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Effects of Erosion Control Treatments on Native Plant and Ryegrass Establishment

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Mark Chiaramonte is a college senior at California Polytechnic State University, San Luis Obispo. He majors in Soil Science and minors in Water Science in the College of Agriculture. Mark is a Research Associate for a Caltrans funded project focusing on vegetation establishment and maintenance at a Cal Poly facility. He has worked on the project for over two years and currently leads site operations of the facility. Mark is a graduate of Paso Robles High School and plans on finding a career in soil and water conservation on or near the central coast of California where he has grown up and continued his education through college at Cal Poly, San Luis Obispo.

Misty Scharff

Ms. Misty Scharff has been involved with California State University Sacramento performing research on erosion and sediment control for Caltrans since 2000. Misty was educated in soil science from California Polytechnic State University, San Luis Obispo, where she assisted in numerous erosion control research studies. Misty has been a member of the IECA since 1996.

Brent G. Hallock

Brent G. Hallock, Ph.D., CPSS, and CPESC, is a professor at California Polytechnic State University, San Luis Obispo, since 1979. He teaches an undergraduate course in Soil and Water Conservation, an upper division course in Rangeland Resources, and a graduate course in Soil Erosion and Sediment Control. Brent earned Cal Poly's highest award of Distinguished Teacher in 2000. He has taught over 30 seminars and short courses in site analysis, erosion control, and selection of management measures. Dr. Hallock's research grants with Caltrans, RWQCB, and EPA on the use of vegetation in erosion control and water quality total over two million dollars in the past six years.

Michael Curto

Michael Curto earned a BS in Ecology & Systematic Biology from California Polytechnic State University, San Luis Obispo. His interests and experience center on plant biogeography, ecology, and systematics, especially of Western North American grasses. As a consultant to the Utah Department of Transportation (UDOT), he designed and constructed RoadVeg, their statewide database inventory of roadside vegetation (now a GIS) and performed field inventories of over 2500 miles of Utah roadways.

Abstract:

Disturbed sites characteristically exhibit an encroachment of nonnative plant species and an alteration of native populations due to competition for water, light, and nutrients. The California Department of Transportation (Caltrans) hydroseeds as a standard technique for revegetation of highway construction sites in California. Hydroseeding involves mixing seeds, mulches, and fertilizers and hydraulically spraying the mixtures to disturbed soil banks creating a bed for plant species to germinate and establish. Hydroseeding is less labor intensive and cheaper than alternative methods, though is subject to high failure rates. Seeds have characteristic germination and growth requirements controlled by their unique microclimates; therefore, site-specific preliminary research is important. Over-application of erosion control materials can bury seeds at improper depths decreasing germination potentials. California Polytechnic State University, in conjunction with Caltrans, investigated soil stabilization treatments and burial depth influences on the germination capabilities of seven native District 5 California plant species and annual ryegrass.

Forty-eight 1M by 1M by 0.3 M deep boxes were set up in a 6 X 8 full factorial experiment and filled with 0.16 M (6 inches) of a medium sandy loam (USDA) soil and compacted to 90%. O.1 meters (4 inches) of steam-sterilized soil of the same soil were added to the surface of the nonsterilized soil. Six treatments: gypsum, gypsum and wood fiber, guar tackifier, bonified fiber matrix (BFM), wood fiber, and bare were hydraulically applied to the soil surface. One hundred seeds of 8 plant species (Lotus scoparius, Lupinus succulentus, Artemesia californica, Eriogonum fasciculatum, Escholzia californica, Bromus carinatus, Achillea millefolium, and Lolium multiflorum) were hand planted into each treatment. Seeds were placed at 0.0064 meter (¼-inch) depths for the gypsum, tackifier and bare treatments, while gypsum and wood fiber, wood fiber and BFM were placed at 0.0064 and 0.013 meter (¼ and ½-inch) depths. Climate and watering conditions were kept consistent for all treatments and monitored for 100 days.

