NATURAL MATERIALS FOR EROSION CONTROL AT POINT LOMA

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Erosion control is essential on disturbed and damaged slopes. Often the only consideration is controlling soil movement, but the influence of the material on native seed establishment, container plant survival, aesthetics, and wildlife may be equally important. A series of natural materials and strategies for erosion control were tested during the winters of 1996-97 and 1997-98 in Southern California. These showed significant differences in effectiveness, response and ease of handling and installation. Several methods including all natural fiber mat materials, erosion control check fences with mulch, and pitting were effective and should be considered more often.

INTRODUCTION

Erosion is much less costly to prevent than it is to repair, because even a small erosion gully may involve many cubic meters of soil that must be collected from the bottom of the slope and replaced at a cost of hundreds or thousands of dollars. Erosion also limits plant establishment and can destroy irrigation systems and installed landscaping. Costs are also transferred to others directly through increased flooding, sedimentation and damage, and sediment also causes serious damage to aquatic and riparian ecosystems. In an attempt to find materials that can provide erosion control, enhance germination of native seeds, control weeds, and not pose harm to wildlife a series of test plots were set up at Point Loma during the winters of 1996-7 and 1997-8. In 1996-7 we evaluated 6 strategies at one site and in 1997-8 we tested ten erosion control methods at 4 sites. These were almost all natural materials without the more common plastic or plastic mesh reinforced materials which have proved to be harmful in many cases by trapping wildlife (especially snakes and lizards, but also birds) and looking ugly as they break down.

These tests have showed that the combination of natural erosion control materials and container planting can be as effective as synthetic materials and provide more aesthetically pleasing results while restoring areas to native habitat. To achieve success with biodegradable erosion control methods, materials should be selected to fit the slope steepness, soil type, weed control method, and anticipated foot traffic. 1997-98 was an El Nino Southern Oscillation year during which San Diego received almost twice the normal rainfall, but results were similar to tests in the dry winter of 1996-97. Materials used ranged from manufactured fiber mats made of straw and coconut fiber, to coir check dams, coir mats, and straw flake dams, and a conventional plastic reinforced excelsior fiber mat. The materials were evaluated for to erosion control, effect on native seed germination, and influence on container plant survival. These studies should provide valuable information to a broad range of professionals including construction managers, restoration managers, landscapers and city planners faced with bare slopes needing erosion control, revegetation and restoration.

MATERIALS AND METHODS

Three sites are located on the Point Loma peninsula in San Diego, California and one is in San Pedro, the Palos Verde site. The vegetation surrounding all four sites is native coastal sage, both disturbed and undisturbed. The FISC tank 76 site is a 30 degree slope on the east side of the Point Loma peninsula facing San Diego Bay. It was cleared, disturbed, and cat-walked after construction. The first experiments were set up on the north section of the slope in Fall 1996. Seven plots 2 meters wide by 20 meters up slope were installed testing (Bonterra), coir (Belton), jute, punched straw, HP90 coir fences 5 meters apart, #2307 coir fences and a control (no erosion control). The plots were separated by wooden fences. All plots were seeded with a native seed mix with local collected seed and container planted. Erosion, germination and establishment, and survival were monitored. Porous plastic bags were placed at the bottom of plots to catch sediment which was then weighed with a spring scale. Percent moisture was calculated to record sediment loss and soil dry weight. Percent germination was measured in the spring.

The second set of experiments included seven 2 meter x 5 meter plots at the same site surrounded by wood frames placed on the south end of the same slope. This experiment tested: jute, coconut fiber fences, coconut fiber fences and mulch, pitting and mulch and a loose weave coir net. Erosion control mats were installed with 15 cm metal staples approximately 1 m apart. 15 cm deep ditches were constructed for installation of coconut fiber fences. Once fences were laid and staked the ditches were back-filled. 30 cm wooden stakes were used to anchor the fences into the ground with the fences tied to the stakes with twine. Each plot was seeded with native coastal sage seed measured to yield 100 live seeds per m^2 and given a light surface mulch of 30 liters of cocoa mulch. Punched straw was installed vertically by using a shovel hand creating a fishscale pattern along the slope

The plots at the Fleet Combat Training Center are located on the west side of the peninsula facing the ocean. One set of experiments consisted of seven 2 m by 5 m plots in a wood frame on a 20 degree

slope with an northern aspect. The following methods were tested: pitting and mulch, heavy planting (13 plants/plot), cocoa mulch, jute netting, Curlex (American Excelsior), coir fences (Bonterra), and no erosion control (control). The jute and Curlex are mats which were installed using metal staples. The plots were seeded with native coastal seed measured to yield 100 live seeds per m^2 and covered with 30 liters of cocoa mulch.

