

Native Grass Sod: An Innovative Tool for Reducing Erosion Along Highways: Introduction

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Abstract—The objective of this part of this study was to evaluate a number of native species and reinforcement materials for their suitability for contributing to a harvestable multispecies sod for roadside rehabilitation. This experiment began with an investigation of the basic characteristics of three native grass sods produced by three different commercial farms. While successfully grown in relative small, controlled experimental settings, it was critical to establish the characteristics of these sods when produced at the larger scale necessary for their practical use on highway projects. Tests indicated weedy grass species were present in the highway soil seed bank, and slow development of seeded native grass species provided ample time for invasive species to propagate from the seed bank.

Index Terms—multispecies sod, native sod, percent cover, population dynamics, revegetation practices, turf.

I. INTRODUCTION

Disturbed lands associated with recently completed highway construction can be extremely erosive sources of sediment in water resources. To prevent sediment displacement during runoff events that can impair streams, wetlands, and water quality, surface stabilization is essential on land adjacent to highways, particularly land associated with steep slopes and water conveyance features.

Biological methods of erosion control that establish a protective vegetation cover not only reduce sediment yield and runoff but also enhance the aesthetic values of an area. Numerous methods have been tested for native grass species establishment on highway project sites including broadcast seeding, drill seeding, combinations of broadcast and drill seeding, hydroseeding with mulch, and erosion control blankets impregnated with seed. Common to these methods is that plant establishment and root development that helps to hold the soil together and prevent erosion is slow. Thus soil erosion control may not be effective for many years or never if early erosion reverses the control itself.

During the initial stages of native plant establishment from seed, there is an abundance of bare soil. The bare soil provides potential sites for not only the sown native species but also the non-native weedy species. Many weed species are annuals with high growth rates and seed production, thus are able to exploit the environment more rapidly than the generally slower growing perennials. If weed species become established they

may further jeopardize establishment and growth of native grass species due to their above ground dominance and reduction in the number of safe sites for germination.

The presence of weeds means that considerable resources have to be spent to control them. In many counties, herbicides are the primary management control option, and large quantities of money are spent on an annual basis. Many Californians are concerned about the increasing use of herbicides to reduce noxious and other non-native plant species on highway sites. While selective herbicides can be used to target specific weeds, they often have an injury impact on some of the native species which reduces their productivity.

The use of native grass sod can reduce the risk of non-native weeds because it is placed on top of the soil or geological material and because weed seeds in the seed bank will be buried five centimeters or more. In addition, the native species are well established in the sod, therefore, have a competitive advantage over any weed seeds that do germinate and establish through the reinforced sod layer. Reinforced sod should consolidate the soil more immediately than broadcast seed application approaches, thus reducing soil erosion, and improving water quality. Furthermore, because the native species are adapted to the local environment, once established they should require minimal maintenance and should continue to grow and spread into adjacent areas which were not laid with sod. The growth habit and maximum height of most of the native species means that they should not obstruct the view of highway drivers and that neither mowing nor supplemental water would be required.

With the methods that are currently in place, large amounts of money are being spent trying to resolve the problems associated with highway construction. Using native grass sod is more expensive in the short term, but can reduce maintenance, herbicide and water treatment costs, thus may be more cost-effective in the long term. If sod composed of grass species native to the area of interest can be commercially produced and harvested, native multispecies sod could become another tool for rehabilitation efforts. Such sod could be particularly useful for sensitive areas found along roadsides, including those areas near streams, areas prone to high erosion rates (such as steep slopes), and areas where the rapid establishment of non-native species reduces the establishment success of native species planted by other methods.

II. EVALUATION OF CALIFORNIA NATIVE GRASS SPECIES FOR SOD DEVELOPMENT

Reclamation of disturbed highway areas using native grasses can be considered the best method of reducing erosion without harming native ecosystems. It is anticipated that the use of native grass sod will facilitate quick vegetation establishment and soil reinforcement, reduce the risk of non-native weeds and fire hazards, and thus reduce the use of herbicides, pesticides and fertilizers. In addition, the native grass sod is expected to minimize the amount of mowing and supplemental irrigation needed for the vegetation management. The use of native grass sod can also help Caltrans meet requirements of the Clean Water Act.

Although species do not perform equally in terms of percent cover and biomass production, seeding as many species as possible should aid in the diversity of sod. When grown for seven months (essentially the establishment phase for sod production in California), there appeared to be no difference in establishment success of mixtures that contained four to seven species as indicated by total ground cover. Accordingly, as long as a species does not fail to establish or disappear over the course of sod production, they should be included in the initial mix to ensure ecological versatility and overall diversity in the native rehabilitation sod. This study has demonstrated the capacity for producing native multispecies sod and its potential for use as a rehabilitation tool in these six ecoregions. The methods and results of this study could also be expanded in order to produce native multispecies sod for use in other geographical areas.