Germination percentages were measured. Eriogonum fasciculatum, Artemesia californica, and Lotus scoparius experienced less than 18 % germination for all treatments. Lupinus succulentus experienced less than 13% germination for all treatments. Lolium multiflorum (Ryegrass), with the highest germination rate for all species, had higher tha n 86% germination rates for all treatments. The BFM treatment resulted in the lowest germination percentages. Other methods, such as plugging, may be more suitable for rehabilitating sites depending on plant species and site conditions.

Key Words: Native Vegetation, Erosion Control, Vegetation Establishment, Hydroseeding, and Plant Germination

Marketing Paragraph

Establishing native vegetation through hydroseeding methods may show different germination results under varying erosion control mulches. Native plant species may also have various germination rates among different species. This paper studied the effects of six treatments: gypsum, gypsum and wood fiber, guar tackifier, bonded fiber matrix (BFM), wood fiber, and bare soil on eight plant species Lotus scoparius (Deerweed), Lupinus succulentus (Lupine), Artemesia californica (California Sagebrush), Eriogonum fasciculatum (California Buckwheat), Escholzia californica (California Poppy), Bromus carinatus (Brome), Achillea millefolium (Yarrow), and Lolium multiflorum (Ryegrass) at ¼ and ½ inch depths.

INTRODUCTION

An ecosystem's native plant diversity can never be returned to its original state once anthropogenic disturbances take place, though properly researched rehabilitation may increase success rates. Ecosystems have characteristic disturbance thresholds and once crossed will greatly decrease the resiliency and recovery ability of sites. Engendering scientific research and management is a key component for successful plant reestablishment projects (Friedel, 1991).

Road engineering and development are major contributors to ecosystem alterations and leave harsh conditions for successful site rehabilitation. Disturbed sites are often marked by an increase in exotic weeds and a decrease in native species. Competition for water, light, and nutrients are the likeliest causes for this alteration. The addition of fertilizers has also been shown to increase the population of exotic species over native species (Hamilton et. al, 1999). A native southern California shrub recovery study on one to seventy year old human impacted sites found disturbed sites had 60 % more exotic annual species and undisturbed sites had 68 % of native shrub species. Older sites did not show resiliency in native habitation even after twenty-five years, supporting the theory once disturbance thresholds are crossed they can never be returned to original stable states. Lower amounts of nitrogen and organic matter were found on the majority of disturbed sites analyzed in a study (Stylinski and Allen, 1999). In California, for instance, coastal sagebrush has markedly been reduced since 1945 because of urbanization, recreation, and agriculture expansion (Kirkpatrick and Hutchinson, 1980). Some compaction is necessary for plant establishment, but heavy machinery and constant traffic can destroy soil structure creating lower water holding capacities, alter soil biota populations, and make root penetration difficult (Bouwman and Arts, 2000).

Thus, hydroseeding has become a standard technique for establishing vegetation on large-scale road construction sites and denuded hillsides. This technique involves mixing seeds, mulches, fertilizers,

and emulsion stabilizers then hydraulically spraying the mixture to disturbed soil banks in hopes of controlling erosion, while creating a bed for plant species to germinate and establish (Caltrans, 1999).

Hydroseeding has the advantage of being less labor intensive and allowing for vegetation reestablishment of steep slopes, but is subject to high failure rates due to erosion, drought, temperature extremes, seed predation, and weed competition. All seeds have very different germination and growth requirements controlled by respective microclimates; thus the choice of seed mixes is a primary consideration before beginning a project. Soil stabilizers are applied in hopes of creating suitable beds for seeds to germinate and establish, as well as prevent erosion (Brofas and Varelides, 2000; Bradshaw and Roberts, 1985).

Burial depth influences germination rates of seeds. Seeds can easily be buried too deep or too shallow in the soil. Small seeds are more susceptible to decreased germination the deeper they are in the profile. On the other hand, the more exposed large seeds are to the surface, the more susceptible they are to dehydration than smaller seeds (Forcella et. al, 2000). Over application of erosion control materials may bury seeds at improper burial depths and decrease germination. This project is designed to investigate soil stabilization treatment and burial depth influences on the germination capabilities of several native California plant species and Annual Ryegrass.

