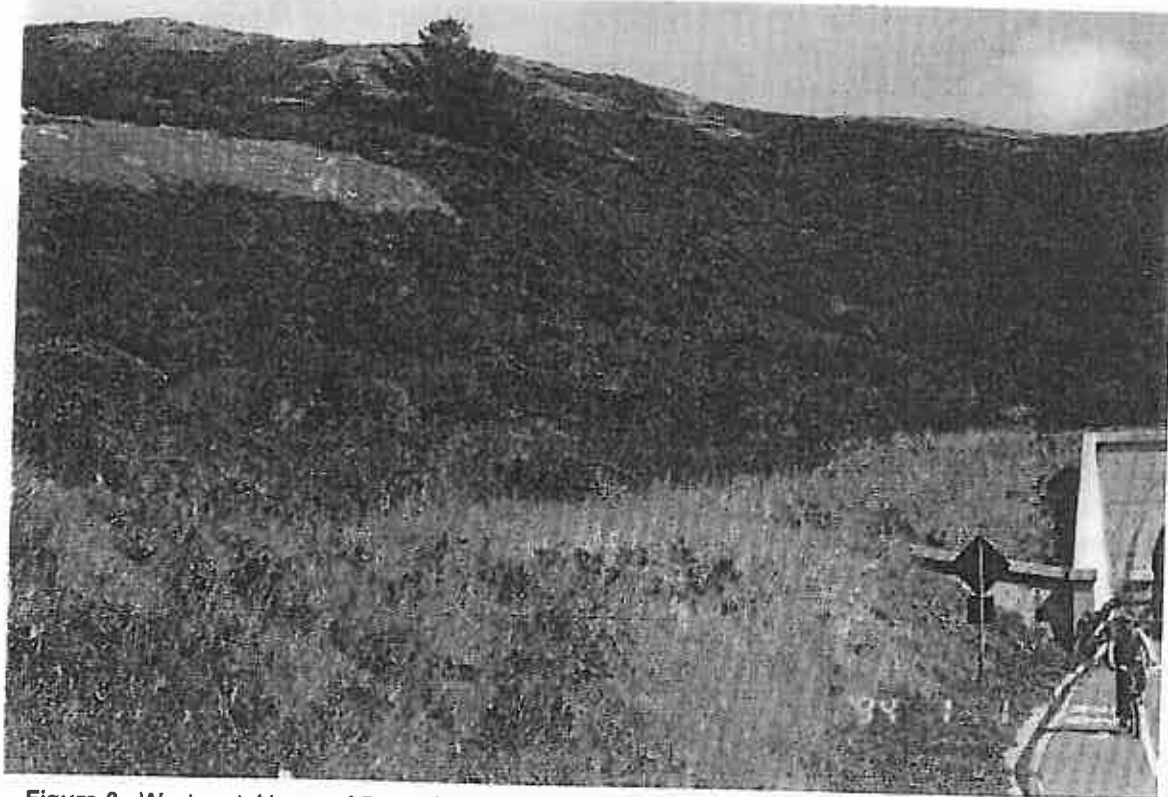


Figure 2. West portal berm of Baker-Barry Tunnel showing revegetated side berm and portion of tunnel top five years following revegetation. Photo taken in 1999 by M. Alvarez.

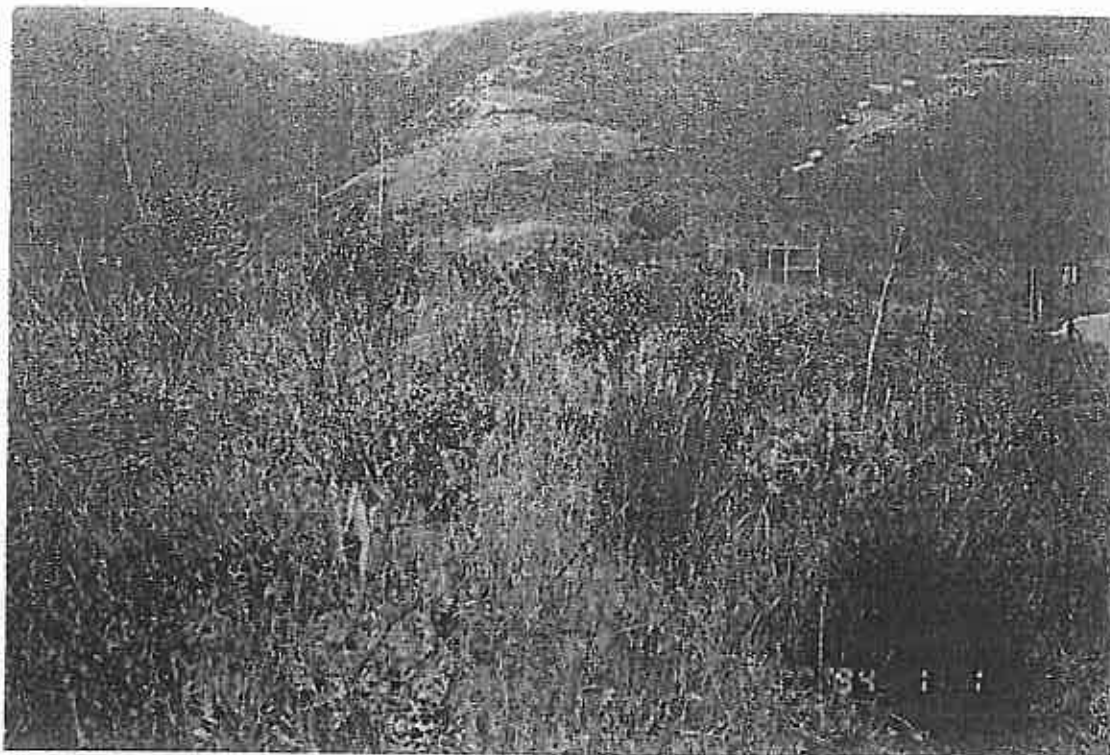


Figure 3. View of West Portal side berm four years after three coastal scrub species were planted. Photo taken in 1999 by M. Alvarez.

- Soil was removed during construction and stored off Bunker Road at a temporary storage facility on the eastern side of the Rifle Range. Excess topsoil was also relocated to partially fill and restore "the notch" a quarried hilltop south of the Roads and Trails office and the Marine Mammal Center.

Revegetation Chronology

Revegetation of five subsites (bus stop and median on the east side and tunnel top, side berm, and culvert on the west side) occurred over a period of three years:

- March 1995 – On the east side, 45,000 *Nassella pulchra* plugs were planted in the parking lot.
- December 1995 – On the east side, 35,000 *Nassella pulchra* plugs were planted in the parking lot subsite.
- Winter 1996 – On the west side, scrub species were planted on the tunnel top and median.
- January-March 1996 – Revegetation by the Marin Conservation Corps.
- February 1997 – Shrub and grass species were planted by the California Conservation Corps and the Tennessee Valley Nursery.
- February 1997 – Shrubs planted in 1995 were monitored.

REVEGETATION METHODS

- Three different prescriptions (wet coastal scrub, seep, and dry coastal scrub) were created from combinations of direct seeding of local native plant species and plantings propagated from site-specific seed (with the exception of *Nassella pulchra*) at the Napa Conservation Corps Nursery.
- *Nassella pulchra* plugs were bare-root grown by Craig Dreaman from a non-local un-



Figure 4. West portal side berm of Baker-Barry Tunnel after construction activities and prior to start of revegetation in January 1996. Photo taken in 1995 by L. Nelson.



Figure 5. West portal berm during process of revegetation. Photo taken in 1999 by M. Alvarez.

- Seed mixtures were developed by Laura Nelson based on a successful broadcast seeding experiment at the "Pipeline" revegetation site just east of the Baker Barry Tunnel at WBR.

Species seeded

- The following seed mix was applied to all five subsites over a total of 76,000 sq. ft.

Anaphalis margaritaceae

Artemesia douglasiana

Artemesia californicum

Aster radulinus

Bromus carinatus

Baccharis pilularis

Elymus glaucus

Heracleum lanatum

Marah oreganum

Mimulus aurantiacus

Scrophularia californica

- Three seed mixes were used for the community types of all subsites. Below is the species list for each seed mix prescription.

Wet coastal scrub

(applied to the west tunnel top)

Artemesia californicum

Aster radulinus

Bromus carinatus

Baccharis pilularis

Heracleum lanatum

Mimulus aurantiacus

Festuca californica

Juncus effusus

Dry coastal scrub

(applied to the west portal berm)

Artemesia californicum

Aster radulinus

Bromus carinatus

Baccharis pilularis

Heracleum lanatum

Mimulus aurantiacus

Seep

(applied to the west tunnel culvert and the tunnel top)

Artemesia douglasiana

Aster radulinus

Carex sp.

Heracleum lanatum

Juncus sp.

Mimulusguttatus

Solidago sp.

Festuca californica

WHAT WORKED

- *Nassella* grassland establishment was extremely successful.
- Monitoring occurred via photo documentation. No monitoring of direct seeding occurred.
- The only revegetation monitoring occurred in December 1995 for 647 plants of three species of scrub planted on the East Tunnel Median. All three species were propagated by

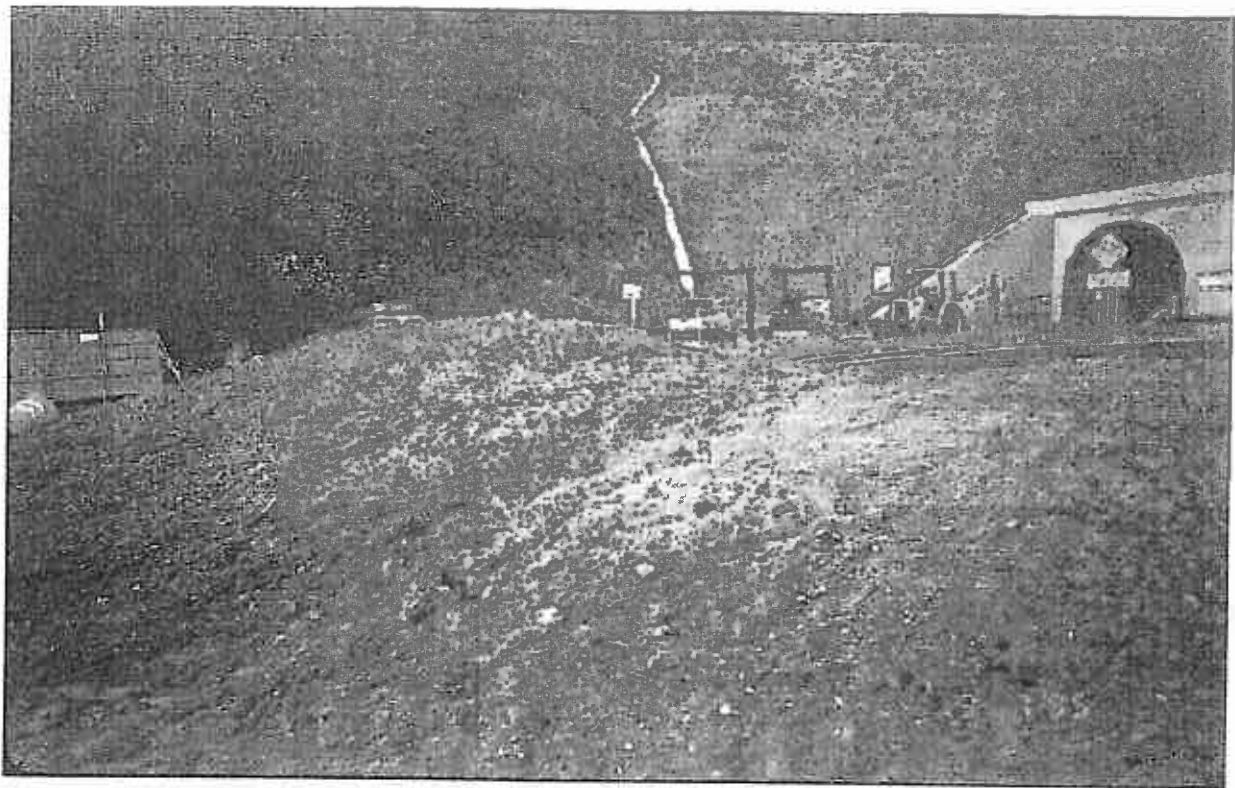


Figure 6. East portal parking lot berm following construction and prior to Spring 1995 revegetation. Photo taken in 1994 by L. Nelson.

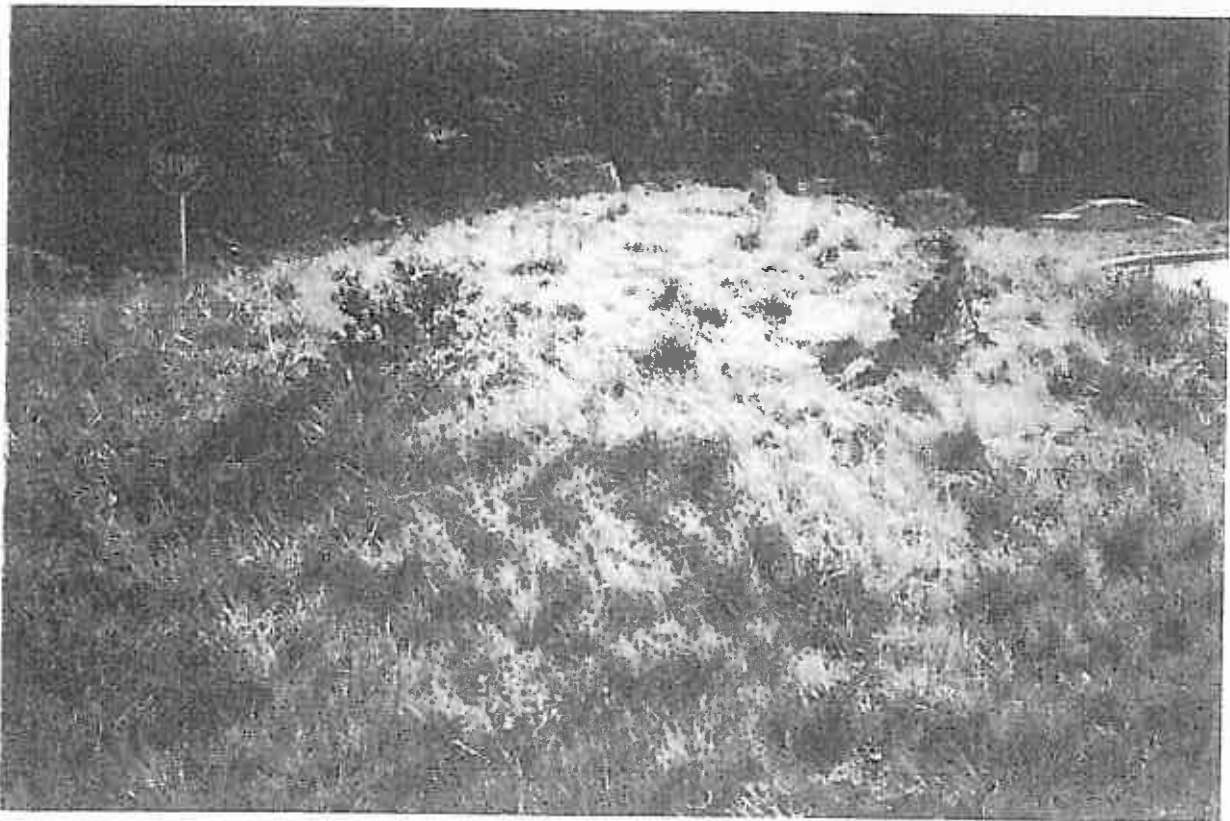


Figure 7. East portal parking lot berm showing vigorous *Nassella pulchra* growth. Photo taken in 1999 by M. Alvarez.

cuttings and grown at the Napa CCC Nursery.

