Society for Ecological Restoration, Annual Meeting
POSTER PRESENTATION 1996. RUTGERS, NJ.

Erosion control in a highly disturbed grassland.

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Introduction

Hungry Valley State Vehicle Recreation Area includes a variety of ecosystems with a long history of grazing, farming, and more recently pipeline construction and maintenance and off-highway vehicle operation. Many areas are degraded but some less-disturbed sites remain and are protected, from native grassland to oak woodland. These will provide useful comparative data and sources of seeds for land repair. Park staff are working closely with researchers from San Diego State University to repair past damage and stabilize actively used areas including roads, trails, and hill climbs. Goals of the project are to improve recreational enjoyment and safety, limit erosion, restore ecosystem structure and function, and protect biodiversity.

Vegetation recovery after disturbance is poorly understood and little studied in the Hungry Valley area. While California's dry soils appear lifeless much of the year, living organisms, from bacteria to animals and plants, strongly influence their structure, fertility, and behavior. Small organisms such as ants, bacteria, fungi, micro-arthropods, nematodes, protozoans, termites and yeasts play important roles in these soils and repairing damage must begin with repairing the below ground foundation (Allen, 1988). Many of these little noticed organisms are easily disturbed or eliminated by human activities and their removal can lead to undesirable changes in soil moisture relations, soil fertility, and plant and animal communities.

Farming, grazing, construction activities (pipelines and roads), and off-highway vehicle operation can all degrade soil structure. Changes in soil and vegetation include a wide range of factors including: soil nutrients, soil strength, infiltration, surface roughness, capture and evaporation on leaves, stems and litter, water retention in the soil, surface storage, and water use (Adams et al, 1982; Bainbridge, 1990, 1993; Bainbridge et al., 1993; Bauder et al., 1994; Charley and Cowling, 1968; Eckert et al., 1979). Most of these changes increase runoff, increase peak flows, reduce flood return interval, and increase erosion potential.

Precipitation that falls on a water shed falls on the vegetation, litter, or the bare soil surface. Much of this rainwater will fall on the soil directly, where it may infiltrate into the soil, evaporate, or accumulate when the ability of the soil to take up water (infiltration) falls behind the input rate. Some excess water will be retained in surface depressions as surface storage, but when that is exceeded the water will runoff.

The removal of vegetation reduces infiltration as the plant benefits (stem flow, litter, etc.) are eliminated. Common activities can reduce infiltration and dramatically increase runoff. For a 5 cm rainfall, there may be no runoff on an undisturbed slope, counting in plant and litter capture of water and surface ponding; while on a disturbed slope in the same area more than 4 cm may become runoff. Over a hectare of slope (2.47 acres, a relatively small area) this amounts to more than 100,000 gallons of water from a modest storm.

The perennial bunch grasses once common (in the 1800s) in the area where HVSVRA is located created a complex microtopography that would have large surface storage. The multiple stems of these native grasses would also increase stem infiltration. These grasses, which benefit from fire, probably benefited from the use of fire by the local Tataviam people (Biswell, 1989; Blackburn and Anderson, 1993). The last known Tataviam speaker died in 1916 and little is known of their culture, though yucca root ovens and camps sites have been identified (Luberski, 1980).

Cattle grazing impacted the area beginning in the early 1800s put probably peaking in the mid 1800s, when cattle drives to the north through the pass were common. These drives rivaled the Abilene trail in importance but are little known. This use and overuse continued as settlement and dry farming began (Burcham, 1957; Luberski, 1980). A second peak of settlement occurred in the 1920's and probably represented the greatest extent of dry farming, which proved problematic in the dry and variable environment. As the soil surface and vegetation deteriorated the runoff and peak flows increased, non-native annual grasses replaced perennial natives, and stream flows in the summer declined or vanished.

During intense storms the effects of these changes in infiltration are accentuated. Areas with good plant cover may hold and save much of the rain that falls in intense storms, while areas that have been disturbed experience sheet flow, flash floods, and severe erosion. Damage was at its worse near the turn of the Century with many fields bare from grazing and agriculture. Runoff and vulnerability of the ecosystem was at its peak. This led to the formation of the enormous gully (30-50 feet deep, 100+ feet wide) at the South side of the park in one intense storm in 1907. The first petroleum pipeline was pushed through the area before 1920.

The floras of the Mojave, San Joaquin, Transverse Range, and Sierra Foothills come together at Hungry Valley with a few Great Basin plants. This area would be expected to recover a little faster than the drier Mojave where studies have suggested that without intervention it may take 180 years for reasonable recovery of species diversity on non-compacted soils (Webb et al., 1983).

The goal at Hungry Valley is to develop strategies that will either allow continued use with minimal erosion or work with cyclic use, with periodic rest and rehabilitation.

The twelve step program - An example

The pipeline cut project is representative of the type of work now underway. This project site had experienced overgrazing but was too steep to farm. Pipeline construction altered the soil surface topography and removed all the vegetative cover. Shrubs were replaced with a mustard/annual grass community which does little to retard erosion. Rains led a small gully to develop, probably initially in a vehicle track along the pipeline road, and this rapidly expanded during heavy Spring rains in 1992, when close to 2" inches of rain fell on 3 separate days in February (NOAA, 1992).