MATERIALS and METHODS

Forty-eight pressure treated 1M x 1M x 0.3M wooden soil boxes were constructed and lined with silt fencing material, for soil moisture retention, covering a steel grating. Unsterilized landscaping soil with a medium sandy loam texture was used to fill the boxes 0.16 meters (6 inches) deep. 0.1 meters (4 inches) of steam-sterilized soil was placed on the unsterilized soil. Six treatments and eight seed species were used in the germination study. The soil, seed, mulching, and application rates met standards (Caltrans, 1999). Gypsum (G) applied at 907 kg/Ha (2000 lbs/ac), gypsum and wood fiber (GF) applied at 723 kg/Ha (1600 lbs/acre), guar tackifier (T) applied at 136 kg/Ha (300 lbs/acre), wood fiber (F) applied at 726 kg/Ha (1600 lbs/acre), and bonded fiber matrix (BFM) applied at 726 kg/HA (1600 lbs/acre), were the hydraulically applied treatments with a bare as the sixth treatment. 100 seeds of eight plant species (*Lotus scoparius* (LSB), *Lupinus succulentus* (LS), *Artemesia californica* (AC), *Eriogonum fasciculatum* (EF), *Escholzia californica* EC), *Bromus carinatus* (BC), *Achillea millefolium* (AM), and *Lolium multiflorum* (LM)) were hand planted in each treatment box. In total each treatment received eight plant species. Each box was hand irrigated with ½ liters of water/day except during rainy weather where natural rain was accepted. Observations were taken 100 days after seed planting.

Observations included germinated plant count for each species and the corresponding treatment. Germinated plant count was performed by placing a planting grid over the plants and recording the number of plants in each grid resulting in a germination percentage. The observations were then used in an ANOVA for statistical correlations of treatments and species.

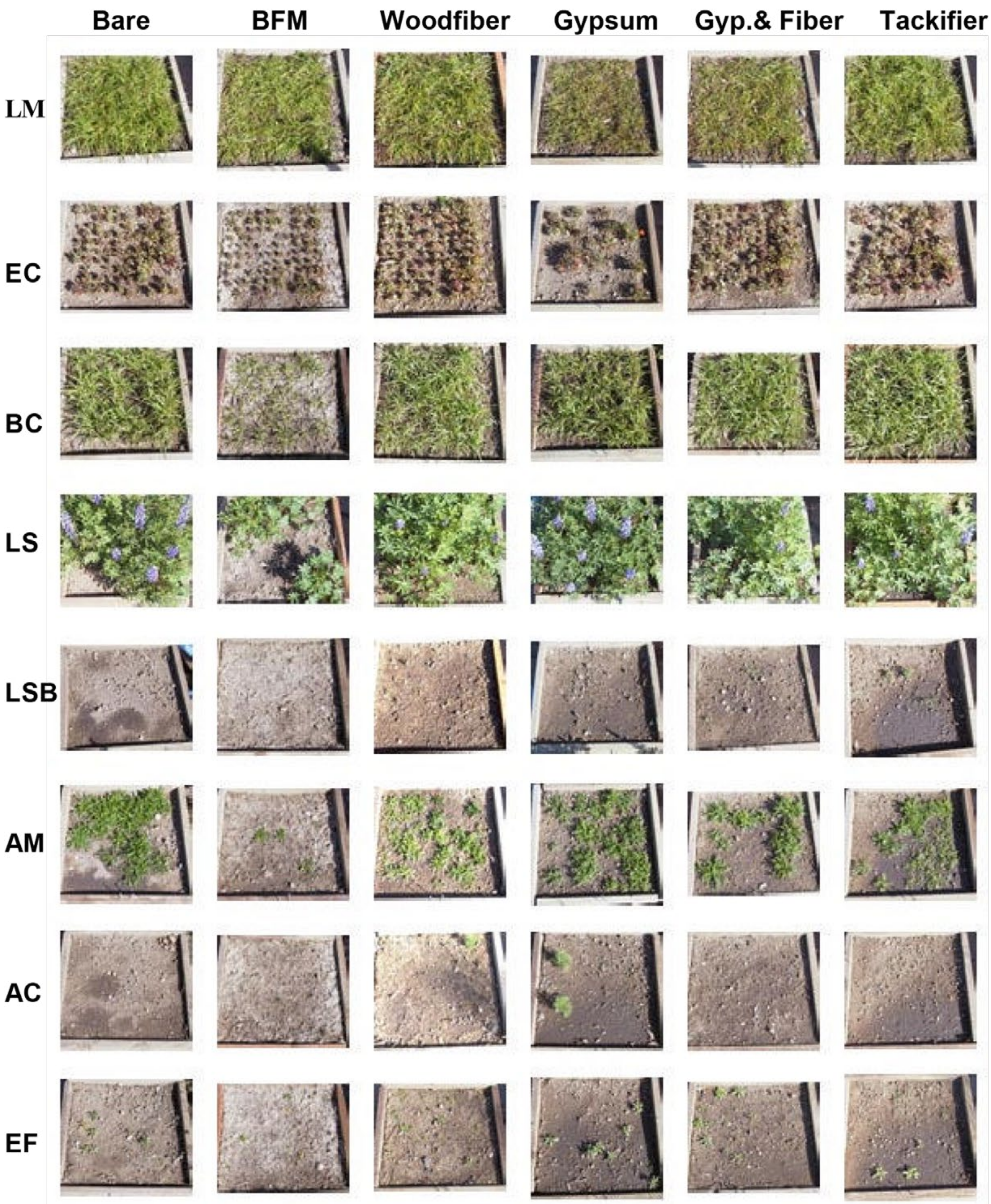
Materials List:

- 2.27M3 (600 gallon) Hydromulcher (Figure 1)
- 4,536 kg (10,000 lbs) landscaping soil
- 48 1M x 1M x 0.3M boxes made of pressure treated wood (Figure2)
- 9.1 kg (20 lbs) gypsum
- 2.3 kg (5 lbs) guar tackifier
- 11.3 kg (25 lbs) bonified fiber matrix (BFM)
- 11.3 kg (25 lbs) wood fiber
- 600 seeds of: *Lotus scoparius* (Deerweed)
  Lupinus succulentus (Lupine)

Artemesia californica (California Sagebrush)
Eriogonum fasciculatum (California Buckwheat)
Escholzia californica (California Poppy)
Bromus carinatus (CaliforniaBrome)
Achillea millefolium (Yarrow)
Lolium multiflorum (Ryegrass)

- 0.51M x 0.51M panel with 0.05 M x 0.05M grid for seed planting
- 2 wooden dowels with 0.0064 and 0.013 meter (¼ and ½ inch) depth markings
- Steam soil sterilizer
- Municipal water supply

Figure 1. 600-gallon hydromulcher used to apply mulch materials.



Species Key

LSB -Lotus scoparius
AC –Artemesia californica
BC -Bromus carinatus
EF –Eriogonum fasciculatum

LS -Lupinus succulentus
EC –Escholzia californica
AM –Achillea millefolium
LM -Lolium multiflorum

Figure 2. Treatment and box layout with the vegetation prior to germination and establishment analysis.

