Post-Fire Seeding & Mitigation on the Butte Fire

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Introduction and Overview

Since 2002, the use of seed in post-fire mitigation projects in California has been confined almost exclusively to state highway and county roads, Federal Emergency Management Agency (FEMA), and other private reseeding efforts. These agencies have found specific situations where seeding and mulching offers appreciable value for the protection of property and reduction of on-site erosion. The reasons stated for not utilizing seed for large-scale fire rehabilitation in the State of California are those usually sited in the 1995 position paper from the California Native Plant Society (CNPS). In the "Seeding After Wildfires" statement of policy, CNPS concludes that: 1) Seeding is not a reliable method of reducing post-fire erosion. 2) Natural vegetative recovery can be compromised by artificial seeding. They enumerate several additional concerns, including:

- Non-local native types may contaminate local gene pools
- Lack of available, adequate, and appropriate seed supply to meet scalable incidents
- Seeding may disrupt small-scale ecological patterns, and
- Artificial seeding with any species is not likely to produce significantly better results than allowing natural vegetative recovery

The use of native seeding following catastrophic fire has been lightly studied. A considerable portion of post-fire rehabilitation literature does not address seeding in general, or as a means to effectively control erosion following fire. Of 1,164 USDA Forest Service Burn Area Reports available in 2011, only 380 contained any information on seeding treatments (Peppin *et al.* 2011). Peppin *et al.* 2011, states that quantitative data and information on overall seeding trends are lacking.

While long-term detailed analysis of plant community regeneration is not yet available for the Butte Fire area, this study provides some preliminary evidence on the effects of native seeding on species diversity and plant community recovery. This study examines the quantitative differences between immediate and delayed seeding and mulching in terms of vegetative cover, plant productivity (residual dry matter =RDM), and soil loss over a two-year period. This information in combination with the developments in the California and national native seed programs invites agencies and practitioners to revisit the questions and concerns of reseeding after fires.

Butte Fire in Perspective

On the afternoon of September 9, 2015, a rapidly moving wildfire began in Amador County, California. Known as the Butte Fire, it spread into and across 14,500 acres in Calaveras County during the first 12 hours. By Day 2, the fire had more than doubled in size as it rapidly spread southward. When the fire was finally extinguished on October 1, 2015, 70,868 acres had burned. At its peak, nearly 5,000 firefighters battled the blaze. Resources included 519 fire engines, 18 helicopters, 8 air tankers, 92 hand crews, 115 bulldozers, and 60 water tenders, according to Cal Fire (Branan 2016). In the aftermath, 475 residences and 343 outbuildings were destroyed, 45 structures were damaged, and 2 people lost their lives.

Recognizing the potential — during the rainy season that would follow the fire — for extensive post-fire erosion and catastrophic sediment-loading to waterways and reservoirs downstream of the fire, East Bay Municipal Utility District (EBMUD) staff moved to address potential erosion and consequent water quality issues in severely burned areas of the Mokelumne River Watershed. EBMUD is a large municipal water utility, offering potable water service to 1.3 million customers in the greater Oakland, California, area. EBMUD elected to fund and facilitate a $330,000 emergency remediation project to install various sediment and erosion control measures that would reduce soil erosion and related impacts from severely burned areas. Treatments included hand-applied native seed, mechanically and hand-applied weed-free rice straw, and late season (winter) aerially applied wood chip mulch.

Selection of Erosion and Sediment Control Measures

Control measures that were selected were based on product availability, effectiveness, cost, and the ability to implement application strategies with available resources. The following materials and methods were adopted:

Native Seed Mixes

Native seed mixtures were developed from local regional seed collections from within Calaveras County and surrounding counties. All species selected/used were of California origin and native to the region. Individual species, composition, and the rate of application changed slightly between erosion control treatments in Table 1.

Rice Straw

Rice straw was noxious-weed-free and hand-applied to the burned area shortly after the fire was extinguished (Fall 2015) by EBMUD staff with support from the California Conservation Corp (CCC) and state crews The estimated mulching rate was 3,250–3,620 pounds/acre. Approximately 36 acres were treated using rice straw. Once seeded, the rice straw treatment was identified as SS = Seeded Straw treatments.