- Planting occurred December 1995. All outplantings were monitored on February 18, 1997.

<u>Number</u>	<u>Species</u>	<u>No. surviving</u>	<u>% success</u>
370 D- pots	<i>Baccharis pilularis</i>	177	47%
160 D-pots	<i>Mimulus aurantiacus</i>	22	14%
117 D-pots	<i>Eriophyllum stachaedifolium</i>	10	8.5%
647 total		total = 209	

- Approximately 50% of those surviving from 1995 had low or poor growth.

WHAT DID NOT WORK

- *Lupinus arboreus* was broadcast seeded into the parking lot subsite but was observed to wash down the slope.
- Coastal scrub and seep establishment has been slow and poor.

REVEGETATION CHALLENGES

- Crop failure of *Nassella pulchra* at the Conservation Corps Napa Nursery delayed outplanting. Cuttings were not successful until a second attempt.
- Plants grown by the Conservation Corps were of poor quality.
- Cypress bark used as mulch was applied unevenly.

REVEGETATION RECOMMENDATIONS

- Monitor recent outplantings.
- *East side*: Continue to remove broom, cypress and fennel.
- *West side*: Continue to remove broom, *Paspalum dilatatum*, *Festuca arundinaceae*, *Dipsaucus sylvestris* and *Picris echioides*.
- If the Conservation Corps is contracte to grow plants then double the numbers and the estimated costs in order to meet production goals.
- Do not outplant *Eriophyllum* in similar sites, as it had poor establishment.
- Do not use chipped cypress trees. Thousands of seedlings sprouted and had to be hand-pulled to prevent forest from establishing.

ESTIMATED LABOR AND COST*

<u>Planning</u>		<u>Site preparation, plant control, monitoring</u>	
8 weeks 1993-94	1 FTE	1993-1997	5 days/yr
6 weeks 95-97	1 FTE		

Native plant propagation

1993-1994 \$4,463

*All costs are not shown. Total budget for project was \$144,000.

Outplanting

Marin Conservation Corps,
1995-1997 \$27,600

Bolinas-Fairfax Region

Site Location: On the western slopes of Bolinas Ridge, along the Bolinas-Fairfax Road from Highway 1 at the upper edge of the Bolinas Lagoon.

Site Type: Natural

Plant Community: Coastal grassland and oak woodland

Soil Type: Cronkhite-Barnabe complex; 15-30% slopes (Marin Soil Survey)

Average Aspect: SW

Average Slope: 15-20% slopes

Size: Restored area: 0.16 acre; total site size: 6 acres.

Restoration Plan: Restoration Action Plan for HRT Bolinas-Fairfax Site by Maria Alvarez, 1995

Site Manager: Maria Alvarez

Reporter: Maria Alvarez

Reporting Date: 1999

RESTORATION GOALS

Revegetation of grassland, woodland and chaparral plant communities following removal of dense *Genista monspessulana* infestations. Due to the presence of intact native plant communities surrounding the broom infestations, very little plant material has been reintro-



Figure 1. HRT removing French broom in 1994 from the lower meadow at the Bolinas-Fairfax site using the weedwrench method. The entire site was subsequently brushcut 1-2 times per year to control broom. Photo by M. Alvarez.

duced into formerly infested areas, particularly those of woodland and chaparral dominance.

REVEGETATION CHRONOLOGY

- 1992 – Began French broom removal. Outplanting and broadcast seeding at Hairpin Turn scrub-dominated site and Guardrail landslide site.
- July 1993 – A point-line transect for species composition was done in the Lower Meadow.
- November 1993 and May 1994 – Outplanted grass plugs in the Lower Meadow site.
- Summer 1994 – Grasses planted in the Lower Meadow received supplemental water and were observed to be drought-stressed at that time. Plantings at the Guardrail site received no supplemental watering.
- January 1995 – Planted grass plugs in the Lower Meadow.
- Summer 1996 – Monitored grass plugs in Lower Meadow.
- January 1998 – Additional outplanting of forbs and grasses in the Lower Meadow. All plants were from divisions.
- May 1998 – Monitored field divisions in the Lower Meadow.
- November 1998 – Additional outplanting of potted grasses and forbs in Lower Meadow.
- August 1999 – Monitored survivorship of 1999 outplants and gathered post-revegetation transect data for species composition.

REVEGETATION METHODS

- Three sites were revegetated: "Hairpin Turn", a scrub-dominated site; "Guardrail", a landslide site; and "Lower Meadow", a grassland. The Lower Meadow had five outplanting events, while the other two sites had one.



Figure 2. Planting and mulching additional grass plugs in Lower Meadow site. Winter 1998-1999.
Photo by M. Alvarez.



Figure 3. At the Lower Meadow, a *Nassella pulchra* division five months after planting in May 1998. Photo by K. Strathmann.

landslide site; and "Lower Meadow", a grassland. The Lower Meadow had five outplanting events, while the other two sites had one.

- At the Guardrail site, *Lupinus arboreus* was outplanted from 1-gallon containers after initial broom removal in 1992.
- At the Hairpin Turn, *Bromus carinatus*, *Elymus glaucus*, *Nassella pulchra* and *Sanicula crassicaulis* were broadcast seeded in 1992.
- At the Lower Meadow, a transect in 1993 showed 100% cover of *Genista* before removal and subsequent revegetation. In 1993, brushcutting broom at this infestation was begun.
- An experiment was conducted in the Lower Meadow to determine the effectiveness of rice straw mulch in killing broom seedlings in brushcut areas. In March 1995, a 9 x 12 m² area was brushcut and divided into 12 - 3 x 3 m plots. Six plots were mulched with 4-5" of rice straw to smother existing seedlings and any that would germinate later in the spring. Plots contained from 67 to 407 seedlings per 0.5 m². Three months later almost all seedlings had been successfully killed. Rice straw also resulted in high mortality for both mature broom plants.
- At the Lower Meadow, two outplantings were done into former broom areas: grass plugs in 1993; and field divisions of grasses and herbaceous plants taken and planted at the site in 1998.
- All plantings were mulched with rice straw to reduce competition from annual grasses and exotic weeds, and plantings were spaced 1-3 feet apart.
- The following potted grasses planted in 1993-1994 were grown in the Tennessee Valley Nursery:
 - Bromus carinatus*
 - Elymus glaucus*
 - Melica torreyana*
- Species planted from field divisions in 1998 are:
 - Agrostis hollii*
 - Chlorogalum pomeridianum*
 - Danthonia californica*

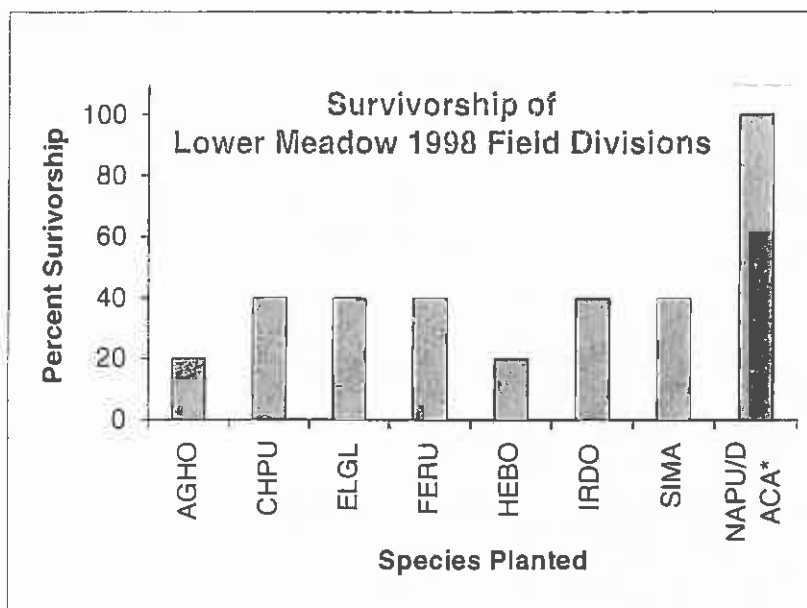


Figure 4. Survivorship at five months following planting (May 1998) of divisions made in the field on the date of planting. Asterisk indicates that *Nassella pulchra* and *Danthonia californica* were pooled for monitoring because they were difficult to differentiate based on vegetative characteristics. Genus and species codes are used on the graph, see plant list for full names.

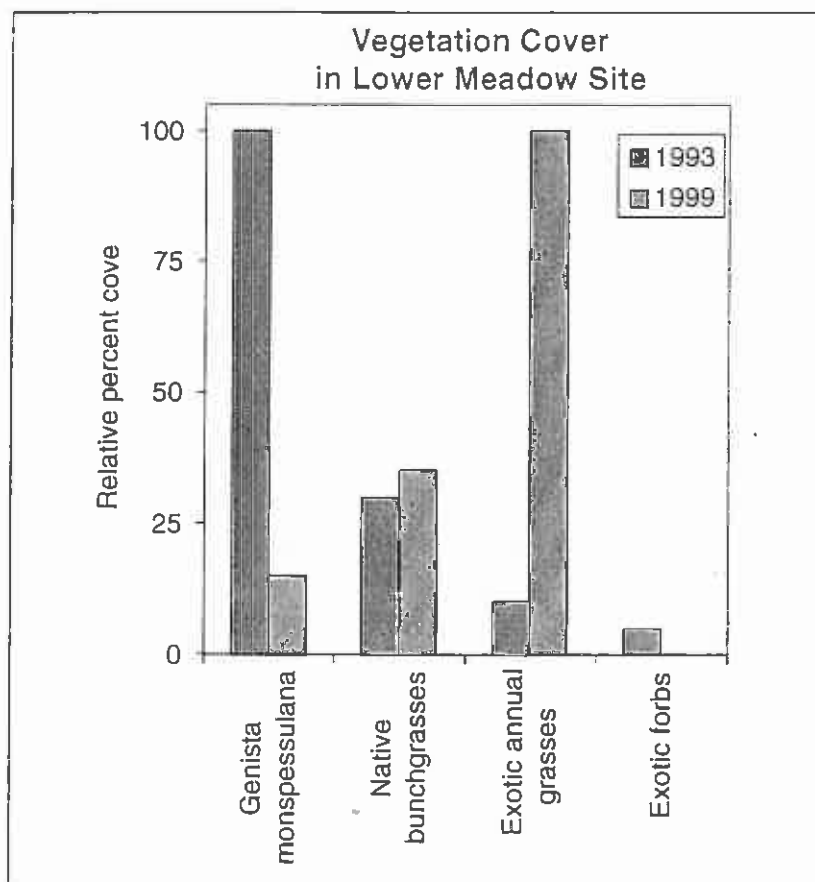


Figure 5. Cover of *Genista*, native grasses, non-native grasses, and non-native forbs in the Lower Meadow site in 1993 prior to removal of broom and in 1999 following four revegetation events.

Elymus glaucus
Festuca rubra
Heterotheca sessiflora
Iris douglasiana
Nassella pulchra
Sidalcea malvaeflora

WHAT WORKED

- Two years following grass plug planting in the Lower Meadow, there was 70% survivorship.
- Five months after 1998 planting of field divisions showed that overall *Nassella pulchra* and *Danthonia californica* survived best of the grasses (nearly 100%) and several of these plants were observed to be in seed the first summer following planting. Although over 40% of *Elymus glaucus* and *Festuca rubra* survived, these plants were small and appeared stressed. *Heterotheca bolanderii* and *Iris douglasiana* also had high survivorship (Figure 4).

WHAT DID NOT WORK

- At the Guardrail site, all but one *Lupinus* died. This may be due to: 1) outplanting in October, one month prior to beginning of winter rains with no supplemental watering, 2) plants were not fully grown into 1-gallon containers (plants were only 4" to 6" tall with poor root development), and 3) soil was rocky and compacted around the guardrail.
- At the Lower Meadow site, most *Melica torreyana* survived the first summer after planting, however, by 1996 *Elymus*



Figure 6. Hairpin Turn site along Bolinas-Fairfax Road during manual removal of *Genista* by Habitat Restoration Team volunteers in 1992. Note grey tree in left of photo; it was poison oak. Photo by M. Alvarez.



Figure 7. Hairpin Turn site in 1999. Poison oak tree was mown by County road maintenance in 1993. Photo by M. Alvarez.

sist.

- At the Lower Meadow, only 20% of *Agrostis hollii* and *Heterotheca sessiflora* divisions survived five months following planting.

REVEGETATION CHALLENGES

- The soil substrate of the Lower Meadow was previously compacted by heavy machinery.
- Winter storm fronts hit the Bolinas Ridge region hard and conditions for winter planting can be extreme.
- The site is remote and transportation of large numbers of potted plants and volunteers can be difficult.