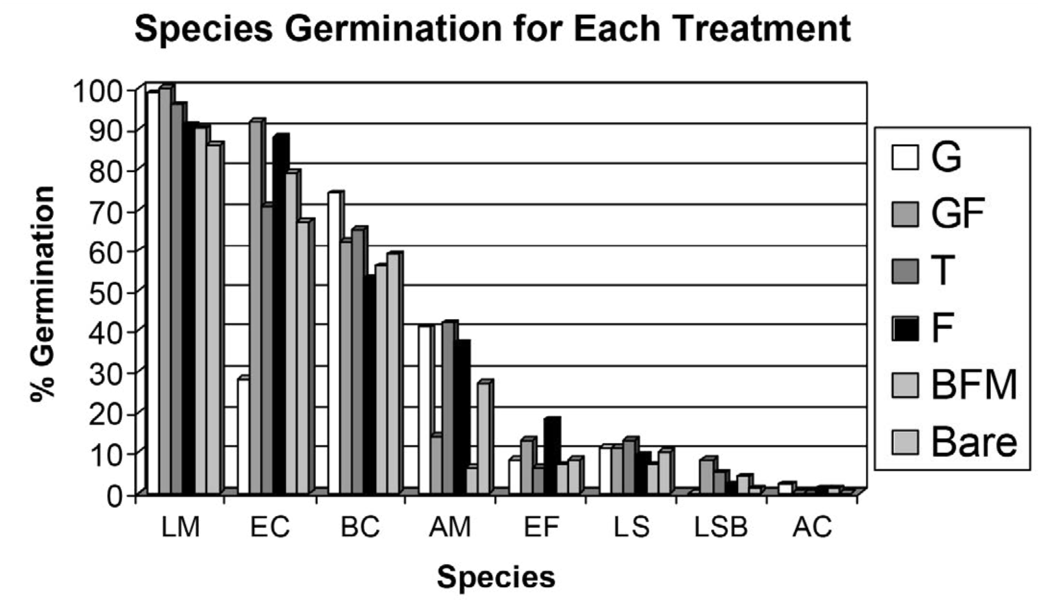


Figure 3. Species germination for each hydraulically applied mulch.

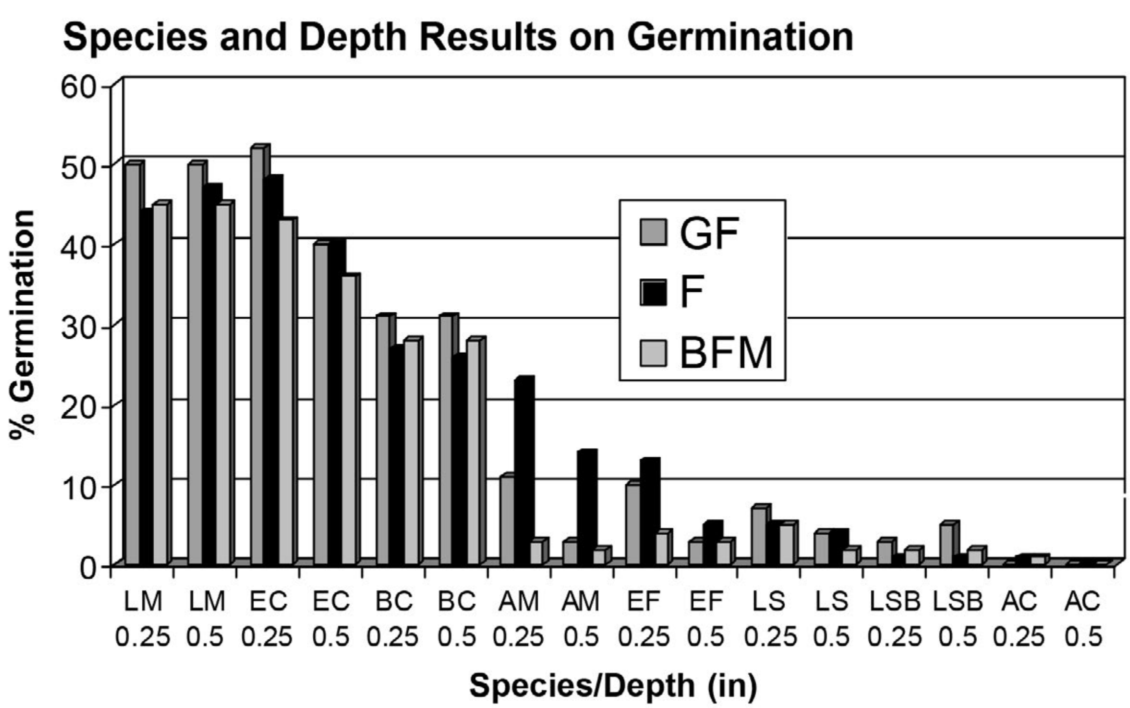


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Figure 4. Species and depth results on germination for 0.0064 and 0.013 meter (0.25 and 0.5 inch) depths on gypsum and fiber, fiber, and bonified fiber matrix only.