Wood Chips

Initially, 28 acres were seeded and then wood chips were applied aerially directly to the charred soil surface at an estimated rate of 4,000

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Table 1. Seed Mixtures

Species	% Species Composition Fall Mix[1]	% Species Composition Winter Mix[2]
California brome (*Bromus carinatus*)	46.3	53.3
Blue wildrye (*Elymus glaucus*)	18.5	20.0
Pacific fescue (*Festuca microstachys*)	11.1	13.3
Tomcat clover (*Trifolium willdenovii*)	7.4	8.9
Purple needlegrass (*Stipa pulchra*)	8.3	4.5
Sky lupine (*Lupinus nanus*)	4.2	0
Western yarrow (*Achillea millifolium* var. *occidentalis)*	4.2	0
Total	100.0	100.0

[1]Seed applied at a rate of 13.0–15.0 lbs/acre on October 25, 2015 under the rice straw mulch treatment

[2]Seed applied at a rate of 20.0–22.0 lbs/acre on January 26, 2016 under wood chip mulch treatment

pounds/acre. Wood chip treatments were applied several months following the fire (winter) and coordinated with the BLM. A total of 900 acres were treated within the Upper Mokelumne watershed using wood chips. Once seeded, the wood chip treatment was identified as SW = Seeded Wood treatments.

Following seeding and erosion control materials installation (rice straw and wood chips), an independent study was initiated to evaluate the performance of erosion control measures in relation to the timing of material installation. Vegetation measurements included canopy cover and herbaceous production. Vegetation cover focused on plant establishment from seeded species and from natural regeneration onsite. To further value the performance of treatment strategies, soil erosion rates were calculated using the Revised Universal Soil Loss Equation (RUSLE2) to estimate soil loss in tons/acre/year for each treatment. Sites were visited periodically to review conditions and vegetation establishment over the following two years.

In the Butte Fire study, it appears timely precipitation following seeding is beneficial to initiate seed germination and plant establishment. The straw treated areas were seeded on October 25, 2015, just before a series of moderate rain events totaling 12.83 inches through January 25, 2016. The seeding associated with the wood chip treatments was initiated on January 27, 2016, and planted on rain-compacted and somewhat eroded surface soils. The January seeding and wood chip treatment was followed promptly by 1.16 inch of precipitation and additional rain events totaling 9.45 inches through April 22, 2016. As reported below,

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vegetation response and effective erosion control were directly correlated to timely seeding in relation to reliable precipitation. The amount of precipitation received during the 2015–2016 study period (September 9, 2015, to September 9, 2016) was 24.77 inches. Weather data in 2017 indicate above-average winter and spring precipitation resulting in accelerated plant growth on all treatments. From September 10, 2016, to September 9, 2017, weather records show 37.08 inches of precipitation (Mokelumne Hill, CA) compared to a historic yearly average of 30.94 inches.

Vegetation and Erosion Control Overview

Rapid vegetation establishment over large areas has been regarded as one of the most cost-effective methods to mitigate the risks of increased runoff and soil erosion (Beyers 2004). A number of researchers including Pinaya *et al.* (2000) reported vegetation cover value to be significantly higher when compared to untreated controls, significantly reducing the erosion rate on their sites six months post seeding. Pinaya's results were supported further by the work of Robichaud *et al.* (2000) who reported similar findings over several growing seasons on their study sites. Vegetation establishment using native species was noted as having a positive outcome to mitigate erosion on the Taylor Bridge Fire in Washington State in 2013 (Goldberg 2017). Although the use of native species in post-fire seeding has increased (Beyers 2004, Wolfson and Sieg 2011), inadequate availability often limits the inclusion of native species. The demand for certified native seed has also increased (Loftin 2004) with native collection and local germplasm the future direction of the native seeding program in California (Lund, personal communication).