The second set of experiments were on a 40 degree slope south facing slope directly across the road from the first set of experiments. Six test plots 2.4 m wide by 7.6 m long up slope compared jute netting and Curlex, punched straw check dams, and coconut fiber fences. Ditches about 7.5 cm wide and 20 cm deep were dug to install the straw flake check dams. The straw flakes were peeled off bales and placed vertically in the ditches, back-filled, and compacted leaving about 15 cm of straw above ground.

The NRaD site is also located on the west side of the Point Loma Peninsula. Experimental plots were set up on three slopes. Two of the slopes are 40 degrees facing 230 degrees southwest. Seven m wide by 16 m long plots compared jute netting, Curlex, and punched straw. Container planting of coastal sage plants was done in each plot and percent survival was monitored. Because of the large area of the plots, sediment loss was not measured, but observations of sediment build-up at the bottom of the slope and formation of erosion gullies were made. The third slope at NRaD averages 35 degrees and was used to more informally test coconut fiber fences and straw flake check dams. Erosion control materials were installed as above with the following exceptions. Since the soil on the 35 degree slope was softer than other sites the 30 cm wooden stakes had to be replaced with 46 cm wooden stakes. The fences were attached to the stakes using a staple gun rather than twine.

The Palos Verde site is in Los Angeles County with south facing slopes up to 30 percent. Fourteen 2 m x 5 m plots compared jute, coconut fiber fences, Curlex, pitting, mulch, heavy planting (13 plants) and a control (no erosion control). The first 6 plots were replicated twice. The plots were seeded with native coastal sage seed to yield 100 live seeds per square meter and covered with 30 liters of cocoa mulch per plot. Sediment loss was weighed and dry weight calculated. Punched straw and jute netting were also placed on additional areas of the slope for informal tests.

RESULTS

Germination of seeds during 1996-7 was monitored in Spring, establishment and cover are shown in Table 1.

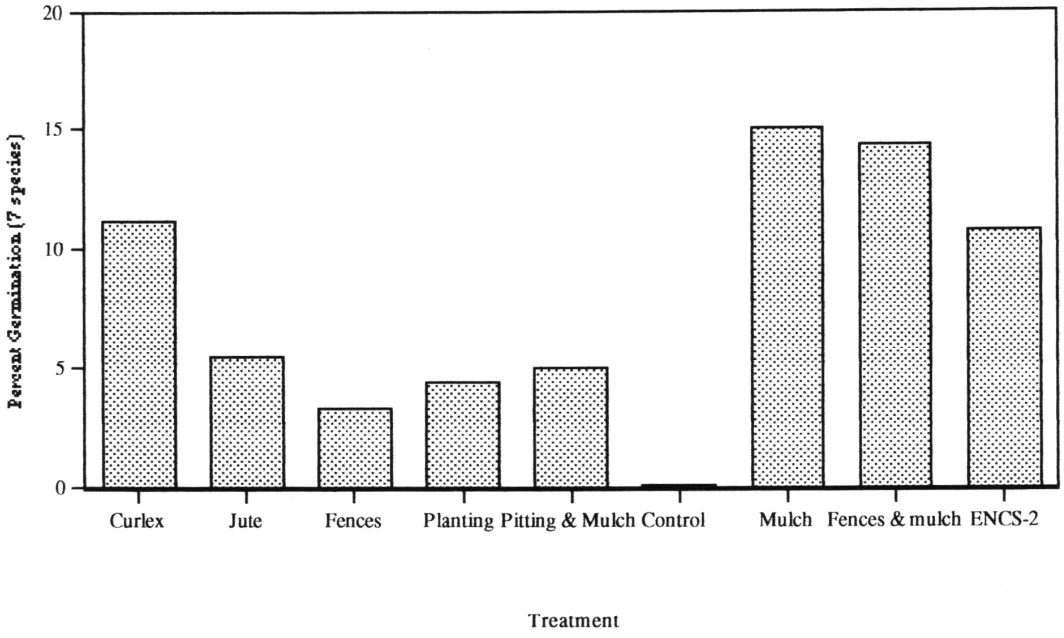
Table 1. Seedling establishment

	Percent cover	Plants per m^2
punched straw	48	3.7
EncS2 straw/coir	23	2.6
jute	37	2.4
Coir mat fence	30	1.9
Coir net fence	27	1.7
coir mat	24	1.4
control	17	0.5
Informal plots		
coir fences and straw	14	0.6
pits+mulch	6	0.8
swales+mulch	1	0.2