GENERAL SITE OBSERVATIONS

- New exotic species are continually introduced to the site: refuse and landscaping debris are routinely (illegally) dumped along the Bolinas-Fairfax Road. Cape-ivy (*Delairea odorata*) has been introduced in this manner.
- The County mows the roadsides in this area; and soil is stockpiled along this road.
- The Lower Meadow undergoing revegetation, which is a mix of native and non-native species, is occasionally lightly grazed by cattle.
- Diversion of water under the Bolinas-Fairfax Road by means of culverts has caused significant erosion and landslides.

REVEGETATION RECOMMENDATIONS

- In similar sites, with medium soil moisture and grass-dominated communities, *Danthonia californica* and *Nassella pulchra* can successfully be outplanted from field



Figure 8. Broom removal at the scrub-dominated landslide area along Bolinas-Fairfax Road in 1992. Photo by M. Alvarez.

divisions. Using field divisions can reduce time and resources used for propagation.

- The use of straw mulch can successfully reduce competition for outplants.
- Monitor outplantings a second time in the fall to determine final survivorship.
- Do not revegetate areas within 5 meters of roadsides. At this site, the County mowed native scrub at the Hairpin Turn site shortly after outplanting.

ESTIMATED LABOR AND COST (1992-1999)

Planning

Writing, planning, mapping	80 hrs
Evaluation and workday planning	2 days/yr

Plant control

8 years	80 hrs/yr
---------	-----------

Native plant propagation/outplanting

2 years (1993-94, 1995)	32 hrs/yr
-------------------------	-----------

Outplanting

4 seasons (1993-4, 1995, 1998, 1999)	40 hrs/yr
--------------------------------------	-----------

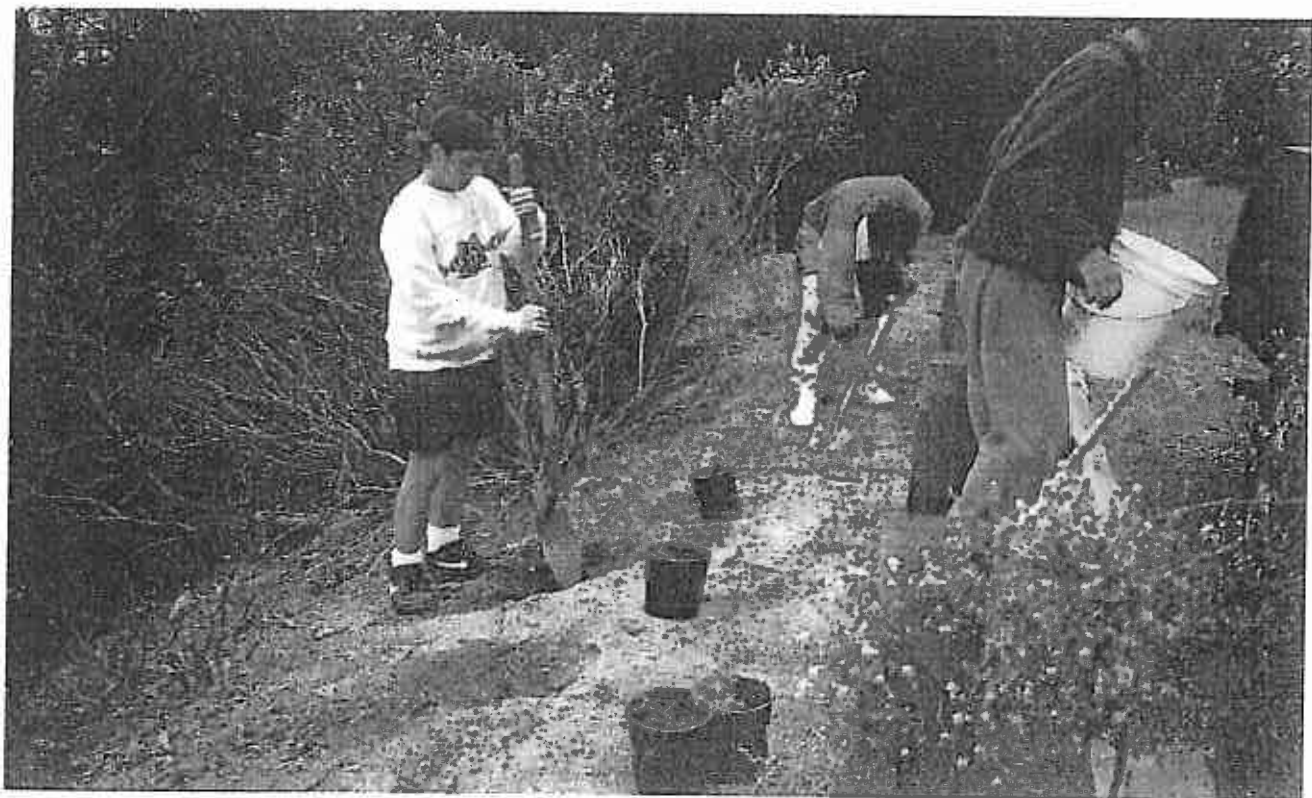


Figure 9. *Lupinus arboreus* planting in the Guardrail landslide site in 1992. Photo by M. Alvarez.

Chaparral Trail Obliteration

Site Location:	Southern-most, steep stretch of Chaparral Trail, just below the junction with the Miwok Trail, in the Tennessee Valley watershed in the Marin Headlands.
Site Type:	Fill and re-creation of previous slope
Plant Community:	Coyotebrush series
Soil Type:	Cronkwhite-Barnabe complex, 30-50 percent slopes (Marin Soil Survey)
Average Aspect:	North
Average Slope:	30-50%
Size:	12,000 square feet
Restoration Plans:	Chaparral Vegetation Restoration Plan, GGNRA, by Laura Nelson, 1995. Marin Headlands Trail Restoration and Rehabilitation Recommendations, GGNRA, prepared by Louise Johnson, Yosemite National Park, March 1992. Chaparral Obliteration Plan, GGNRA, by Al Pond and Solange Russek, 1994.
Site Managers:	Solange Russek, Laura Nelson
Reporter:	Maria Alvarez
Reporting Date:	October 1998

RESTORATION GOALS

- Restore a severely eroded trail to a native plant community.
- Reduce sediment movement during winter and spring rainfall events.
- Successfully refill and recontour a "natural" hillslope surface.

REVEGETATION CHRONOLOGY

- 1994-1995 — Planning.
- 1995-1996 — Plant propagation at Tennessee Valley Nursery.
- Fall 1996 — Soil work.
- October 1996 — Erosion control, including application of mulch.
- January-February 1997 — Premonitoring and outplanting.
- November 1997 — Monitoring success of plantings and weeding.

REVEGETATION METHODS

- Native plant material was collected on-site and propagated at the Tennessee Valley Nursery using soil mix (4:1:1:1 ratio of potting soil, sand, bark and lava rock, respectively) with osmocote fertilizer used on potted plants. native plants were also salvaged and held in Tennessee Valley and the Roads and Trails Nursery. There was no broadcasting of native seed at this site.
- Only the lower section of the trail obliteration was outplanted; the upper section re-

ceived only mulch.

- To monitor the success of the plantings, we established 10 permanent plots, each 2.25 m in size: 5 control and 5 planted plots. The 10 plots were randomly located and spanned 38 linear meters of the trail. We sampled cover (using point-intercept method), species richness (using species lists), and counted the number of seedlings present on January 19,



Figure 1. Portion of lower Chaparral Trail filled, outsloped and ready for revegetation crews in January 1997. Note light application of straw mulch for erosion control. Photo by L. Nelson.



Figure 2. Lower Chaparral Trail in Spring 1999, two years following revegetation. Photo by M. Alvarez.

present on January 19, 1997, prior to revegetation that occurred later that day. Each of the 5 planted plots received the same number and size of the following species:

6	grasses	1t	1	<i>Iris douglasiana</i>	4"
2	<i>Achillea millefolium</i>	4"	1-2	<i>Satureja douglasii</i>	flat
3	<i>Baccharis pilularis</i>	4"	1	<i>Agrostis hollii</i>	1t
1	<i>Symphoricarpos albus</i>	4"	1	<i>Horkelia californica</i>	4"
1	<i>Artemesia californica</i>	4"			

- In addition to the plots, appx. 1600 plants were planted. on an average of one plant per meter square. Planting occurred from the bottom up in order to allow volunteers to subsequently complete the upper portion via access by the Miwok Trail, thus preventing trampling of the planted area.

WHAT WORKED

- Slope recontouring by Park Maintenance staff were excellent, the deep ruts and entire trail was obliterated and tons of fill from the Marincello trail were imported to restore the slope.
- An intentional project partnership was developed between several Park Vegetation Management programs so that each group contributed resources to complete the project:

Roads and Trails Division
(Al Pond and Solange Russek)

Site Stewardship Program
assisted in plan development (Sue Gardner, Lara Wood and Alison Fisher)

Aim High Program students
propagated plants

Tennessee Valley Nursery
volunteers propagated plants, monitored and weeded (Maria Alvarez and Alison Fisher)

Habitat Restoration Team
monitored, outplanted and weeded (Maria Alvarez)

- Chert fill soil was imported from the Marincello-Bobcat Trail with native topsoil added from the lower slope of the trail restoration.

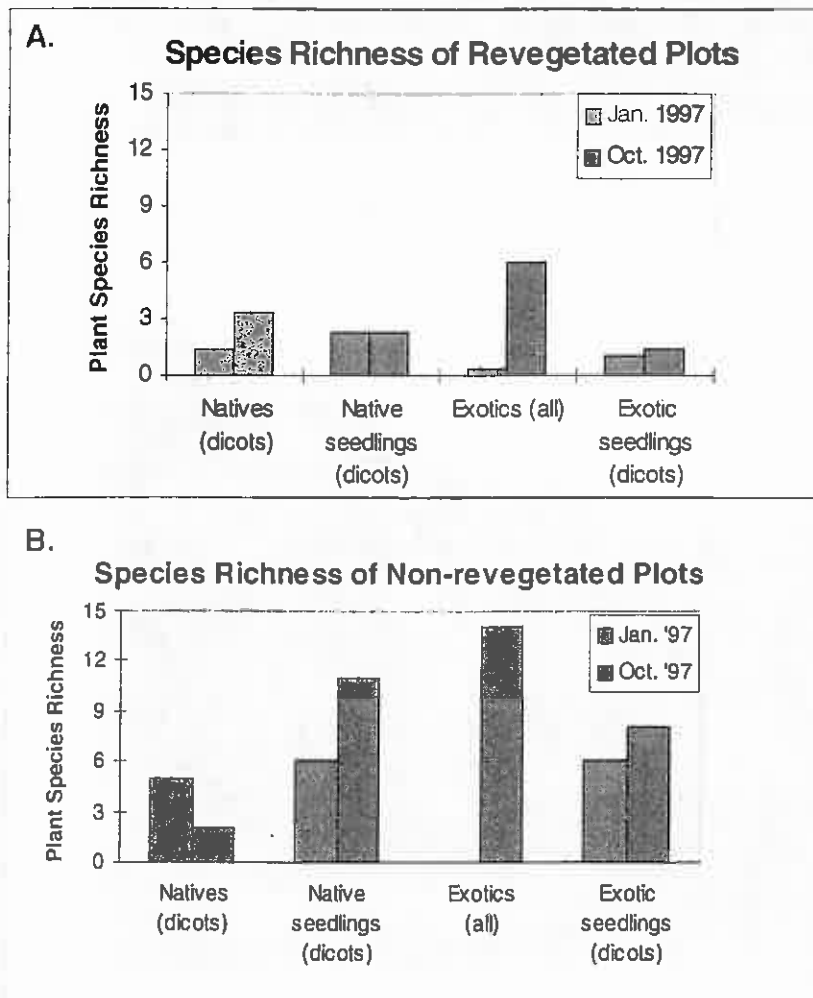


Figure 3. Species richness for the above plant groups prior to revegetation in January 1997 and following revegetation in October 1997 in (A) revegetated plots and (B) non-revegetated plots.

- Outplanted species:

<i>Achillea millefolium</i>	<i>Horkelia californica</i>
<i>Agrostis hollii</i>	<i>Iris dougalsiana</i>
<i>Artemesia californica</i>	<i>Nassella pulchra</i>
<i>Artemesia douglasiana</i>	<i>Rhamnus californica</i>
<i>Baccharis pilularis</i>	<i>Satureja douglasii</i>
<i>Chlorogalum pomeridianum</i>	<i>Stachys ajugoides</i>
<i>Elymus glaucus</i>	<i>Symphoricarpos albus</i>
- Native plant survivorship averaged 95% for all 5 outplanted plots
- Native thistles, cow parsnip, hedgenettle, and poison oak resprouted on edges and are re-establishing in the fill site.
- Outplanting occurred over only one season, it was successful in terms of survivorship and speeding up the recovery of native vegetation. As long as harding grass (*Phalaris aquatica*) is prevented from establishing in the first three years, the restored area should rebound with native vegetation since it is surrounded on all sides by a rich and impenetrable native plant community.

WHAT DID NOT WORK

- Some native plants were salvaged from the site: *Chlorogalum*, *Baccharis*, and *Horkelia*. Keeping plants alive was problematic: soaproot rotted from overwatering and shrubs were potted in heavy, native soil with poor drainage which is not conducive to maintaining plants in a nursery. Weeds also grew heavily in the pots. I would not recommend salvaging plants again due to high space requirements, poor drainage, and transport needs to and from the site.
- Of all the species outplanted, only *Satureja douglasii* did poorly.
- It was unrealistic to expect middle school students from the Aim High program to weed the site due to the presence of poison oak, the density of unmaintained vegetation along the closed trail that provides access from Back Door Pond, and the sensitivity of the outplantings.

REVEGETATION CHALLENGES

- We did not encounter any extreme challenges to revegetating this site with the exception of the steep slope and presence of poison oak.

GENERAL SITE OBSERVATIONS

- *Heracleum lanatum* germinated abundantly but failed to establish during the first year. It will probably be too exposed during the first few years for this species to survive the summer and I have observed high seedling mortality in other sites. Surprisingly, small cow parsnip plants are now (1999) abundant on portions of the recovering Chaparral Trail, indicating that cow parsnip successfully established during the second season 1997-1998 of the trail recovery. *Cirsium brevistylum*, a native, germinated and grew robustly in the upper 100 ft. of the restored section, as well as a small number of non-native *Cirsium vulgare*, which were removed. Approximately 125 small harding grass plants established in the upper 150 ft., and were removed by a volunteer steward, Suse

Hartig. Native shrubs resprouted on the edges, including *Toxicodendron*, *Rubus ursinus* and *Baccharis*.