Sediment yield from high severity burn plots were 10–26 times greater than unburned plots as observed in a Colorado study (Benavides-Soloria 2001). Bautista *et al.* (1996) reported runoff and sediment yields to be significantly greater from control plots with soil loss approximately 7.2 times higher than the loss from mulched plots.

Methods

Percent Herbaceous Canopy Cover

Herbaceous canopy cover and composition sampling consists of two staged point-intercept layouts at each of the treatment areas. Random starts on transects were used, while intercept interval was developed by calculating intercepts based on estimated 85% confidence interval. Multiple hits per intercept were recorded and the corresponding height class identified to a species level classification.

Herbaceous Productivity as Residual Dry Matter (RDM)

Herbaceous production samples were collected at estimated peak production based on phenology of the species. RDM samples were collected at the end of summer prior to new germination onset by autumn rains. Sample locations were taken at random, alternating the baseline transect within each treated area. Herbaceous forbs were

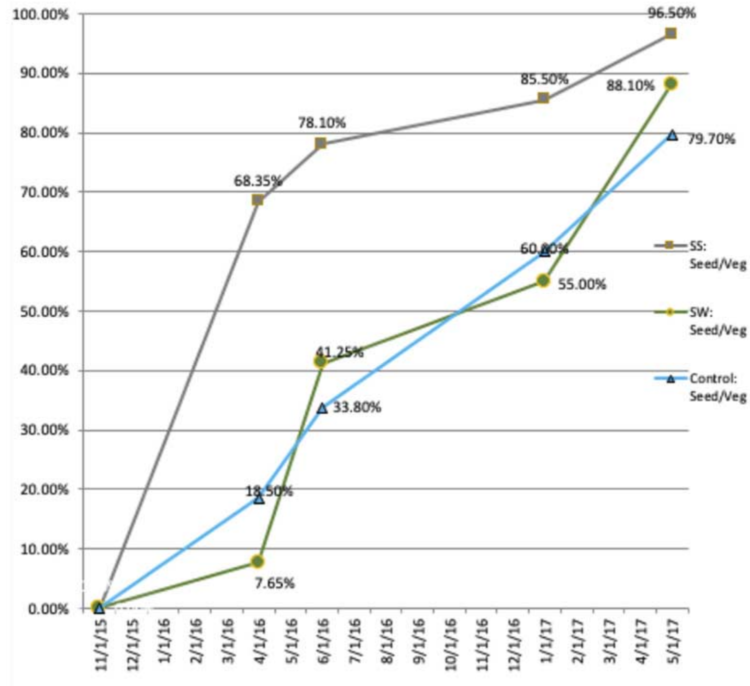

Figure 1. Herbaceous canopy cover over time on all treatments.

removed from the samples and grey residual matter from previous year's growth. Productivity samples were air-dried for an estimated ten days, then dried further in an oven at 100° F for 10 minutes and weighed. RDM was determined to be the best measure of herbaceous production. Aboveground herbaceous biomass was collected in early October prior to the new growing season.

Photomonitoring

Benchmarks used for the baseline transects were also used as photomonitoring locations. Photos were taken with the direction of the baseline referencing the opposite benchmark location for each treatment area.

Sediment Loss

The Revised Universal Soil Loss Equation 2 (RUSLE2) was used to compute sediment loss from erosion. RUSLE2 software predicts sediment loss on a single hillslope profile based on project site characteristics. RUSLE2 "pulls" location-specific data for climate (R), soil (K), slope steepness (S), slope length (L), compaction/tillage practices (P), and vegetative or mulch cover (C) from an established database. This data is used in conjunction with user-input data which describe the hillslope profile: topography, yield (production level), rock cover, and type (e.g. mulch, rice-straw) and amount of applied materials.