1. Survey and diagnosis

The first step was surveying the gully and determining the amount of material that had been removed. This was done using simple field methods figure 1, photo 1. The gully volume was found to exceed 100 cubic meters, about 153,000 kg of soil. The nick point was clear in the survey, and on-site review suggested that the pipeline construction had removed a cross slope ridge that would have reduced erosion risk.

2. Seed collection and plant production

Seeds were collected on site by SDSU staff, park personnel and by Bob Noll, a professional seed collector. At the same time plant identifications and communities were reviewed to suggest most likely candidates for revegetation efforts (Eliason, 1995). Seed lots ranged from a few to many pounds of seed, with major collection efforts directed to the perennial bunchgrasses *Nasella cernua* and *Elymus elymoides* (Jepson). The CDF Seed Lab in Davis cleaned and analyzed the major collections for us, Table 1.

Table 1. Seed data

	Purity after cleaning	Seeds/lb	Germination
Nasella cernua	92.6	160,000	75
Elymus elymoides	90	119,000	69

3. Earth moving

A bulldozer was used to fill the gully. Needed fill material was taken from deposits collected in a sediment basin downstream. The fill operation required the use of a skiploader, dumptruck and the dozer for several days. Soil was wetted periodically during filling to get a solid pack that would resist gully formation. The cross slope ridge was also recreated. Surfaces were left as rough as possible with cross contour lineation if possible.

4. Decompaction

Areas that had been severely compacted and would be seeded or container planted were ripped with the dozer and/or bucket.

5. Fencing

To prevent further vehicle operation on the freshly prepared slope a fence was installed around the site. This fence is a smoothwire fence with wood posts to minimize risk to off-highway vehicle riders.

6. Erosion control

Erosion control structures were placed on the recontoured slope to minimize surface flow velocity and risk of gullying. Three types of structure were used: straw bale dams (set 4-6 inches deep and staked), straw wattles (set 2-3 inches deep and staked), and coir (coconut fiber mesh) erosion fences (set 4-5" deep and staked).

7. Pitting.

The slope was also pitted using McLeods and shovels. Pits were made by crew members working their way down slope and might typically be 1 foot square by 1-2" deep spaced about 1-2 feet apart. These pits provide safe sites for seeds, help trap mulch, and provide increased surface storage for rainfall.

8. Seeding

The site was broadcast seeded on Feb. 1, 1996 with a mix of seeds from the site collection. *Nassella cernua* (1 bag~20 lbs uncleaned seed), buckwheat (~20 lbs), *Lotus scoparius* (~10 lbs) and *Phacelia* (~10 lbs) were applied.

9. Mulching

The site was mulched with a combination of rice straw and native grass straw. Straw was spread relatively thinly, perhaps 15 square yards per bale.

10. Planting

The site was container planted with grasses in February 1996, and a variety of shrubs in April/May 1996. The grasses were grown by both MidValley Growers (mini-plugs), California Dept. of Forestry (plantbands), and SDSU (a mix of plant bands and supercells) (Basinbridge, 1994; Bainbridge et al., 1995a,b). Plants received water on planting and follow-up watering because rainfall this year was limited. Half of the plants initially had treeshelters for protection, but these were removed after 6 weeks. Subsequent plantings include some treeshelter v/s control tests.

11. After care

Plants placed late in the year will be watered occaisonally this summer because spring rainfall was limited.

12. Monitoring

The site will be monitored for at least the following year and the intention is to follow it for at least five and preferably ten years.

Results

The site shows that rehabilitation of even large gullies is possible. Heavy equipment operation quickly increases the cost of work on this type of project. The slope appears very stable and the erosion control materials worked well in this low rainfall intensity year. Plant cover is high, but appears to be predominantly mustards and bromes. The native grasses and shrubs will be more visible in the fall.

The crews preferred the coir fiber erosion fences, which installed quickly and appear effective. Straw wattles were also easy to install but longevity of the plastic mesh is a concern. The straw bale structures may prove useful in a major flow event but were labor intensive and are very visible.

Broadcast seeding was straightforward for the forbs but the *Nasella* is much easier to apply if it is cleaned first. The CDF Seed Lab in Davis cleaned other lots of *Nasella* for us and it was much easier to handle. Studies on relative success have not been done to our knowledge.

The small grass plugs were vulnerable as expected, but low cost may more than offset low survival. They are very easy to plant and handle. The plant band grasses placed in February appear to be doing well. The container plants put out in April are showing greater stress even though soil moisture was still encountered on most sites when these were planted. The delay was occasioned by the usual biological challenge of growing seedlings in the winter for spring planting (Bainbridge, 1994).

Research and monitoring now underway will provide further information on the best strategies for stabilizing slopes and gullies at Hungry Valley and other state parks. Information gathered here will also enable us to develop a hands-on guide for treating similar areas. Some of the techniques used here were first tested at Cuyumaca Rancho State Park in an effort to protect a rare and endangered plant (Bauder et al., 1994) and the process will be a continuous one.

Extensive disturbance for more than 100 years makes revegetation and stabilization challenging. Assessing the nature and magnitude of changes in key factors can improve restoration planning and reduce costs by enabling limited resources to be directed at critical problems. Consider the use history and treat problems rather than symptoms if possible. Stabilizing slopes and gullies will be easier if native vegetation is reestablished in the areas of concern and across entire watersheds.

The most important lesson from these studies is obvious - treat small problems before they become big problems. Indications of erosion potential are usually clear and preventative treatment is much less costly than repair.

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