DISCUSSION

Soil stabilization treatment and burial depth influences on the germination capabilities of several native California plant species and annual ryegrass were statistically nonsignificant after ANOVA was performed. On the other hand, further statistical analysis of the species and their treatment and or depth interactions revealed a highly significant result. Graphing the results from the germination percentage count show a significant difference between species germination percentage for the treatments (Figure 3). The species, *Lolium multiflorum, Escholzia californica*, and *Bromus carinatus*, maintained a commanding high germination percentage over the shrubs and forbs of *Lotus scoparius, Lupinus succulentus, Artemesia californica, Eriogonum fasciculatum,* and *Achillea millefolium* . Similar results were further shown regardless of the two different depths and treatment type (Figure 4).

The best overall treatment based upon all species and treatments shown in Figure 3 and Figure 4, which resulted in the highest germination percentage, was gypsum and fiber (GF). The depth resulting in the greatest germination percentage was the 0.25-inch burial depth. *Lolium multiflorum* (Ryegrass) maintained between 86 and 100 percent germination for all treatments (Figure 3). *Artemesia californica* (California sagebrush) maintained a germination percentage range of 0 to 2 percent germination for all treatments (Figure 3). Such varying results between species showing grasses and forbs with the highest germination and shrubs and other forbs with the lowest germination.

If these seeds used were to be hydraulically applied together then many interactions would undoubtedly occur. For example, ryegrass has been found to compete with brush seedlings by using large amounts of water. Ryegrass will provide a large density of coverage the first year but in subsequent years density will be greatly reduced and perennials will increase in yield if managed correctly. The perennials are slower in establishment and will not compete with brush seedlings as much as Ryegrass. Brush seedlings planted in dense stands of Ryegrass have not been found with sufficient root depth to reach late summer water depths (Shultz and Biswell, 1952). Deep-rooted shrubs are more likely to prevent erosion and slope failure more than shallow rooted grasses (Shultz and Launchbaugh, 1955). To further enhance shrub usage, a succession from annual exotics to perennial natives was observed over a studied time period on a disturbed field site (Brofas and Varelides, 2000).

In one study, under hydraulic methods, the most successful establishments were on plots only receiving seed and seed plus mulch. Seedling establishment requires the proper mix of moisture and surface sites. The more the seed is buried, the more surface area is exposed for water loss (Bradshaw and Roberts, 1985). Similarly, the results of this project show gypsum and fiber (gypsum and mulch) to be the most successful treatment in establishing seedlings.

From the results of this research, one can expect Ryegrass, California Poppy, and Brome to establish quite well using most hydraulic applications within California's Central Coast conditions. The shrubs and other forbs will be more intolerant of being applied by hydraulic applications of their seeds. Therefore, it is intrinsically better to establish early erosion control with grasses and forbs, and then later introduce shrubs and other forbs as young plants in plugs into the soil months after establishment. The plugs will be able to bypass early shrub/grass competition for water and, thus, increase establishment of the shrubs. Further, diversity of the plant ecosystem will be increased due to increased inhibitive competition of other plant species against invasive species such as Ryegrass (*Lolium multiflorum*).

SEED SPECIES BACKGROUND

Each of the eight plant species used in this experiment were unique in their environmental backgrounds. All were partially or highly drought tolerant, thus, requiring little water. This would be an important consideration as a roadside erosion control using vegetation. The seven California native species can be found in many erosion control seed mixes throughout California. Ryegrass is a non-native invasive and drought tolerant plant species which out competes many native Californian plant species.

Lotus scoparius (Deerweed)

Mixing genetically different varieties of Lotus scoparius can adversely affect the survivability of the indigenous strain (Montalvo et.al., 2001). Deerweed is a perennial with small leaves and yellow flowers. It likes the sun, is drought tolerant, and is found throughout California. It is also commonly used for revegetation in sunny and dry climates. When water is sufficient *Lotus scoparius* will have an equal number of large and small leaves, but under low water conditions the large leafs will abscise. During short photoperiods *Lotus scoparius* is able to resist leaf fall, increasing photosynthesis. The smaller leaves of Lotus scoparius and stomata insensitivity help in moisture retention (Ni lsen et.al., 1981).