Findings

Vegetation Cover, 2015–2017

Our data clearly indicates that SS treatment (immediately after the fire has been extinguished and prior to the onset of reliable precipitation)

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provided the greatest benefits, increasing vegetation establishment and reducing the amount of erosion. As a result of early and timely seeding in October 2015, the vegetation canopy cover associated with the SS treatment was initially higher when compared to other treatments. For the SS treatment, total canopy cover, including seeded and volunteer species, was 68.35% in April 2016 and 78.10% in June 2016. The untreated control treatment had 18.50% canopy cover by April 2016 and 41.25% canopy cover by June 2016. SW treatment had 7.65%

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Figure 2. (left column, from top) Ocular canopy cover of the seeded rice straw treatment — Early Spring (April 16) 2016, Late Spring (June 5) 2016, and Spring (May 8) 2017.

Figure 3. (right column from top) Ocular canopy cover of seeded wood chip treatment — Early Spring (April 15) 2016, Late Spring (June 6) 2016, and Spring (May 9) 2017.

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canopy cover in April 2016 and 33.80% canopy cover in June 2016. Figure 1 shows herbaceous canopy cover, over time, from the initial sampling period (April 2016) through the May 2017 sampling date, for all treatments. The data indicated that the SS treatment consistently outperformed the other two treatments. In the latter part of the second growing season (May 2017), the SW treatment and untreated control treatment began to approach the cover performance of the SS treatments. Figures 2–4 shows estimated vegetation cover percentage establishment on each treatment over time.

Figure 4. (from top) Ocular canopy cover of the control — Early Spring (April 18) 2016, Late Spring (June 7) 2016, and Spring (May 10) 2017.

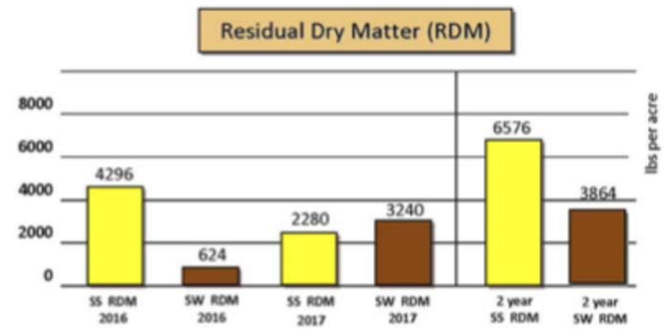

Figure 5. RDM for seeded rice straw (SS) and wood chip (SW) treatments by year and between years

Herbaceous Production

Herbaceous vegetation production (aboveground herbaceous biomass) was more abundant on early seeded areas. The SS Treatments produced 4,296 lbs RDM/acre in 2016 (Figure 5). The wood chip treatments produced 624 lbs RDM/acre. To reiterate, the SS treatment was completed in late October (24–27) 2015 and the SW treatment was completed later, in January (25–29) 2016. The data suggests that early seeding and timely precipitation are directly related to the amount of plant biomass produced in this study area. Other collateral benefits include enhanced habitat cover and increased forage value at the site.

In 2017, RDM production in the SS treatments decreased to 2,280 lbs/acre. In the SW treatment, RDM production was more than five times the 2016 production levels, outperforming the SS with a calculated 3,240 lbs RDM/acre. Total RDM over the two-year period on the seeded straw was 6,576 lbs RDM/acre and 3,864 lbs RDM/acre on the seeded wood chip plots (Figure 5). The data indicate that perennial grasses, mostly California brome and Blue wildrye, returned strongly from their crowns and provided significant cover in the second year. The authors suspect that the total RDM of the wood chip site may continue to trail the seeded straw treatment for years due to nutrient loss associated an estimated loss of 78 tons/acre over the initial two recovery years.