The percent germination of native plants from seed during 1997-8 was measured at FCTCP and FISC and the combined results for each erosion control treatment are shown in Figure 1. The erosion control material yielding the highest percent germination was the cocoa mulch alone and the cocoa mulch in combination with fences. The Curlex and jute netting also did well resulting in over 10% germination. The

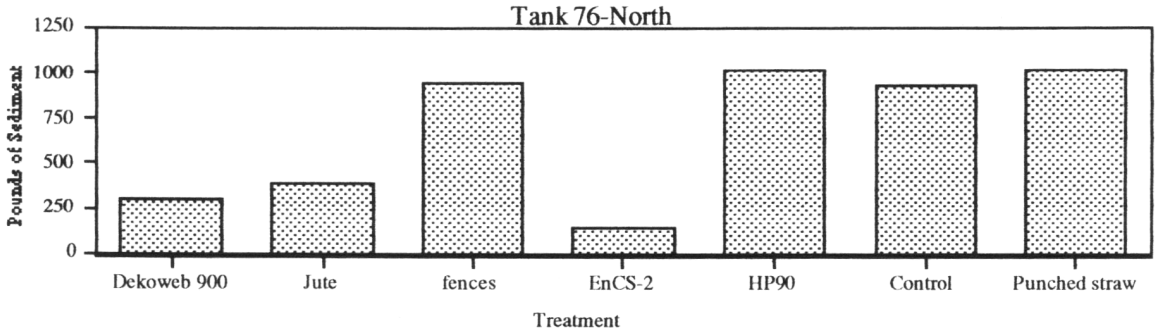
Palos Verdes plots were not included because there was very little germination, probably because of poor seed quality (it also had to be local ecotypes).

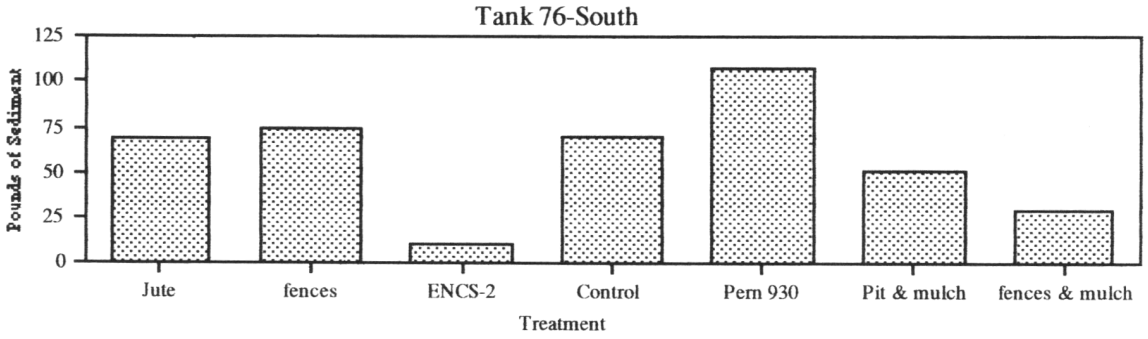
Figure 1. Percent germination of coastal sage seeds on plots at FCTCP and FISC (seeding rate100 live seeds per m^2)