Lupinus succulentus (Lupine)

This legume is a very large purple flowering annual plant species. It is used for bank stabilization due to its large root system. Lupine grows in heavy soil, has succulent stems, and is commonly found in the coastal sage scrub areas of the central coast of California (Las Pilitas Nursery, 1995).

*Eriogonum fasciculatum (*California Buckwheat)

California Buckwheat is a hardy drought tolerant plant. These plants are very important for butterflies, and the seeds are used by smaller animals. California Buckwheat propagates in semidisturbed soils naturally (Las Pilitas Nursery, 1995). It also has many adventitious roots (Bradbury, 1978).

Escholzia californica (California Poppy)

California Poppy tolerates sandy dry conditions. The flower is yellow and can tolerate drought stress mildly. Other species will germinate and establish in various wet and dry conditions quite well (Las Pilitas Nursery, 1995).

Artemesia californica (California Sagebrush)

California sagebrush is the most important member of the coastal sage scrub community. California sagebrush is commonly selected for rehabilitation of degraded coastal sage scrub and watersheds, and for improvement of wildlife habitat. A natural colonizer, it is easily established from commercially available seed. It also transplants well. Hydroseeding is the common method of seed application.

California sagebrush has shallow roots, and often fails to develop a seed bank adequate for recruitment of large numbers of seedlings during the first post disturbance-growing season. California sagebrush attains greatest development on the coastal side of mountains. California sagebrush tolerates a wide range in degree of slope, but slopes are most frequently steep. Soil textures supporting California sagebrush include sand, sandy loam, clay, and gravelly clay-loam. It also grows in unconsolidated soils that occur in gravel washes, tallus slopes, and colluvial deposits. Soil parent materials include granite, andesite, shale, sandstone, and mudstone (U.S. Department of Agriculture, 2002).

Achillea Millefolium (Yarrow)

Due to its extensive system of rhizomes, western yarrow is a good soil binder. Western yarrow usually occupies dry, open sites in a variety of habitats across its range including sagebrush. It is intolerant of dense shade. It is common on thin soils and sandy gravelly loam on open flats, parks, and dry meadows. Western yarrow is a pioneer species everywhere it is found. It is usually present in the earliest stages of vegetation development and persists throughout succession (U.S. Department of Agriculture, 2002).

Bromus Carinatus (California Brome)

California brome is useful for revegetating disturbed sites due to rapid establishment and good soil stabilizing capability. California brome is a cool-season perennial bunchgrass. Its roots are deep and wide spreading. Germinative capacity of fresh California brome seed is 85 to 90 percent under laboratory conditions. It is widely reported that seeds require fluctuating temperatures and light to germinate. Seedlings attain height and root biomass rapidly. California brome occurs on mountain slopes, ridge tops, valleys, meadows, and waste places. It is adapted to moderately moist to dry soils, and is most common in areas receiving 16 to 30 inches (410-760 mm) of annual precipitation. California brome grows in all soil textures. It tolerates soils in the pH range of 5.5 to 8.0 (U.S. Department of Agriculture, 2002).

Lolium Multiflorum (Ryegrass)

Ryegrass is a quick, effective groundcover for erosion control and as a winter cover crop. It is often used for temporary erosion control. It tolerates a lower pH limit of 4.5. If seeded together, Ryegrass often out competes the perennials. Ryegrass is an introduced, annual or biennial, cool-season bunchgrass. Roots are shallow when irrigated, which has led to the assumption that Ryegrass has a shallow root system. However, the fine, fibrous root system extends over 3 feet (1 m) deep on non-irrigated sites. Seeds germinate rapidly without pretreatment. Seed dormancy is induced when seeds are buried in cold, wet soil. Ryegrass grows in a wide range of soil types except for excessively drained or very poorly drained soils. It requires medium to high soil fertility in order to persist on a site. Ryegrass is intolerant of hot, dry weather. It can survive short periods of flooding if well established (U.S. Department of Agriculture, 2002).

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