REVEGETATION RECOMMENDATIONS

- Continue weed control until scrub is large (3-5 years).
- Monitor the frequency of illegal trail use and or social trail development.
- Monitor erosion.

ESTIMATED LABOR AND COST*

<u>Planning</u>	160 hrs
<u>Plant control</u>	30 hrs/yr until 2003
<u>Native plant propagation</u>	
Seed collection and propagation	600 hrs
<u>Outplanting</u>	120 hrs
<u>Installing fencing/signs</u>	32 hrs

* This estimate includes only the revegetation component of the project. Estimates for cost of trail obliteration and contouring are not included.

Frank Valley Eucalyptus Site

Site Location:	Frank Valley Road, a few hundred yards from Highway 1, Marin Co.
Site Type:	Riparian
Plant Community:	Riparian scrub, coastal prairie, coastal scrub
Soil Type:	Cronkhite-Barnabe complex; 30-50% slopes (Marin Soil Survey)
Average Aspect:	SW, W
Average Slope:	30-50% above Redwood Creek Trail, 10-25% below Redwood Creek Trail
Size:	2 acres
Restoration Plan:	Frank Valley Eucalyptus Removal, May 1992, on file in Resource Management Office, located in Muir Woods maintenance bldg.)
Site Manager:	Mia Monroe, Heather King, Sharon Farrell
Reporter:	Heather King, Maria Alvarez
Reporting Date:	November 30, 1998

RESTORATION GOALS

- Control erosion.
- Restore coastal prairie to the hillside on the site.
- Restore riparian scrub to the two drainages.
- Restore coastal scrub to the lower slope on the site.

REVEGETATION CHRONOLOGY

- 1992 – Write restoration plan; photomonitor site; establish 6 permanent transects; remove approximately 100 large *Eucalyptus* (3 ft. diameter).
- 1993 – Clean-up slash from *Eucalyptus* removal; mulch impacted areas; exotic plant removal (*Eucalyptus* sprouts, French broom, fennel, poison hemlock, cape-ivy, vinca); outplant 2,000 plants (container plants from seed and cuttings as well as willow and dogwood stakes); mulch plantings with straw.
- 1994 – Exotic plant removal (*Eucalyptus* resprouts, vinca, cape-ivy, pampas grass, French broom, poison hemlock); outplant 2,655 plants (container plants and stakes); mulch plantings with straw.
- 1995 – Exotic plant removal (tarweed, thistle, cape-ivy, vinca, radish, mustard, French broom); outplant 2,922 container plants and 100 willow stakes; mulch plantings with straw; monitor 6 permanent transects.
- 1996 – Exotic plant removal (cape-ivy, French broom, radish, thistle, poison hemlock, mustard); outplant 535 container plants, 150 willow stakes and 50 dogwood stakes; mulch plantings with straw; photomonitor site.
- 1997 – Exotic plant removal (cape-ivy, French broom, *Eucalyptus* resprouts); outplant 480 container plants and 24 willow stakes.
- 1998 – Cut *Eucalyptus* resprouts; a rapidly-growing population of cape-ivy rebounds on site.

REVEGETATION METHODS

- 8,816 natives planted (both container plants and wands) 1992-1997. 1-gallon pots were used for most shrubs and leach tubes for grasses.
- 6 permanent transects were established in 1992; 30-meter transect monitoring in 1992 and 1995.
- Photomonitoring in 1992 and 1996.
- No accurate outplanting survival data was collected; just visual observation and photos.
- Direct seeding was done, but results were not reported.

Species outplanted 1992-1997

<i>Achillea millefolium</i>	1-gal		
<i>Anaphalis margaritacea</i>	1-gal	<i>Juncus patens</i>	1-gal
<i>Baccharis pilularis</i>	1-gal	<i>Lupinus propinquus</i>	unknown
<i>Bromus carinatus</i>	lt	<i>Mimulus aurantiacus</i>	1-gal
<i>Clarkia</i> sp.	unknown	<i>Nassella pulchra</i>	lt
<i>Cornus stolonifera</i>	1-gal and stakes	<i>Rubus ursinus</i>	1-gal
<i>Danthonia californica</i>	lt	<i>Salix lasiolepis</i>	1-gal and stakes
<i>Elymus glaucus</i>	lt	<i>Satureja douglasii</i>	1 flat
<i>Eriogonum latifolium</i>	1-gal	<i>Scrophularia californica</i>	1-gal
<i>Grindelia</i> sp.	1-gal	<i>Wyethia angustifolia</i>	1-gal

WHAT WORKED



Figure 1. Eucalyptus site in 1998, 6 years following original *Eucalyptus* removal. Photo by M. Alvarez.



Figure 2. Surviving willow stakes in 1998. Few established, and all trees are stunted in growth. Photo by M. Alvarez.

- According to a visual survey of the site, *Baccharis pilularis*, *Mimulus aurantiacus*, and *Scrophularia californica* have survived and flourished and have been setting seed on site.
- Large *Eucalyptus* that were felled continue to resprout but these can be kept under control with annual cutting.

WHAT DID NOT WORK

- In 1995 the State Park cut large *Eucalyptus* adjacent to the site, felling them on top of revegetated grassland in the NW corner of the site, smothering and killing outplanted grasses. Slash is still present on the grassland and grasses were never replanted.
- According to visual observation, very few planted *Bromus carinatus* survived. It is speculated that the tall overstory of poison hemlock and mustard shaded them out.
- Cape-ivy on site was removed between 1992-1997. By 1997, it was almost completely removed, but follow-up did not

continue. Following a wet winter, cape-ivy rebounded and by winter 1998-99 had almost returned to its former range preceding initial 1992 removal efforts.

REVEGETATION CHALLENGES

- Poison oak makes it difficult to access all areas to remove *Eucalyptus* resprouts and cape-ivy.
- Thick blackberry makes cape-ivy removal difficult and complete removal nearly impossible. Blackberry will need to be brushcut, possibly down to ground level, to allow cape-ivy root and resprout removal.
- Annual exotics, mainly poison hemlock, mustard and radish, cover a large percentage of the site and create a shady overstory under which perennial grasses cannot establish.

GENERAL SITE OBSERVATIONS

- The site needs maintenance for exotic species removal. Recommend hiring a crew to complete intensive cape-ivy removal and establishing a maintenance calendar for the site to assure that cape-ivy resprouts are removed for the next 7 to 10 years.
- Recommend removal of downed *Eucalyptus* slash on the site. Recommend annual photomonitoring and transect monitoring. The challenge for these recommendations is funding staff to perform ongoing maintenance and monitoring of the site.

- A mated pair of red-tailed hawks as well as native rodents have been observed on this site on numerous occasions.

REVEGETATION RECOMMENDATIONS

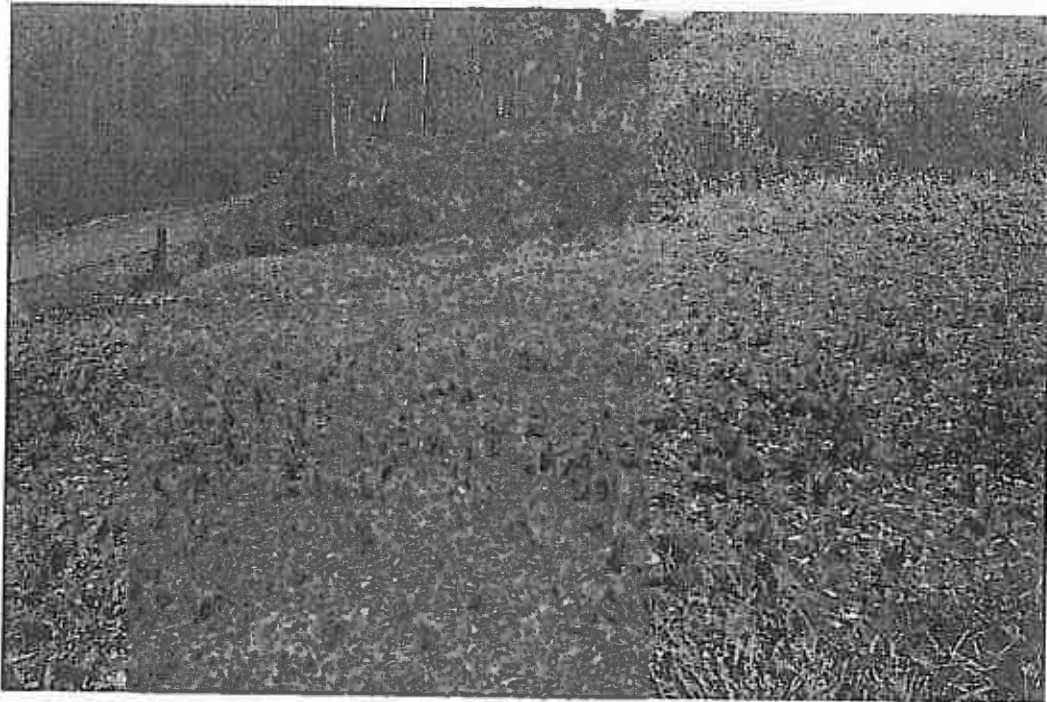


Figure 3. Looking northeast across the site. Photo taken in 1993, prior to revegetation and following Eucalyptus removal. Photo by M. Alvarez.

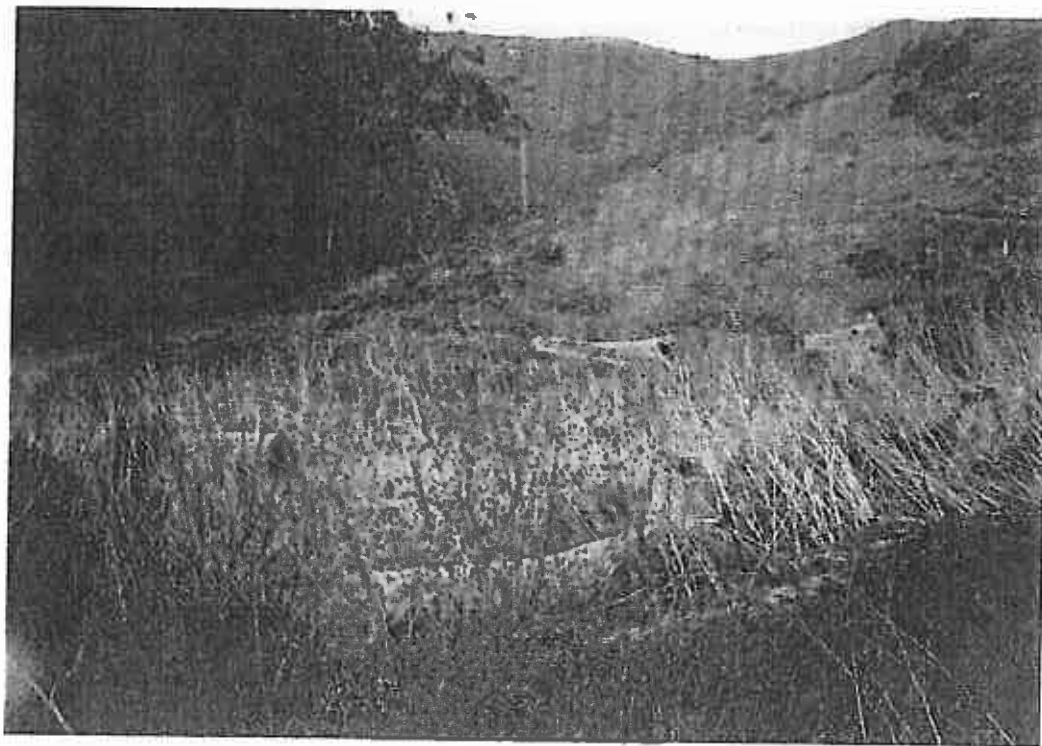


Figure 4. Looking northeast across the site. Photo taken in 1998 following revegetation efforts. Photo by M. Alvarez.

- Once downed *Eucalyptus* slash is removed, reseed with grasses and outplant container plants.
- Consider planting *Lonicera involucrata* along the tributary to increase species richness on the site and to establish a new population of this plant, which is becoming uncommon in the watershed.
- Investigate control of non-native annuals in order to establish grasslands.
- Revise revegetation objectives and consider planting willow and riparian scrub in failed grassland area.

ESTIMATED LABOR AND COSTS (1992-1997)

Planning

Writing and meetings 3-4 weeks, 1FTE

Plant Control

HRT 2 days/yr for 3 yrs, crew of 10-20
 Muir Woods Nursery Crew 10 days/yr for first 2 yrs, crew of 5
 Marin Conservation Corps 4 weeks

Native Plant Propagation

Muir Woods Nursery

Outplanting

Muir Woods/HRT 20 hrs, crew of 8

Rock Garden

Site Location:	Serpentine bluffs and adjacent fill site, west of the Golden Gate Bridge view area and Battery Marcus Miller.
Site Type:	Natural and fill
Plant Community:	Restoration site community is California annual grassland (exotic species invading fill soil); surrounding in-tact community is blue-blossom series and serpentine endemics.
Soil Type:	Serpentine and fill
Average Aspect:	North
Average Slope:	<10 degrees for revegetated areas; serpentine Rock Garden approximately 65 degrees
Size:	1.5 acres total site; revegetated area is 12,500 sq. ft.
Restoration Plan:	Project review - Battery Boutelle Marcus Miller Scenic Vista by Dennis Glass and Maria Alvarez, February 1993 Restoration Action Project Plan - Battery Boutelle, Coastal Trail by Maria Alvarez, 1993
Site Manager:	Maria Alvarez and Presidio Park Stewards
Reporter:	Ingrid Cabada
Reporting Date:	1997-1998

RESTORATION GOALS

Protect the native plant community of the serpentine bluffs (the "Rock Garden") from exotic plant invasion by controlling and eradicating invasive exotics in adjacent sites, eliminating social trails and rerouting the Coastal Trail.

REVEGETATION CHRONOLOGY

- 1989 — Staircase was built above the Rock Garden to reroute the Coastal Trail. Monterey cypress were cut and five trees were thinned.
- 1992 — The Habitat Restoration Team began invasive plant management and restoration.
- 1992 — Initial transect sampling was conducted.
- 1993 — T-stake fencing was erected to reroute social trails.
- 1994 — Social trails leading through Rock Garden were planted and mulched.
- Ongoing planting, weeding and transect monitoring.