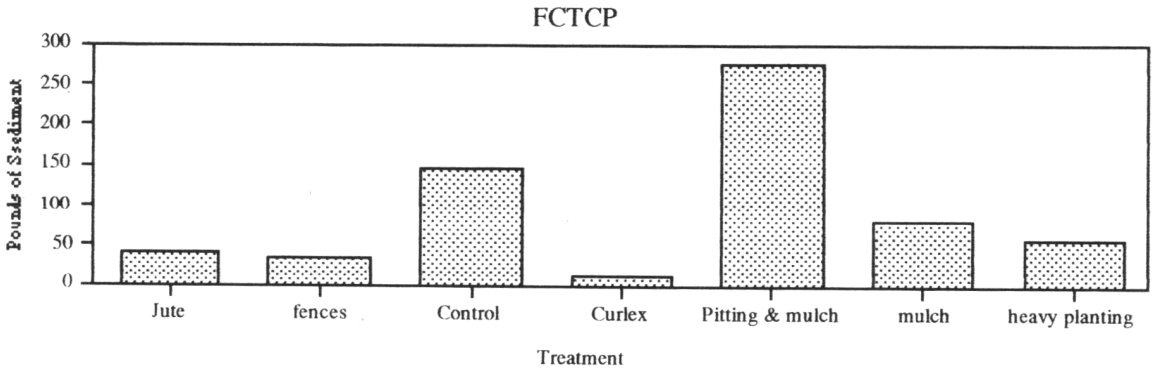


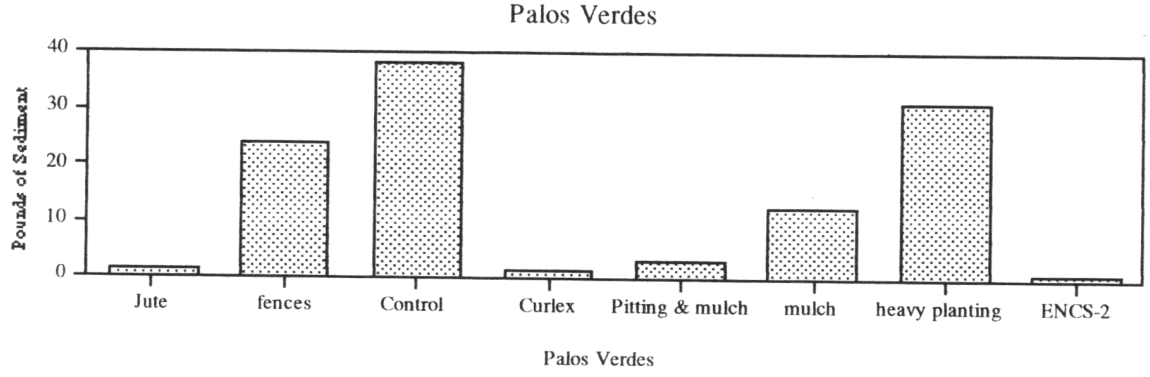
The erosion control measurements in 1996-7 were made after each significant storm. These storms were well spaced and easy to monitor. In the following season erosion sediment measurements were taken on Point Loma from December 1997 through April 1998, 36 cm of rain. The Palos Verdes erosion sediment measurements were taken from February 1998 through May 1998, 30 cm of rain. The total pounds of sediment loss in each treatment at the four sites measured is shown in Figure 2. The plots with the least erosion were the Encs2 and the Curlex.

Figure 2. Sediment loss per plot with each erosion control treatment



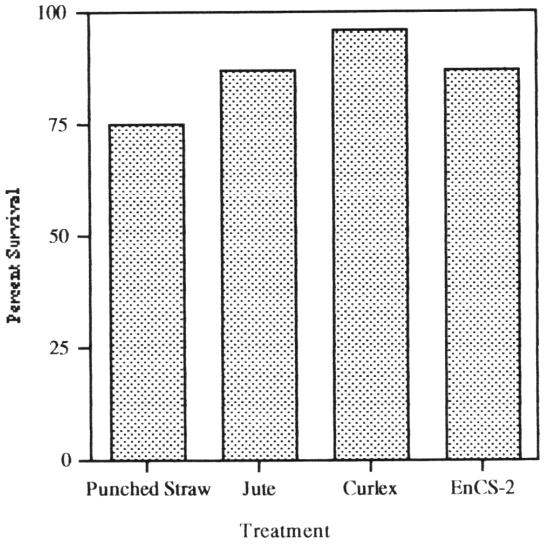






Container seedlings survival for plants at NRaD and FCTCP were combined for each treatment. The highest percent survival was with the Curlex matting, while the lowest was in the punched straw , but survival was good for all erosion control treatments, figure 3.

Figure 3. Percent survival of container planted seedlings observed at NRaD and FCTCP sites.



DISCUSSION

Several of these fully biodegradable methods were very effective in both seasons. The most effective materials for erosion control appeared to be the coir and Encs2 mats. Jute netting does well for its relatively low cost, but it is not as stable or easy to install. The Encs2 coir/straw mat material provided very effective erosion control and good seed germination and plant survival. These are made of completely natural, biodegradable materials, and can be generally recommended for areas where little or no foot traffic is expected. They should also be used whenever lizard or snake populations are present.