Sediment Loss

In the first year after seeding, SS plots, SW plots, and the control plots yielded 6.4, 50.0, and 64.0 tons per acre year, respectively (Table 2). By the end of the second year, the calculated erosion rate from the early seeded plot was 3.9 ton/acre/year. Estimates are that erosion will continue to decline to a baseline level of 2.4 ton/acre/year in calendar years 2018 and 2019. The SW plots show a steady decline in the rate of erosion when compared to soil loss estimates on SS plots. The soil loss from the control plots over the next four years decreased significantly over time. Over the five-year estimate, the SS treatment yielded 18 tons per acre of sediment, the SW treatment yielded 104 tons per acre of sediment, and the control yielded a staggering 137 tons per acre of sediment. While vegetative cover appears to show nearly equal recovery

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Table 2. RUSLE 2 calculated sediment delivery rates (tons/acre/year) over 5-year period all treatments

Treatment	Immediate Seeding Plus Rice Straw Mulch		Delayed Seeding Plus Wood Chip Mulch		Untreated Control	
Description	Grass/Forb Vegetation Seeded 10/25/2015 plus 3,000 lbs Rice Straw Mulch		Grass/Forb Vegetation Seeded 01/25/2016 plus 4,000 lbs Wood Chip Mulch		No Seed or Mulch; Only Volunteer Vegetation Modeled	
Average Annual Soil Loss (tons/acre/year)	3.6		21.0		27.6	
Sediment Delivery (tons/acre/year)	Yearly	Cumulative	Yearly	Cumulative	Yearly	Cumulative
Year 1 (2015–2016)	6.4		50.0		64.0	
Year 2 (2016–2017)	3.9	10.3	28.0	78.0	43.0	107.0
Year 3 (2017–2018)	2.9	13.2	15.0	93.0	17.0	124.0
Year 4 (2018–2019)	2.4	15.6	7.4	100.4	8.5	132.5
Year 5 (2019–2020)	2.4	18.0	4.0	104.4	4.9	137.4

Note: Yearly sediment delivery is from September 15 to September 14 of next year

of vegetation after two full growing seasons, the difference in soil loss per year continues to be relatively high in the SW and untreated control plots, resulting in substantial soil loss over the first five years after the fire.

The modeled rate of erosion in the control treatment was 10 times that of the SS plots during the initial modeling period (September 15, 2015 to September 14, 2016) (Table 2). The erosion rate modeled for the SW treatment was over seven times that of the SS treatment. The ability of wood chips to reduce the erosion rate relative to the control was also evident but to a lesser degree. Regardless of treatment, sediment loss was consistently greater in untreated control plots compared to treated areas.

Conclusions

The data collected on this Butte Fire Study strongly indicate that early seeding of native grasses and forbs in conjunction with straw mulching produced the most beneficial outcome in the form of increased vegetation canopy cover, reduced surface erosion, and accelerated vegetation production. Late seeding with wood chip mulching applications resulted in lower vegetative cover and productivity the first season and higher soil erosion rate when compared to the early seeding treatment. Note that every treatment demonstrated more effective outcomes, for every category, when compared to the control. The control plots showed the lowest rates of vegetative cover and the highest rates of soil erosion. Thus, the data supports early seeding and mulching to minimize erosion from the severely burned areas.

Although there are still challenges associated with seeding natives after fires, this study indicates that early seeding and mulching can be a highly effective post-fire treatment. Even mid-season seeding and mulching demonstrated a positive response. While more information and a follow-up study of this site will improve our understanding of treatment efficacy, the natural vegetative recovery did not appear to be compromised by the artificial seeding. The questions from the 1995 CNPS position paper regarding the use of non-local native seed types, lack of seed supply, disruption of small-scape ecological patterns, and success of natural vegetation recovery are all valid and should continue to be examined.

When addressing lack of seed stocks of a local source for large projects, the California seed industry understands the varied and dynamic nature of supplying seed to end users and has made

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great strides to fill the gaps and provide significant quantities of local native species for projects. Unfortunately, conducting local collections is still an expensive proposition for a seed company. Seeds have a fixed lifespan and it is impossible to know when and where fires will break out. Clearly a more centralized and comprehensive system for sources of emergency seed supplies is needed and would allow for prompt and effective treatments, particularly when dealing with local ecotypes. As the National Seed Strategy for Rehabilitation and Restoration becomes the established norm, it should allow the seed industry, agencies, and practitioners to identify the seed supply needs to make timely and informed decisions for current and future ecological restoration projects regardless of scale.

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