REVEGETATION METHODS

- Two areas were revegetated: the serpentine bluffs for bike path restoration, and several fill soil sites on Battery Boutelle.
- Following trail re-routing, ongoing planting and weeding of exotic species was done. Planted sites were supplemented with broadcast seed. Seedling establishment was not monitored.



Figure 1. View looking south (upslope) at erosion scars caused by unofficial visitor trails and mountain bike paths through the upper edge of the fragile serpentine endemic community known as the "Rock Garden." Photo taken in 1992 by M. Alvarez.

Species planted

<i>Achillea millefolium</i>	<i>Heracleum lanatum</i>
<i>Aster chilensis</i>	<i>Heteromeles arbutifolia</i>
<i>Baccharis pilularis</i>	<i>Hordeum brachyantherum</i>
<i>Bromus carinatus</i>	<i>Iris douglasiana</i>
<i>Ceanothus</i> sp.	<i>Koeleria macrantha</i>
<i>Eriogonum latifolium</i>	<i>Phacelia californica</i>
<i>Eriophyllum staechadifolium</i>	<i>Scrophularia californica</i>

Species seeded

<i>Anaphalis margaritacea</i>	<i>Festuca rubra</i>
<i>Baccharis pilularis</i>	<i>Heracleum lanatum</i>
<i>Bromus carinatus</i>	<i>Lupinus arboreus</i>
<i>Chlorogalum pomeridianum</i>	<i>Phacelia californica</i>

- Pre-revegetation transects performed in 1992 showed non-native plant cover ranging between 60% and 95%. Subsequent transects showed an increase in native plant cover. This is due to introducing native species to the site. Figure 4 shows species richness increasing, for both native and exotic species.

WHAT WORKED

- In the serpentine soil revegetation, installation of 150 ft. of t-stake fencing protected areas degraded by three social trails through the Rock Garden. These trails have been restored to native vegetation.
- Species planted include: *Bromus carinatus*, *Hordeum brachyantherum*, *Koeleria macrantha*, *Elymus glaucus*, *Aster chilensis*, *Achillea millefolium*, *Phacelia californica*, *Iris douglasiana*, *Heracleum lanatum*, *Plantago erecta* and *Scrophularia californica* established.



Figure 2. Rock Garden bluffs and main revegetation site in 1992 prior to closure of social trail and fence installation. Photo by M. Alvarez.



Figure 3. Rock Garden bluffs and main revegetation site in 1994 following trail closure, mulching of trails, and erection of t-stake fencing. Straw mulch is evident on former social trails. Photo by M. Alvarez.

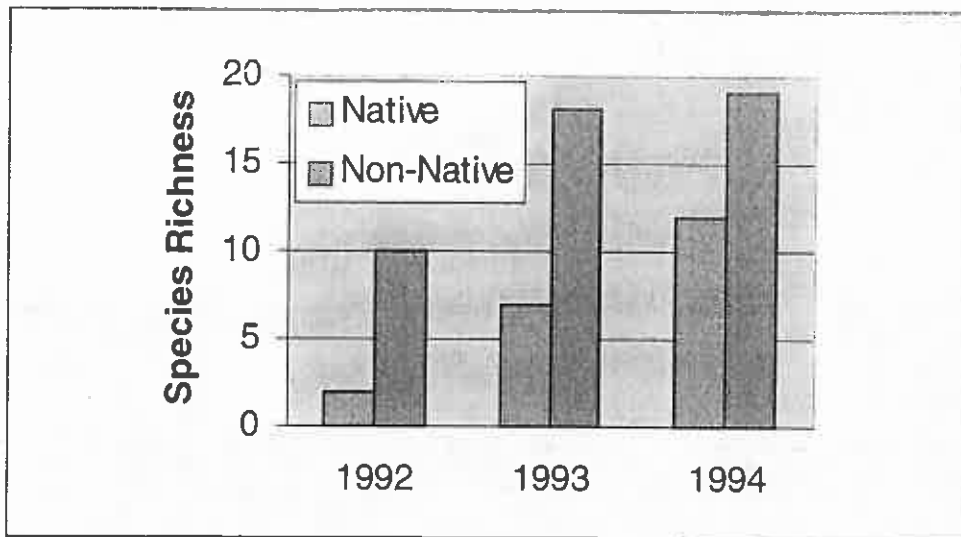


Figure 4. Plant species richness, showing pre-revegetation richness (1992) and post-revegetation richness (1993 and 1994).

- *Lupinus* and *Eriophyllum* grew to maturity, but these species are short-lived and did not reproduce.
- Some *Elymus triticoides*, *Iris* and *Aster* recolonized the site naturally.

WHAT DID NOT WORK

- *Heteromeles*, *Ceanothus* and *Baccharis* did not survive in planting areas where fill soil (less than 12" depth) had been placed over cement bunkers. (The existence of this historic fabric was not known at the time of that outplanting.)
- *Arabis blepharophylla* and *Erysimum franciscanum* planted on the serpentine bluffs in the Rock Garden did not establish.
- Lack of trail fencing in a high-traffic area. Bicyclists cut through a revegetated site in the fill soil area and some trampling of native plants occurred.

REVEGETATION CHALLENGES

- The Rock Garden is a much-visited area, posing a threat to the native plant community because of the routing of the Coastal Trail through the sensitive habitat and the subsequent development of social trails in the area. Successful revegetation and eradication of the social trails was possible after the Coastal Trail was rerouted and protective fencing was erected in 1993.
- The area adjacent to the Rock Garden that is most impacted by non-native species (mustard, *Solanum*, radish, annual grasses, cheeseweed) is fill soil of several inches in depth over cement bunkers ("historic fabric" of the Park). It is hypothesized that the fill soil is more nutrient-rich than serpentine soil native to the site, so that exotic species are able to outcompete natives.
- Species richness has not increased and native species have not volunteered in unplanted yet heavily weeded areas. It is suspected that if planted sites are not continually weeded, these plantings will disappear.



Figure 5. Fill soil slope on Battery Boutelle, southwest (upslope) of the Rock Garden, prior to revegetation in 1994. Photo by M. Alvarez.

GENERAL SITE OBSERVATIONS

- Radish removal resulted in an increase in exotic species the following year including *Solanum* and *Malva*.
- Removal and thinning of cypress provided more light, possibly increasing the quantity of radish, *Solanum*, and mustard.
- Felled tree debris left on-site provided excellent habitat for cape-ivy to establish.
- The original action plan proposed trail improvements to accommodate bicyclists that never



Figure 6. Three months following revegetation in 1994, radish has covered the fill soil slope. Photo by M. Alvarez.

were implemented. The trail is technically closed to bicyclists, but they continue to use it due to lack of enforcement and adequate trail development.

REVEGETATION RECOMMENDATIONS

- Continue the removal of cape-ivy from the Rock Garden and annual exotics from the surrounding sites. Establish a peripheral boundary where restoration work stops.
- Use a master plan and promote the cooperation between Park departments before aligning trails and beginning restoration work.
- Maintain fencing in good condition.
- Replant natives that have been successful in establishing at the same time when exotics are removed.
- Introduce native species that are adapted to wetter soils or strong winds, such as *Juncus sp.*, *Vicia gigantea*, *Heracleum lanatum*, *Aster chilensis*, *Hordeum brachyantherum*, and *Stachys*, to areas with poor drainage such as fill soil sites.
- Monitor 1992-1994 revegetation efforts to observe changes in this planted area (which has not been weeded), and discontinue planting.

ESTIMATED LABOR AND COST

1991-1997

Planning

Writing, meetings

National Resources staff, Roads and Trails staff
and South District Supervisor

160 hrs

Plant Control

1991-1997

80 hrs per year

Native Plant Propagation

Tennessee Valley and Fort Funston Native Plant Nurseries

40 hrs

Outplanting

Habitat Restoration Team volunteers

45 hrs

Installing Fencing/Signs

Maintenance

20 hrs per year

Initial installation

200 hrs

Muir Woods Fern Creek

Site Location: One-mile up the main asphalt trail at Muir Woods; Fern Creek trailhead is on the right side with a sign; the trail runs along Fern Creek tributary.

Site Type: Natural area; highly compacted; riparian zone was re-created from an almost bare area.

Plant Community: Redwood forest-riparian

Soil Type: Centissima-Barnaby complex

Average Aspect: None

Average Slope: Flat, to <5%

Size: 44,083 sq. ft.

Restoration Plan: On file in Resource Management office at Muir Woods maintenance bldg.

Site Manager: Mia Monroe, Heather King

Reporter: Heather King

Reporting Date: February 14, 1999

RESTORATION GOALS

- Delineate, fence and chip the hiking trail along Fern Creek.
- Establish a minimum 20 ft. riparian corridor between the creek and human activity (hiking).
- Re-establish native redwood-riparian understory.
- Replenish and re-build native soil on site through mulching and planting.
- Prevent further erosion along creek bank and repair past erosion problems when possible.
- Return large woody debris to the creek to slow water flow and re-create redds (spawning grounds for coho salmon).
- Provide those conditions necessary to encourage the return of coho salmon and steel-head trout to Fern Creek for spawning purposes.

REVEGETATION CHRONOLOGY

- 1996 – Delineate hiking trail up to State Park boundary sign; fence trail; mulch heavily with native duff and incorporate mulch into native soil with hand tools; plant 350 plants (see species list) in riparian corridor. Most plants were planted on south side of creek and a few along the bank on the north side.
- 1997 – Cover surface of trail with wood chips to prevent gullyng; plant 200 plants (same location as above); mulch around plantings.
- 1998 – Photomonitor; plant 400 plants (site was extended into newly fenced area); extend fencing and delineated trail beyond State Park boundary; mulch around plantings.
- 1999 – Photomonitor; plant 800 plants in area fenced in 1998 (mostly south side of

creek but some along bank on north side); establish monitoring plot in new planting area to evaluate outplant survivorship; mulch around plantings.

REVEGETATION METHODS

Species planted:

Adenocaulon bicolor

Alnus rubra

Aralia californica

Cyperis sp.

Disporum hookeri

Elymus californicus

Euonymus occidentalis

Frageria californica

Hierochloe occidentalis

Iris douglasiana

Juncus patens

Lithocarpus densiflorus

Oxalis oregana

Polystichum munitum

Rhododendron occidentale

Ribes menzesii

Rosa gymnocarpa

Satureji douglasii

Stacchys bullata

Tellima grandiflora

Vaccinium ovatum

Viola sempervirens

- Soil was very compacted from years of trampling by Park visitors, so heavy mulching and rototilling using hand tools was necessary prior to planting.
- Planting holes were dug at least twice as wide as the root ball to loosen soil as much as possible for newly establishing roots.
- Many sword ferns were planted – these do well in compacted soils.



Figure 1. Example of bare understory in impacted area, looking upstream from point near Fern Creek Trail. Prior to revegetation in October 1996. Photo by H. King.

- Outplanted areas were mapped in 1996-1998 but no follow-up or monitoring was completed to evaluate survivorship. In 1999, a monitoring plot was established to evaluate survival of 20% of the outplanted plants.
- Area was photomonitored in 1998 and 1999 using established photomonitoring points.

WHAT WORKED

- Fencing was successful in keeping hikers on the delineated path and preventing further trampling; sprouts of native plants appeared along the fenced-off corridor, where nothing had been able to sprout for years without getting trampled.
- There was no official assessment of outplant survivorship but from visual observation there was a very high survival rate among sword ferns and most herbaceous species.
- Anchoring large woody debris in the creek slowed the water down, preventing further erosion and making the creek more appealing to trout. Trout have been observed spawning in Fern Creek for the first time in decades!
- Signage at the entrance of the trail explains our project and further encourages hikers to stay on the delineated trail..

WHAT DID NOT WORK

- When delineating the trail, we attempted to transplant some large tanoak that were in the proposed path; as with other tanoak transplant attempts, these failed. Even after carefully digging up the taproot, the trees died. Sword fern and groundcover, however,



Figure 2. Two years following planting, mulching and fencing. Photo shows restored site adjacent to that pictured in Figure 1. Note *Polystichum* planted to the left of the trail. Photo taken December 1998 by H. King.

were transplanted successfully.

- Some of the the alder, rush and *Tellima grandeflora* died. Alder and *Tellima* were planted in deep shade, and the rush was probably planted in too dry of an area.
- The fenced trail begins at the junction of Redwood and Fern Creeks and continues into State Park property, where the fence ends abruptly. Hikers accessing Fern Creek Trail from Muir Woods meet signs about the project and begin their walk on a fenced trail and are likely to stay on the delineated trail. Hikers who access the the trail from State Park land often go around the fencing - it's may not be clear why the fencing is there and it starts abruptly that hikers feel that it is not important to remain on it. We need signage at both ends.
- Despite spreading wood chips on the path, it still gullies with the water flow down the trail from rain.
- Photomonitoring and outplant monitoring efforts should have begun at the start of this project.