The Curlex mats were also effective but include plastic reinforcing net. The Curlex netting had the best plant survival of all and the best germination among the mats. These results may reflect the greater thickness of the Curlex and better light penetration than with Encs2. However, the green plastic photodegradable netting that holds the material together made it difficult to walk on while planting and in other areas created an unsightly mess. Although problems with bird and reptile entrapment using plastic materials are not uncommon, none were observed at these sites, perhaps because the top layer of plastic netting was removed from some test areas (effectiveness or durability was not noticeably reduced) and reptile populations are low. These could perhaps be reformulated with a jute, hemp, or coir net, but until that is done they should only be used on sites without lizard and snake populations.

Jute netting provides tolerable erosion control and is economical. Jute netting is more difficult to install than the rigid mats, and can be irritating to the skin. It was the easiest material to walk on for planting and installing irrigation systems. The coir fiber erosion control fences worked well in some cases, but spacing should be closer than manufacturers recommend and it must be carefully installed. The net should be stapled to the stakes used to hold the net in place, back-filled and compacted. Long stakes should be used on soft sandy slopes. Combining cocoa mulch with these fences cut erosion in half and

some form of mulch should generally be used with these erosion fences. Mulch alone was more effective than erosion control fences at one site. The cocoa mulch appeared to improve native seed germination and has the advantage of not having any weed seeds which may survive composting operations. This material was heavy enough to keep the seeds from blowing away and retained moisture, but readily allowed the seedlings to grow. The new seedlings were noticeably clustered in patches of mulch. Pitting and mulch showed very variable results depending on the soil conditions and slope. At the Tank 76 south site pitting and mulch controlled erosion better than jute netting. At the FCTCP site pitting appeared to disrupt the soil and created more erosion than the control.

CONCLUSIONS

The method of erosion control that is best for a given site will depend upon the slope steepness, soil texture, revegetation or restoration goals, wildlife (especially lizards and snakes), aesthetic requirements, future use, budget, and installation team. In general, the natural fiber mats appeared to be the most effective on long (greater than 8 m) steep slopes. The mats helped control exotic weed better than other methods. The Encs2 coir/straw mat is a good all around choice. Encs2 provided excellent seed germination and plant survival with better weed control than jute, but was more sensitive to damage from foot traffic. The Curlex netting provided the best combination of erosion control, seed germination and plant survival, but did entail the problems inherent in using plastic reinforcing netting. It would be good to have it available in a natural fiber net reinforced form.

The erosion control fences provide some erosion control, but they must be closely spaced on steep slopes, carefully installed, and combined with mulch. It is desirable to use much closer spacing than manufacturers recommend. Erosion control fences and mulch can also improve plant germination. This may be one of the best options for less steep slopes. These fences are less costly than the matting and can be installed quickly in some soil types. The key is to cut a narrow slot to install the fence and to stake it carefully, stapling the fence to each post to prevent sagging and compacting backfill to prevent undercutting.

Mulch alone or pitting and mulch can work well on shallow slopes or small pockets of disturbed soil where sheet flow is not expected. Dense planting alone is suitable on some sites. This might be more effective with grasses than with shrubs. The roots of container plants also help stabilize slopes. Straw flake check dams are inexpensive and recommended for areas which are narrow and may have substantial water flow, such as old dirt roads. These dams are inexpensive and easy to install. A 7.5-10 cm wide slot 15-25 cm deep is cut across the slope and then flakes of a straw bale 5-10 cm thick are placed in the trench. The soil is then back-filled and compacted around the vertical straw fence. Weed free straw or rice straw, which persists longer thanks to high silica content, is recommended to reduce the risk of introduction of exotic species.

These natural fiber erosion control methods should all be more widely used. Although the installation cost may be higher than conventional plastic silt fences or hydromulching the net benefits of seed establishment and improved plant survival provide a much better life cycle return. At the NRaD site an adjacent site was hydroseeded, this site experienced substantial erosion and is now dominated by exotic weeds. It will have to be retreated at substantial cost. The goal is to install materials that control erosion, encourage germination of native seeds, improve survival of container plants, reduce weed development, and look good without endangering animals, lizards, snakes and birds.

ACKNOWLEDGEMENTS

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PROCEEDINGS

1st REGIONAL CONFERENCE ON EROSION AND SEDIMENT CONTROL

April 8-9, 1999
San Diego, California

WESTERN CHAPTER
INTERNATIONAL EROSION CONTROL ASSOCIATION