Native grass seed at this juncture can be prohibitively expensive. In the initial experiment, multispecies sod growth efforts produced some sods with adequate sod strength. For the Pacific Forest region, the standard 500 PLS/ft² should be adequate. For all other ecoregions, a higher seeding rate should be considered. Due to sod production issues, the sod was not grown for the three ecoregions per request of Caltrans. Research emphasis shifted from this set of experiments to the next phase, Establishment Success and Weed Suppression Potential of Multispecies Sod.

III. ESTABLISHMENT SUCCESS AND WEED SUPPRESSION POTENTIAL OF MULTISPECIES SOD

Field experiments were conducted to assess the potential of multispecies sod to suppress weeds of different density and with different reinforcement materials over a two year period. Two distinct series of trials were performed. Plots sodded without reinforcement materials were used to assess suppression of weeds sown at six densities (the "A" trials). Reinforcement materials are often required to transport harvest sod. The effect of this material on weed suppression was assessed (the "B" trials). Both experiments were conducted from 2006 to 2008 at Montana State University. In both experiments the surrogate weed, canola (*Brassica napus*), was sown either below the sod to represent the existing weed seed bank or into the sod from above to represent weed seed rain. In the second year seed was sown from above only. All

experiments were subjected to five different water regimes including a no irrigation/natural precipitation only regime. The initial trials (A₁ and B₁) were conducted for two years, 2006-2007. Identical trials (A₂ and B₂) were then started in adjacent plots in 2007 and were also conducted for two years, 2007-2008. This design enables two years of first-year data and two years of second-year data to be collected and compared within and between years so that the experiments are replicated in both time and space.

In general these experiments provide evidence that emergence of canola is low when sown as seed rain or seed bank with multispecies sod and is significantly ($p < 0.001$) lower the second year after sod is laid. Experiment B results indicate the reinforcement materials did significantly ($p < 0.05$) further decreased canola emergence in experiment B₂ (2007). Of the emerged seedlings survival to maturation, and the vegetative and seed biomass of these plants was significantly affected by water regime for both the A and B experiments. In contrast in the reinforcement (B) experiments water regime did not affect survival but the presence of the material increased the proportion of surviving plants.

These experiments indicated that multispecies sod could be used as an alternative roadside revegetation technique. It established and survived without supplemental water and reduces weed emergence and survival.

IV. HIGHWAY RECLAMATION USING NATIVE GRASS SOD FOR SEDIMENT CONTROL AND AESTHETIC ENHANCEMENT

A field experiment was conducted using native grass sod to revegetate a disturbed area along a California highway at a location just south of Sacramento. This experiment began with an investigation of the basic characteristics of three native grass sods produced by three different commercial farms. While successfully grown in relative small, controlled experimental settings, it was critical to establish the characteristics of these sods when produced at the larger scale necessary for their practical use on highway projects. The commercially grown sods were evaluated with respect to species abundance, canopy coverage, and weed emergence. Based on the results of this investigation, two of these native grass sods were subsequently transplanted to the field test site, where their performance was evaluated over a 20 month period relative to a control section that used Caltrans standard hydroseeding practice.

The purpose of this research was to develop and demonstrate native grass sod potentially suitable for control of sediment loss from land disturbances associated with the California highway system.

Two types of native grass sod were developed at two different nurseries in the California Grassland Ecoregion near Sacramento. The first, MSU Native Grass Sod-Hedgerow, was composed of five species: creeping wildrye, purple needlegrass, Sandberg's bluegrass, California meadow barley, and squirrel tail. The second, MSU Native Grass Sod-Delta, was developed 18 months after the Hedgerow sod and was composed of two species common to the Hedgerow mix,

purple needlegrass and California meadow barley and two new species California brome and red fescue.

A. Native Grass Sod Propagation and Harvest

Two months after seeding, the MSU Native Grass Sod-Hedgerow had fair seedling density (2418 tillers/m²), low canopy cover, and some weedy forbs were present indicating site preparation procedures failed to kill all undesired species in the soil seed bank beneath the sod. After six months of growth, seeded native grass species composed 80% of the canopy cover while bare ground and weedy species (5%) composed the remainder. When harvested one year after seeding, the root binding ability was poor and the sod could not be rolled for transport. Broken half meter square slabs of sod were placed on boards for transport and the sod was reassembled at the highway test plot area.