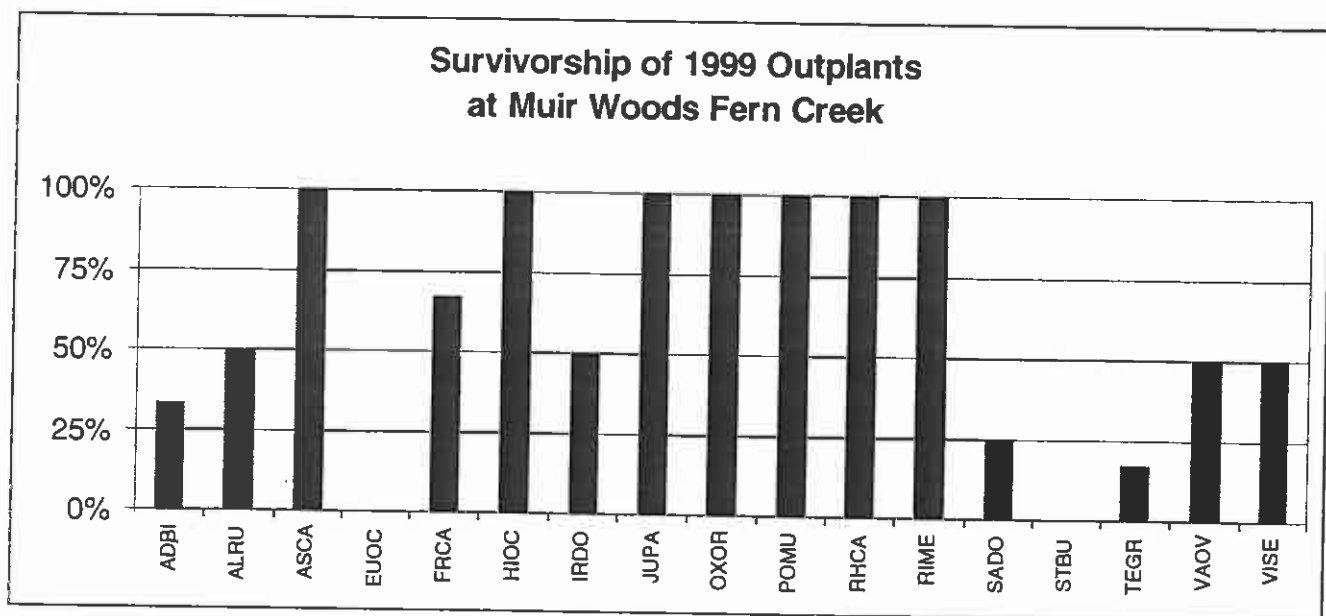


Figure 3. Outplant survivorship at Muir Woods Fern Creek revegetation site. Outplants were planted in January 1999 and monitored in October 1999. Four-letter codes are abbreviations of scientific names; see species planted list for the site for complete names.

REVEGETATION CHALLENGES

- Highly compacted soil due to trampling; it is hard to dig in and difficult for plants to establish.
- Difficult to bring mulch to site; it is a narrow, muddy, bumpy path.
- The dark and cold location makes photomonitoring, and sometimes working, difficult.
- People walking on the trail from State Park direction often do not stay on fenced trail.

GENERAL SITE OBSERVATIONS

- Site is in significantly better shape then before restoration efforts began — more native vegetation, less erosion, slower-moving water, less trampling.

- Very little threat from exotics (too little sunlight for most) — potential threats are English ivy and forget-me-nots.

REVEGETATION RECOMMENDATIONS

- Outplant efforts in 1999-2000 are scheduled for the same subsite as 1998-1999 (the recently fenced area on State Park property).
- This may be the last year outplanting is needed in this section.
- Delineate and fence as much of the State Park part of the path as possible; this is the only way to prevent trampling and allow the site to recover. Revegetation efforts are pointless in any sections along this trail that aren't fenced; there are too many hikers that would trample new plants.
- Continued mulching will hasten the rebuilding of soil.
- The general plan used for this site would be good for similar sites in which fencing and/or delineating a trail followed by revegetation were in order.

ESTIMATED LABOR AND COST

Native Plant Propagation and Outplanting

\$5,250 1750 plants and 500 hours of outplanting, mulching, and crew leadership

Tennessee Valley Dam

Site Location:	Tennessee Valley Dam near Tennessee Cove in the Marin Headlands.
Site Type:	Natural/cultural
Plant Community:	Maritime prairie and scrub
Soil Type:	Chert fill, rocky substrate, no topsoil. Site is located where level Hydraquents soils (layers of peat and clay) would be along coast (from Marin Soil Survey).
Average Aspect:	North and south-facing slopes on dam; no aspect on dam.
Average Slope:	55 degrees on slopes
Size:	2,000 sq. ft.
Restoration Plan:	Tennessee Valley Dam and Vicinity Vegetation Restoration Action Plan by Maria Alvarez, 1994.
Site Manager:	Maria Alvarez
Reporter:	Maria Alvarez
Reporting Date:	November 1998

RESTORATION GOALS

- The primary goal of this site was to eliminate the perennial non-native herb capeweed (*Arctotheca calendula*) which blanketed both sides of the dam in 1989. This was 95% complete by 1991, when former capeweed patches began to be colonized by non-native species such as mustard, thistles and fennel. Since these species could spread into adjacent diverse native plant communities, especially fennel and pampas grass, the revegetation goal was to try various revegetation methods in order to best shift succession towards dominant cover of native vegetation.

REVEGETATION CHRONOLOGY

- 1989 – Removal of capeweed by the Habitat Restoration Team began. By 1991, following capeweed removal, non-native herbs such as annual grasses, wild mustard, thistles, bindweed, fennel and pampas grass became the dominant cover (60%) at the site. Mustard occupied 700 square feet at that time and there were about 25 mature fennel plants on the site.
- 1991 – Three line transects were established prior to outplanting and were monitored annually from 1992-1994.
- 1991 – Broadcast seeding was done.
- 1991 – Outplanting occurred for three seasons until 1994.

REVEGETATION METHODS

- The Tennessee Valley dam was mapped and divided into eight plots and different revegetation methods were performed in each plot.
- Seed and plant material was collected locally and plants were grown at the Tennessee Valley Nursery each year.

- Two different size plots (6 m² and 30 m²) received different broadcast seed mixes in winter 1991-92 after both sites had been hand-weeded for mustard. The seed was cleaned, weighed and mixed with 0.5 cubic feet of potting soil in a bucket and hand broadcasted onto the site. The mixture was covered with four 5-gallon buckets of fine sawdust. These plots were also seeded with 1 lb. of *Vulpia megalura*, a non-native annual grass (0.25lb. in the smaller plot and 0.75 lb. in the larger plot) to establish cover to compete with non-native herb seedlings.
- All plants were planted by the Habitat Restoration Team and Tennessee Valley Nursery volunteers using handpicks.
- 380 plants (8 different species) were outplanted into 6 plots in December 1991 through April 1992. Grasses and lupines were planted from leach tubes, *Mimulus aurantiacus* from 4" pots, and *Myrica californica* from 1-gallon pots.
- 10 willow stakes cut at the site were planted at the waters edge on the east side down from the first culvert.
- 102 plants (4 species) were planted in 4 plots along the path on the upper east top of the dam in March 1993.
- 144 plants (9 species) were planted in bare areas among 2 plots on the upper edge of on the east side of the dam in 1994.

Species planted include:

Artemisia californica
Bromus carinatus
Elymus glaucus
Festuca californica
Grindelia stricta
Juncus patens
Lupinus propinquus
Mimulus aurantiacus
Myrica californica
Nassella pulchra
Phacelia californica
Salix lasiolepis (from stem cuttings only)
Urtica dioica var. *holoserica*

Species seeded in 12/91 and 1/92:

Achillea millefolium (1.25 oz.)
Artemisia californica (0.75 oz.)
Aster radulinus (0.95 oz.)
Baccharis pilularis (0.06 oz.)
Elymus glaucus (0.5 oz.)
Eriophyllum stachaedifolium (1.875 oz.)
Eschscholzia californica (0.25 oz.)
Heracleum lanatum (2.76 oz.)
Vulpia megalura "Zorro fescue" (1 lb.)

WHAT WORKED

- Overall, the richness of native species increased from 4 to 10 species due to their reintroduction to the site as outplantings and broadcast seed over three seasons (Figure 1A), while the richness of non-native species remained the same.
- Vegetation cover also changed (Figure 1B). Each summer, from 1991 to 1994, we sampled two 30-m line transects: one along the eastern top edge of the dam (this was the control, and it was not reseeded or planted); and one placed midslope on the east side of the dam. Native plant cover was highest right after revegetation in 1992, mainly because we had weeded the planting/seeding site and removed the most dominant non-native species, wild mustard. Over time, the annual non-natives increased, but so has the richness and cover of perennial native plants.

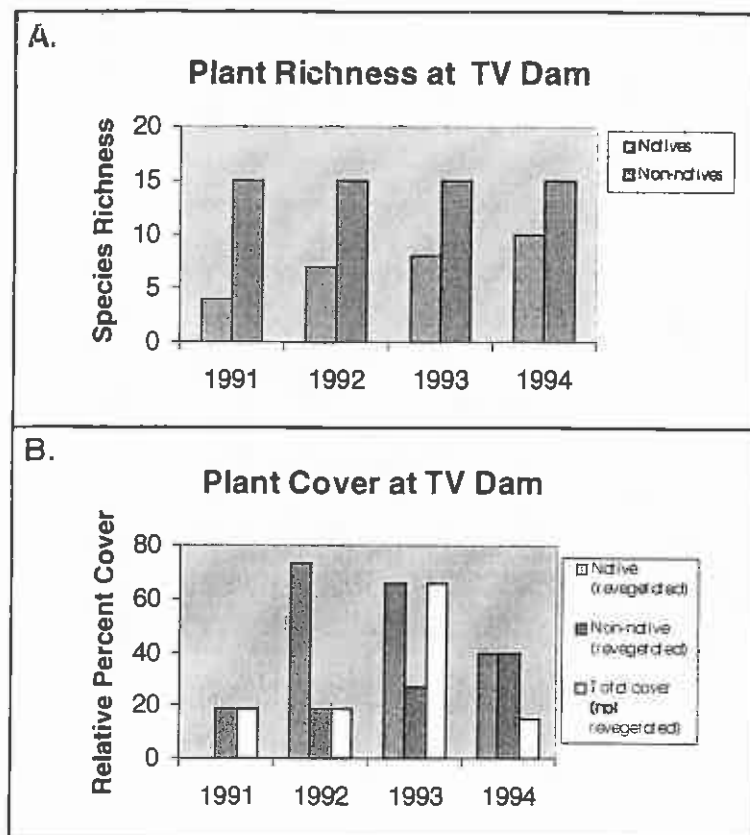


Figure 1 (A) Species richness in revegetated plots. Native species richness increased over time while non-native richness stayed the same. (B) Relative percent cover of plants at the dam site, showing native and non-native cover in revegetated plots and total cover in non-revegetated plots. 1991 monitoring occurred prior to revegetation.

from deer browsing (2" diameter) while those at the south end were twice as large. All 3 *Juncus* plants survived, *Festuca californica* held on but did not expand very much, and the one *Grindelia* survived.

- By January 1993, *Nassella* at the southwest end had "tripled in size" (see Figure 3). By October 1993, the *Mimulus* had survived into the first summer and were tagged and in 1998, there were 6 plants left (35% survivorship) after 7 years.
- One of 3 *Myrica* survived the first summer and the surviving tree was still present in 1998 (2 m tall). It will probably remain in shrub form due to fierce coastal winds.
- By May 1992, 8 of the willow cuttings had rooted (80% survivorship). By August 1993, at 15 months of age, they had grown several feet tall despite being completely covered by water in February 1993. In 1998, the willows were 2 m tall.
- *Artemisia californica* has grown to a height of 0.75 m and 1.25 m in diameter.

WHAT DID NOT WORK

- Very few seedlings survived to establish in the smaller plot (6 m²). The sawdust may not have provided enough cover, as the site had no topsoil. *Heracleum lanatum* direct seeded in the smaller plot germinated but very few established. Germination of seeded *Elymus*, *Artemisia* and *Aster chilensis* was low.
- Stinging nettles (*Urtica dioica*) did not establish. They were planted low on the slopes and

1991-92 Seeding Results:

- By March 1992, seedlings were visible at both seeded sites. Sawdust was still present on-site. *Heracleum lanatum*, *Eriophyllum stachaeifolium*, *Achillea millefolium* and *Eschscholzia californica* were the most abundant species observed. *Aster* established from seed only along the lower watery edge of the dam and was not noticeable until later in 1992. *Vulpia* did not germinate well. By July 1994, *Eriophyllum* shrubs were 1 ft. in diameter and starting to fill in the bare spaces and form a solid cover. *Artemisia californica*, *Achillea millefolium* and *Aster* were also enlarging, but were more patchily distributed.

1991-92 Planting Results:

- By spring 1992, *Bromus*, *Elymus*, and *Nassella* in plots on the west side of the dam averaged 5-9" diameter. *Bromus* and *Elymus* on the northeast side were still stunted



Figure 2. Volunteers remove capeweed (*Arctotheca calendula*) on Tennessee Valley Dam prior to planting. Looking north across the dam from the south end. Photo taken in March 1992 by M. Alvarez.

were probably flooded as pond water level rose.

- *Vulpia megalura* did not germinate well and it was later concluded that the seed which had been purchased by staff before 1991 was very old and probably no longer viable.



Figure 3. Looking north across the dam from the south end, following planting in March 1993. Photo by M. Alvarez.

REVEGETATION CHALLENGES

- The site was not particularly challenging to revegetate. The dam slopes are steep, which makes it difficult to work on. Visitors also walk across the top of the dam, so nothing was planted close to the trail to avoid trampling of plants.

GENERAL SITE OBSERVATIONS

- In 1991, newly-planted *Bromus* and *Elymus* in plots lower on the dam slopes had been browsed by deer, possibly because of good access to the shore for a drink.
- *Cirsium andrewsii*, a CNPS-listed native thistle, historically occurred northeast of the dam at the upper edge of the lagoon but has not been observed since 1985.

REVEGETATION RECOMMENDATIONS

- Coastal scrub did better than grasses on the north side, and grasses did better on the windy south side of the dam.
- *Eriophyllum* established from seed extremely well and saved a lot of time that would have been spent outplanting. *Aster*, *Achillea* and *Heracleum* did reasonably well from seed but could have been planted.

ESTIMATED LABOR AND COST (1991-1995)

Planning

Writing and revegetation design	
2 weeks	1 FTE

Plant Control

HRT and TV Nursery volunteers	
	8 days/yr = 350 hrs/yr

Native Plant Propagation

TV Nursery volunteers	40 hrs/yr
-----------------------	-----------

Outplanting

1991-1992	160 hrs/yr
1993-1995	40 hrs/yr

Monitoring

1991-1994	2 days/yr
-----------	-----------

Tennessee Valley Quarry

Site Location:	Just south of the barn that houses the Tennessee Valley Native Plant Nursery. A small seep occurs on the northeast side of the site.
Site Type:	Chert quarry
Plant Community:	Grassland
Soil Type:	Soil should be Tamalpais-Barnabe variant, very gravelly loams, 30-50% slopes, but the site is a former quarry and the soil has been removed.
Average Aspect:	SW
Average Slope:	30-50%
Size:	Large quarry, 0.5 acre; small quarry, 0.25 acre.
Restoration Plan:	Chaparral Watershed by Amy Fesnock, 1992.
Site Manager:	Maria Alvarez
Reporter:	Maria Alvarez
Reporting Date:	1997-1998

RESTORATION GOALS

- Control *Genista monspessulana* and *Cortaderia jubata* infestations.
- Revegetate a degraded slope that had once been a quarry site.



Figure 1. Erosion on Tennessee Valley large quarry site is stabilized, herbaceous cover is increasing (including non-native perennial grasses), and French broom (*Genista monspessulana*) and pampas grass (*Cortaderia jubata*) are under control. Photo taken in 1999 by M. Alvarez.

- Control erosion resulting from previous quarry damage.

REVEGETATION CHRONOLOGY

Large quarry

- 1988 – Began removal of *Genista monspessulana* and *Cortaderia jubata*. Follow-up removal has continued annually. By December 1991, *Genista* density was down to 4.5 plants/m² and *Cortaderia* was .33 plants/m².
- 1991 – A revegetation experiment using potted plants and broadcast seeding was conducted.
- December 1991 – Began annual outplanting.
- November 1993 – Brushbars were installed to control erosion and help outplants establish.
- Summer 1993 – Began monitoring the site annually, until Spring 1995.
- 1995 – Sonoma State University student Stacy Andrews reviewed results and summarized the brush bar experiment.

Small quarry

- 1993 – French broom removal began and brushbars were installed.
- 1993 – Outplanting of container plants began.

REVEGETATION METHODS

- The Tennessee Valley Quarry restoration area consists of two sites: the large quarry, on the northwest side; and the small quarry, on the northeast side near the cistern.
- An experiment was conducted on the large quarry in 1991 to determine the most effective means of revegetating the quarry. Three treatments were evaluated: native plant seed broadcast with sawdust mulch (.25 lb. of seed mix per .0015 acre); native plant seed broadcast under Curlex layer (.25 lb. of seed mix per .0015 acre); and outplanting of native



Figure 2. Following initial broom removal on the large quarry, *Nassella* and *Festuca rubra* were outplanted from leach tubes. Photo taken in December 1991 by M. Alvarez.

broadcast with sawdust mulch (.25 lb. of seed mix per .0015 acre); native plant seed broadcast under Curlex layer (.25 lb. of seed mix per .0015 acre); and outplanting of native grass and herb plugs (55 plants per 6.75 square meters). None of the plants seeded or outplanted existed in the plots prior to the experiment.

- Species outplanted in the experimental plots included:

	<u>Number</u>
<i>Dudleya sp.</i>	2
<i>Festuca rubra</i>	20
<i>Grindelia sp.</i>	2
<i>Heterotheca sessiflora</i>	4
<i>Lupinus arboreus</i>	10
<i>Mimulus aurantiacus</i>	4
<i>Nassella pulchra</i>	13

- Species seeded in the experimental plots included:

	<u>Amount</u>
<i>Achillea millefolium</i>	0.5 oz.
<i>Artemisia californica</i>	0.75 oz.
<i>Baccharis pilularis</i>	0.031 oz.
<i>Chlorogallum pomeridianum</i>	1.0 oz.
<i>Eriogonum latifolium</i>	0.5 oz.
<i>Eriophyllum stachaedifolium</i>	0.5 oz.
<i>Heterotheca bolanderi</i>	0.5 oz.
<i>Koeleria macrantha</i>	0.25 oz. (including stems)
<i>Vulpia megalura</i>	approx. 2 to 4 oz., applied to 1/3 of sawdust treatment only



Figure 3. Tennessee Valley large quarry, showing curlex that was applied in 1991 over broadcast seed. Native plants in the plot are only 1" tall and have begun to disappear from the site. *Lupinus arboreus* in upper right is naturally occurring. Photo taken in March 1993 by M. Alvarez.

- Species outplanted in the non-experimental area included:

<i>Achillea millefolium</i>	<i>Lupinus propinquus</i>
<i>Artemisia californica</i>	<i>Mimulus aurantiacus</i>
<i>Baccharis pilularis</i>	<i>Myrica californica</i>
<i>Eriogonum latifolium</i>	<i>Nassella pulchra</i>
<i>Escholzia californica</i>	<i>Phacelia californica</i>
<i>Festuca rubra</i>	<i>Rhamnus californica</i>
<i>Iris douglasiana</i>	<i>Ribes sanguineum</i>
<i>Juncus sp.</i>	<i>Tellima grandiflora</i>
<i>Koeleria macrantha</i>	
- In winter 1991, 415 commercially-grown *Nassella pulchra* were planted into the non-experimental area.
- At the small quarry, brushbars were installed, using removed French broom plants, in order to reduce erosion. Container plants were outplanted annually.

WHAT WORKED

Study Plots

- The following species had high germination: *Achillea millefolium*, *Eriogonum latifolium*, *Eriophyllum staechadifolium*, *Chlorogalum pomeridianum*, *Artemisia californica*, *Baccharis pilularis* and *Escholzia californica*.
- Results at the end of the first summer (1991) also showed that curlex served as the best protector for the broadcast seedlings.
- Five years following the experiment (1995), *Nassella pulchra* had 100% survival and was observed to be reproducing.

Outplanting (Non-study plots)

- While most grasses and herbs were dwarfed and appeared stressed, those species that were observed to survive from first season to year five include:

<i>Danthonia californica</i>
<i>Festuca rubra</i>
<i>Koeleria macrantha</i>
- Healthy and reproducing *Danthonia californica* established naturally on the site.

WHAT DID NOT WORK

Study Plots

- Five years following the experiment (1995), all experimental outplantings except *Nassella* and *Lupinus arboreus* had no or poor survivorship. *Lupinus arboreus* persisted for 4 years, flowered and died. Perennial herbs *Grindelia* and *Heterotheca sessiflora* var. *bolanderi* did not establish the first season, possibly because they were outplanted at a very small size.
- Only *Eriogonum* and *Baccharis* persisted from the broadcast seeding treatments, and these plants were dwarfed.

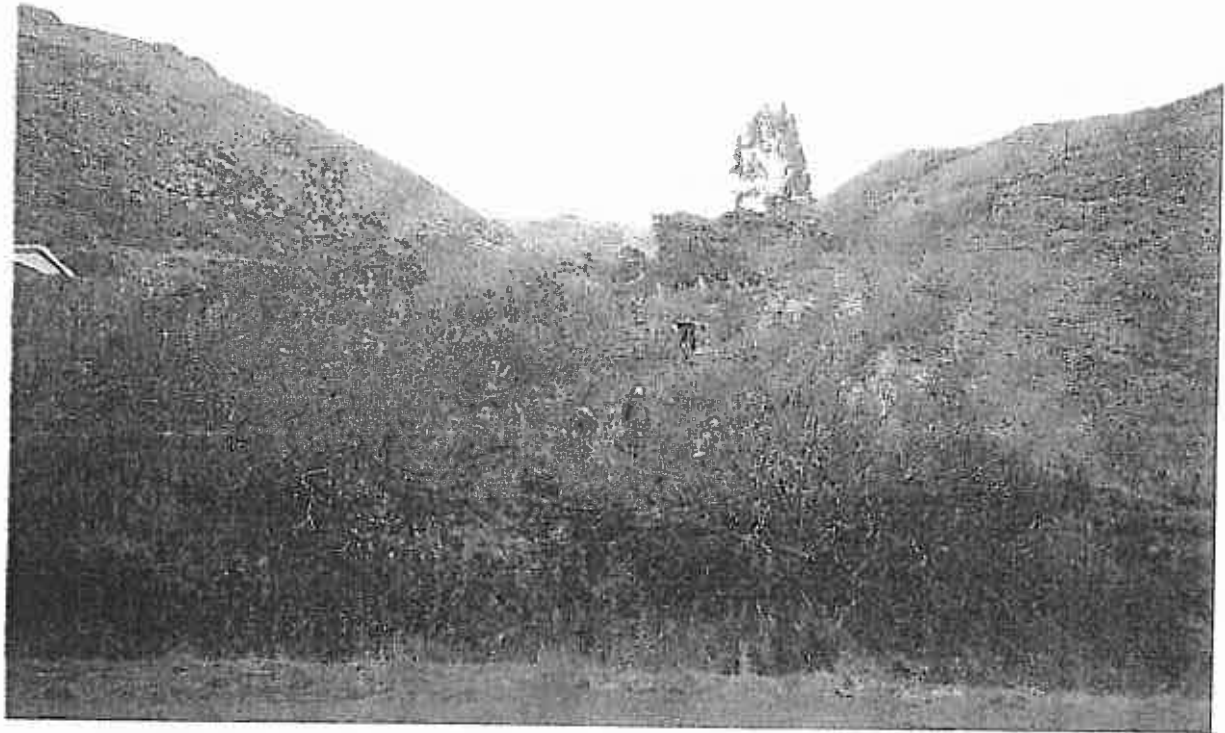


Figure 5. Habitat Restoration Team volunteers are removing broom on the north side of the Tennessee Valley small quarry in January 1993. Photo by M. Alvarez.



Figure 6. Tennessee Valley small quarry, showing pulled broom made into brushbars for erosion control. Photo taken in 1993 by M. Alvarez.

Outplanting (Non-study plots)

- 60% of outplanted *Lupinus arboreus* var. *propinquus* survived 3 years to reproduction but recruitment did not occur. 24% of *Nassella pulchra* survived from 1992 to 1997 but is stunted due to erosion.
- Although it was planted in volume, *Achillea* did not establish well and had less than 10% survivorship.
- The following species were also planted in volume and completely failed to establish:
Eschscholzia californica
Mimulus aurantiacus
- Brushbars appeared to slow erosion. As soil developed, annual grasses and velvet grass have increased on the site.

REVEGETATION CHALLENGES

- Erosion and lack of topsoil make native plant establishment - via natural re-establishment, planting or broadcast seeding - very difficult.

REVEGETATION RECOMMENDATIONS

- Limit revegetation on the quarry to outplanting of the following species: *Nassella pulchra*, *Danthonia californica*, *Festuca rubra*, *Koeleria macrantha* and *Lupinus arboreus* var. *propinquus*.
- Control erosion and add organic material (such as straw mulch) before attempting a broadcast seeding or outplanting revegetation effort on quarry sites.
- Perform a broadcast seeding experiment above brushbars.
- Increasing exotic grass cover indicates accumulation of soil on the quarry's rocky surface, which may indicate adequate topsoil is present to finally support outplants.

ESTIMATED LABOR AND COST (1988-1999)

<u>Planning</u>		<u>Native Plant Propagation*</u>	
Writing, revegetation design, monitoring		1991, 415 commercial grass plugs	
1 FTE	4 weeks		Cost unknown
volunteers*	40 hrs/yr	1991-1994	60 hrs/yr
<u>Plant Control*</u>		<u>Outplanting*</u>	
1988-1993	400 hrs/yr	1992-1995	40 hrs/yr
1994-1996	150 hrs/yr	1996-1999	20 hrs/yr
1997-1999	80 hrs/yr		

*Labor includes volunteers are from HRT, TV Nursery and Aim High.

GGNRA Restoration Site Evaluations

Appendix I Species Used at Revegetation Sites

<i>Abronia latifolia</i>		Tennessee Valley Dam	52
Feral Dunes	1	<i>Astragalus nuttallii</i>	
<i>Achillea millefolium</i>		Fort Funston Bank Swallow Site	7
Chaparral Trail Obliteration	31	North Baker Beach	12
Feral Dunes	1	<i>Baccharis pilularis</i>	
Fort Funston Bank Swallow Site	7	Baker-Barry Tunnel	17
Frank Valley Eucalyptus Site	36	Chaparral Trail Obliteration	31
Rock Garden	41	Feral Dunes	1
Tennessee Valley Dam	52	Fort Funston Bank Swallow Site	7
Tennessee Valley Quarry	57	Frank Valley Eucalyptus Site	36
<i>Adenocaulon bicolor</i>		North Baker Beach	12
Muir Woods Fern Creek	47	Rock Garden	41
<i>Agoseris apargioides</i> var. <i>apargioides</i>		Tennessee Valley Dam	52
Feral Dunes	1	Tennessee Valley Quarry	57
<i>Agrostis hollii</i>		<i>Bromus carinatus</i>	
Bolinas-Fairfax Region	24	Baker-Barry Tunnel	17
Chaparral Trail Obliteration	31	Bolinas-Fairfax Region	24
<i>Alnus rubra</i>		Feral Dunes	1
Muir Woods Fern Creek	47	Frank Valley Eucalyptus Site	36
<i>Ambrosia chamissonis</i>		Rock Garden	41
Fort Funston Bank Swallow Site	7	Tennessee Valley Dam	52
<i>Amsinckia spectabilis</i> var. <i>spectabilis</i>		<i>Camissonia cheiranthifolia</i>	
Feral Dunes	1	Feral Dunes	1
<i>Anaphalis margaritacea</i>		North Baker Beach	12
Baker-Barry Tunnel	17	<i>Camissonia contorta</i>	
Fort Funston Bank Swallow Site	7	Feral Dunes	1
Frank Valley Eucalyptus Site	36	<i>Camissonia micrantha</i>	
North Baker Beach	12	Feral Dunes	1
Rock Garden	41	<i>Cardionema ramosissimum</i>	
<i>Aralia californica</i>		Feral Dunes	1
Muir Woods Fern Creek	47	<i>Carex</i> sp.	
<i>Armeria maritima</i>		Baker-Barry Tunnel	17
Fort Funston Bank Swallow Site	7	<i>Castilleja</i> sp.	
<i>Artemisia californica</i>		Feral Dunes	1
Baker-Barry Tunnel	17	Fort Funston Bank Swallow Site	7
Chaparral Trail Obliteration	31	North Baker Beach	12
Fort Funston Bank Swallow Site	7	<i>Castilleja wightii</i>	
North Baker Beach	12	Feral Dunes	1
Tennessee Valley Dam	52	North Baker Beach	12
Tennessee Valley Quarry	57	<i>Ceanothus</i> sp.	
<i>Artemisia douglasiana</i>		Fort Funston Bank Swallow Site	7
Baker-Barry Tunnel	17	Rock Garden	41
Chaparral Trail Obliteration	31	<i>Chlorogalum pomeridianum</i>	
<i>Artemisia pinocephala</i>		Bolinas-Fairfax Region	24
Fort Funston Bank Swallow Site	7	Chaparral Trail Obliteration	31
<i>Aster chilensis</i>		Rock Garden	41
Rock Garden	41	Tennessee Valley Quarry	57
<i>Aster radulinus</i>			
Baker-Barry Tunnel	17		