Ten weeks after seeding, the MSU Native Grass Sod-Delta had very high grass seedling density (7,200 tillers/m²), a 90% canopy cover, and no weed species were present. Prior to seeding, soil in the propagation area was fumigated with methyl bromide and covered with plastic for five days to kill weedy species in the soil seed bank. Fumigation was a key step to insure weedy species do not grow into seeded native grass sod. Five months after seeding, a test cut of the sod indicated excellent root binding ability and the sod rolled easily. When harvested eight months after seeding, use of conventional sod cutting, rolling and transport equipment was successful. At the highway test plot area, sod was unrolled with no breakage and no bare ground was exposed between sod seams on the steep slope and drainage swale.

B. Highway Demonstration Area

Native grass sod was transplanted to a highway steep slope, 41% gradient, and drainage swale area located south of Sacramento, California.

As a control treatment, the standard Caltrans Hydroseed-mulch treatment was implemented with Spanish clover, blue wildrye, meadow barley, tidy tips, creeping wildrye, and purple needlegrass.

Sod and hydroseed-mulch treatments were replicated on the steep slope and drainage swale area.

C. Vegetation Growth Traits at the Highway Demonstration Area

Eighteen months after implementing the Caltrans Hydroseed-mulch treatment, invasive weedy grasses had greater canopy cover, density and biomass compared to seeded species. Tidy tips, the seeded forb, dominated the canopy cover. Tests indicated weedy grass species were present in the highway soil seed bank, and slow development of seeded native grass species provided ample time for invasive species to propagate from the seed bank.

For the MSU Native Grass Sod-Hedgerow, canopy cover, density and biomass for invasive non-native grasses was greater than for sod grass species on the steep slope. In the drainage swale, the abundance of native grass species and non-native species was similar. Since this sod had to be harvested in broken slab-like pieces as opposed to conventional rolls, the

sod could not be tightly butted across the soil surface. Bare soil surface between sod pieces provided opportunity for weedy grasses to develop from the soil seed bank. Tests also indicated the transplanted sod contained one or more weedy grass and forb species from the original nursery propagation area. This result indicates a native grass sod species mix must be one that develops a strong-contiguous root mat, enabling harvest of large-as-possible sod rolls, and provides a dense root-grass mat at the transplant location that will preclude weedy species propagation from the soil seed bank.

Three months after transplanting the MSU Native Grass Sod-Delta, approximately 93% of the canopy cover and 96% of the plant density was native grass. The sod very effectively resisted weed invasion from the underlying soil seed bank. On both the drainage swale and steep slope, the dominant native grass in the sod was California meadow barley. Supplemental sprinkler irrigation likely contributed to the dominance of California meadow barley which can prevail over other grass species in moist soils. On California highway projects, in the absence of irrigation, purple needlegrass is often the dominant grass species on steep slopes. It is possible that after sprinkler irrigation is terminated, California meadow barley may die back and purple needlegrass may develop as the dominant grass species on the steep slope area. No bare ground was present. Absence of bare ground serves to resist invasion of weedy grass and forb species and decrease sediment loss during storm water runoff. No weedy forb species invaded the native grass sod. Propagation, transplanting, and plant growth traits of the MSU Native Grass Sod-Delta was a complete success as of August 2008.

D. Sediment Loss from Sod and Hydroseeded Areas

Using the RUSLE2 sediment loss model, it was determined the freshly tilled steep slope (41% gradient) sediment loss rate was 155 tons/hectare/year, while the drainage swale loss rate was 15-18 tons/hectare/year. This result indicated freshly tilled slopes are highly erosive and should receive mulch or sod as soon as possible following highway construction.

When no plant cover was present, application of straw hydromulch decreased the sediment loss rate to 1-2 tons/hectare/year in the drainage swale, and to 17 tons/hectare/year on the steep slope.

Eighteen months after hydroseeding, the plant cover composed of native and non-native species had a 0.9 tons/hectare/year sediment loss rate in the drainage swale and 4.4 tons/hectare/year on the steep slope.

In comparison, the MSU Native Grass Sod-Delta had a near zero sediment loss rate (steep slope 0.6 and drainage swale 0.1 tons/hectare/year) beginning the day of sod installation, and three months after installation the site was almost entirely composed of desired native grass species.

V. CONCLUSIONS

These results have several important implications for practice including:

Native grass sod mixtures can mimic the diversity of native ecosystems while providing a method for rapid rehabilitation and restoration.

Mixtures of native grass species can be grown together and harvested as sod.

Native grass sod provides immediate soil surface stabilization and plant cover and can be used in areas where rapid rehabilitation is required.

Theoretically, native grass sod for restoration should be composed of many species. However, native grass seed availability is limited. As demand for native grass seed increases, more consistent sources of quality native seed will be required.

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