<i>Chorizanthe cuspidata</i>		Rock Garden	41
Feral Dunes	1	Tennessee Valley Dam	52
<i>Cirsium occidentale</i>		Tennessee Valley Quarry	57
Feral Dunes	1	<i>Erysimum franciscanum</i>	
North Baker Beach	12	Feral Dunes	1
<i>Cirsium occidentale</i> var. <i>venustum</i>		North Baker Beach	12
Feral Dunes	1	<i>Eschscholzia californica</i>	
<i>Clarkia</i> sp.		Feral Dunes	1
Frank Valley Eucalyptus Site	36	Tennessee Valley Dam	52
<i>Cornus stolonifera</i>		Tennessee Valley Quarry	57
Frank Valley Eucalyptus Site	36	<i>Eunymous occidentalis</i>	
<i>Croton californicus</i>		Muir Woods Fern Creek	47
Feral Dunes	1	<i>Festuca californica</i>	
<i>Cryptantha leiocarpa</i>		Baker-Barry Tunnel	17
Feral Dunes	1	Tennessee Valley Dam	52
<i>Cyperus</i> sp.		<i>Festuca rubra</i>	
Muir Woods Fern Creek	47	Bolin-Fairfax Region	24
<i>Danthonia californica</i>		Rock Garden	41
Bolin-Fairfax Region	24	Tennessee Valley Quarry	52
Frank Valley Eucalyptus Site	36	<i>Fragaria californica</i>	
North Baker Beach	12	Muir Woods Fern Creek	47
<i>Disporum hookeri</i>		<i>Fragaria chilensis</i>	
Muir Woods Fern Creek	47	Feral Dunes	1
<i>Dudleya farinosa</i>		Fort Funston Bank Swallow Site	7
North Baker Beach	12	<i>Gilia capitata</i> ssp. <i>chamissonis</i>	
<i>Dudleya</i> sp.		Feral Dunes	1
Fort Funston Bank Swallow Site	7	<i>Grindelia hirsutula</i> var. <i>hirsutula</i>	
North Baker Beach	12	North Baker Beach	12
Tennessee Valley Quarry	57	<i>Grindelia</i> sp.	
<i>Elymus californicus</i>		Frank Valley Eucalyptus Site	36
Muir Woods Fern Creek	47	Tennessee Valley Quarry	57
<i>Elymus glaucus</i>		<i>Grindelia stricta</i>	
Baker-Barry Tunnel	17	Tennessee Valley Dam	52
Bolin-Fairfax Region	24	<i>Heracleum lanatum</i>	
Chaparral Trail Obliteration	31	Baker-Barry Tunnel	17
Frank Valley Eucalyptus Site	36	Rock Garden	41
Tennessee Valley Dam	52	Tennessee Valley Dam	52
<i>Ericameria ericoides</i>		<i>Heteromeles arbutifolia</i>	
Feral Dunes	1	Feral Dunes	1
Fort Funston Bank Swallow Site	7	Fort Funston Bank Swallow Site	7
North Baker Beach	12	Rock Garden	41
<i>Erigeron glaucus</i>		<i>Heterotheca sessiflora</i> var. <i>bolanderii</i>	
Feral Dunes	1	Bolin-Fairfax Region	24
Fort Funston Bank Swallow Site	12	Tennessee Valley Quarry	57
<i>Eriogonum latifolium</i>		<i>Hierochloa occidentalis</i>	
Feral Dunes	1	Muir Woods Fern Creek	47
Fort Funston Bank Swallow Site	7	<i>Hordeum brachyantherum</i>	
North Baker Beach	12	Rock Garden	41
Rock Garden	41	<i>Horkelia californica</i>	
Tennessee Valley Quarry	57	Chaparral Trail Obliteration	31
<i>Eriogonum</i> sp.		<i>Iris douglasiana</i>	
Frank Valley Eucalyptus Site	36	Bolin-Fairfax Region	24
<i>Eriophyllum staechadifolium</i>		Chaparral Trail Obliteration	31
Baker-Barry Tunnel	17	Muir Woods Fern Creek	47
Feral Dunes	1	Rock Garden	41
Fort Funston Bank Swallow Site	7	Tennessee Valley Quarry	52
North Baker Beach	12		

<i>Juncus effusus</i>			
Baker-Barry Tunnel	17	Tennessee Valley Quarry	57
<i>Juncus patens</i>		<i>Oxalis oregana</i>	
Frank Valley Eucalyptus Site	36	Muir Woods Fern Creek	47
Muir Woods Fern Creek	47	<i>Phacelia californica</i>	
Tennessee Valley Dam	52	North Baker Beach	12
<i>Juncus sp.</i>		Rock Garden	41
Tennessee Valley Quarry	57	Tennessee Valley Dam	52
<i>Koeleria macrantha</i>		Tennessee Valley Quarry	57
North Baker Beach	12	<i>Phacelia distans</i>	
Rock Garden	41	Feral Dunes	1
Tennessee Valley Quarry	57	<i>Plantago erecta</i>	
<i>Lathyrus littoralis</i>		Feral Dunes	1
Fort Funston Bank Swallow Site	7	<i>Polygonum paronychia</i>	
North Baker Beach	12	Feral Dunes	1
<i>Leymus mollis</i>		Fort Funston Bank Swallow Site	7
Fort Funston Bank Swallow Site	7	North Baker Beach	12
<i>Lithocarpus densiflorus</i>		<i>Polystichum munitum</i>	
Muir Woods Fern Creek	47	Muir Woods Fern Creek	47
<i>Lotus scoparius</i>		<i>Pteridium aquilinum var. pubescens</i>	
Feral Dunes	1	Feral Dunes	1
<i>Lupinus arboreus</i>		<i>Quercus agrifolia</i>	
Fort Funston Bank Swallow Site	7	Feral Dunes	1
Rock Garden	41	<i>Rhamnus californica</i>	
Tennessee Valley Quarry	57	Chaparral Trail Obliteration	31
<i>Lupinus chamissonis</i>		Feral Dunes	1
Feral Dunes	1	Fort Funston Bank Swallow Site	7
Fort Funston Bank Swallow Site	7	North Baker Beach	12
North Baker Beach	12	Tennessee Valley Quarry	57
<i>Lupinus propinquus</i>		<i>Rhododendron occidentale</i>	
Frank Valley Eucalyptus Site	36	Muir Woods Fern Creek	47
Tennessee Valley Dam	52	<i>Ribes menziesii</i>	
Tennessee Valley Quarry	57	Muir Woods Fern Creek	47
<i>Marah fabaceus</i>		<i>Ribes sanguineum</i>	
Feral Dunes	1	Tennessee Valley Quarry	57
<i>Marah oreganum</i>		<i>Rosa gymnocarpa</i>	
Baker-Barry Tunnel	17	Muir Woods Fern Creek	47
<i>Melica torreyana</i>		<i>Rubus ursinus</i>	
Bolinas-Fairfax Region	24	Frank Valley Eucalyptus Site	36
<i>Mimulus aurantiacus</i>		<i>Rumex sp.</i>	
Baker-Barry Tunnel	17	Fort Funston Bank Swallow Site	7
Feral Dunes	1	North Baker Beach	12
Fort Funston Bank Swallow Site	7	<i>Salix lasiolepis</i>	
Frank Valley Eucalyptus Site	36	Frank Valley Eucalyptus Site	36
North Baker Beach	12	Tennessee Valley Dam	42
Tennessee Valley Dam	52	<i>Satureja douglasii</i>	
Tennessee Valley Quarry	57	Chaparral Trail Obliteration	31
<i>Mimulus guttatus</i>		Frank Valley Eucalyptus Site	36
Baker-Barry Tunnel	17	Muir Woods Fern Creek	47
<i>Myrica californica</i>		<i>Scrophularia californica</i>	
Tennessee Valley Dam	52	Baker-Barry Tunnel	17
Tennessee Valley Quarry	57	Feral Dunes	1
<i>Nassella pulchra</i>		Frank Valley Eucalyptus Site	36
Bolinas-Fairfax Region	24	North Baker Beach	12
Chaparral Trail Obliteration	31	Rock Garden	41
Frank Valley Eucalyptus Site	36	<i>Sidalcea malvaeflora</i>	
Tennessee Valley Dam	52	Bolinas-Fairfax Region	24

<i>Silene verecunda</i> ssp. <i>verecunda</i>	
Feral Dunes	1
<i>Solidago</i> sp.	
Baker-Barry Tunnel	17
<i>Stachys ajugoides</i>	
Chaparral Trail Obliteration	31
<i>Stachys bullata</i>	
Muir Woods Fern Creek	47
<i>Symphoricarpus albus</i>	
Chaparral Trail Obliteration	31
<i>Tanacetum camphoratum</i>	
Feral Dunes	1
Fort Funston Bank Swallow Site	7
<i>Tellima grandiflora</i>	
Muir Woods Fern Creek	47
Tennessee Valley Quarry	57
<i>Uropappus lindeyi</i>	
Feral Dunes	1
<i>Urtica dioica</i> var. <i>holoserica</i>	
Tennessee Valley Dam	52
<i>Vaccinium ovatum</i>	
Muir Woods Fern Creek	47
<i>Viola sempervirens</i>	
Muir Woods Fern Creek	47
<i>Vulpia megalura</i>	
Tennessee Valley Dam	52
Tennessee Valley Quarry	57
<i>Wyethia angustifolia</i>	
Frank Valley Eucalyptus Site	36

Appendix II

Author Index for Site Reporters and Managers

Marc Albert

Presidio Park Stewards
Presidio Natural Resources, GGNRA
Wherry Housing Field Office
1539 Pershing Drive
San Francisco, CA
(415) 668-4392

Maria Alvarez

Habitat Restoration Team
Resource Management, GGNRA
Bldg. 1064, Ft. Cronkhite
Sausalito, CA 94965
(415) 331-0732

Ingrid Cabada

Habitat Restoration Team and Fort Funston
volunteer
434 Fair Oaks
San Francisco, CA 94110
(415) 285-9058

Sharon Farrell

Plant Ecologist
Resource Management, GGNRA
Bldg. 1061, Ft. Cronkite
Sausalito, CA 94965
(415) 331-0743

Amy Fesnock

contact Maria Alvarez

Louise Johnson

contact Maria Alvarez

Heather King

Muir Woods Native Plant Nursery, GGNRA
Administration Bldg., Muir Woods
(415) 388-4390

Jean Koch

Presidio Native Plant Nursery, GGNPA
Bldg. 1244, Presidio
San Francisco, CA
(415) 561-4830

Jim Milestone

contact Mary Petrilli

Mia Monroe

Muir Woods, GGNRA
Administration Bldg., Muir Woods
(415) 388-2596

Laura Nelson

contact Sharon Farrell

Mary Petrilli

Fort Funston, GGNRA
Fort Funston Visitor Center
San Francisco, CA
(415) 239-2366

Al Pond

Chief, Marin Roads and Trails, GGNRA
Bldg. 1107, Fort Cronkhite
Sausalito, CA 94965
(415) 331-1831

Solange Russek

Marin Roads and Trails, GGNRA
Bldg. 1107, Fort Cronkhite
Sausalito, CA 94965
(415) 331-1254

Terri Thomas

Chief, Natural Resources, GGNRA
Bldg. 1061, Ft. Cronkhite
Sausalito, CA 94965
(415) 331-0771

Monica Wadsworth

Presidio Native Plant Nursery, GGNPA
Bldg. 1244, Presidio
San Francisco, CA
(415) 561-4830

GGNRA Restoration Site Evaluations

Index

Cultural site type	Natural site type
Tennessee Valley Dam 52	Bolas-Fairfax Region 24
Erosion control sites	Fort Funston Bankswallow Site 7
Chaparral Trail Obliteration 31	Muir Woods Fern Creek 47
Tennessee Valley Quarry 57	North Baker Beach 12
Exotic species control	Rock Garden 41
Bolas-Fairfax Region 24	Tennessee Valley Dam 52
Chaparral Trail Obliteration 31	North district sites
Feral Dunes 1	Baker-Barry Tunnel 17
Fort Funston Bankswallow Site 7	Bolas-Fairfax Road 24
Frank Valley Eucalyptus Site 36	Chaparral Trail Obliteration 31
North Baker Beach 12	Frank Valley Eucalyptus Site 36
Rock Garden 41	Muir Woods Fern Creek 47
Tennessee Valley Dam 52	Tennessee Valley Dam 52
Tennessee Valley Quarry 57	Tennessee Valley Quarry 57
Field divisions (use at sites)	Planting, container plants
Bolas-Fairfax Road 24	Baker-Barry Tunnel 17
Fill soil (occurrence at sites)	Bolas-Fairfax Road 24
Chaparral Trail Obliteration 31	Chaparral Trail Obliteration 31
Rock Garden 41	Feral Dunes 1
Tennessee Valley Dam 52	Fort Funston Bank Swallow Site 7
Tennessee Valley Quarry 57	Frank Valley Eucalyptus Site 36
Mulch (use at sites)	Muir Woods Fern Creek 47
Bolas-Fairfax Region 24	North Baker Beach 12
Frank Valley Eucalyptus Site 36	Rock Garden 41
Tennessee Valley Quarry 57	Tennessee Valley Dam 52
Natural recolonization of natives (occurrence at sites)	Tennessee Valley Quarry 57
Chaparral Trail Obliteration 31	Quarry site type
Feral Dunes 1	Tennessee Valley Quarry 57
Fort Funston Bankswallow Site 7	Re-creation sites
North Baker Beach 12	Baker-Barry Tunnel 17
Rock Garden 41	Chaparral Trail Obliteration 31
	Feral Dunes 1

Riparian site type	
Frank Valley Eucalyptus Site	36
Muir Woods Fern Creek	47
Tennessee Valley Quarry	57
Salvage plants (use at sites)	
Chaparral Trail Obliteration	31
Muir Woods Fern Creek	47
Seeding (use at sites)	
Baker-Barry Tunnel	17
Bolas-Fairfax Road	24
Feral Dunes	1
Rock Garden	41
Tennessee Valley Dam	52
Tennessee Valley Quarry	57
South district sites	
Feral Dunes	1
Fort Funston Bank Swallow Site	7
North Baker Beach	12
Rock Garden	41
Tree stakes/wands (use at sites)	
Frank Valley Eucalyptus Site	36
Tennessee Valley Dam	52