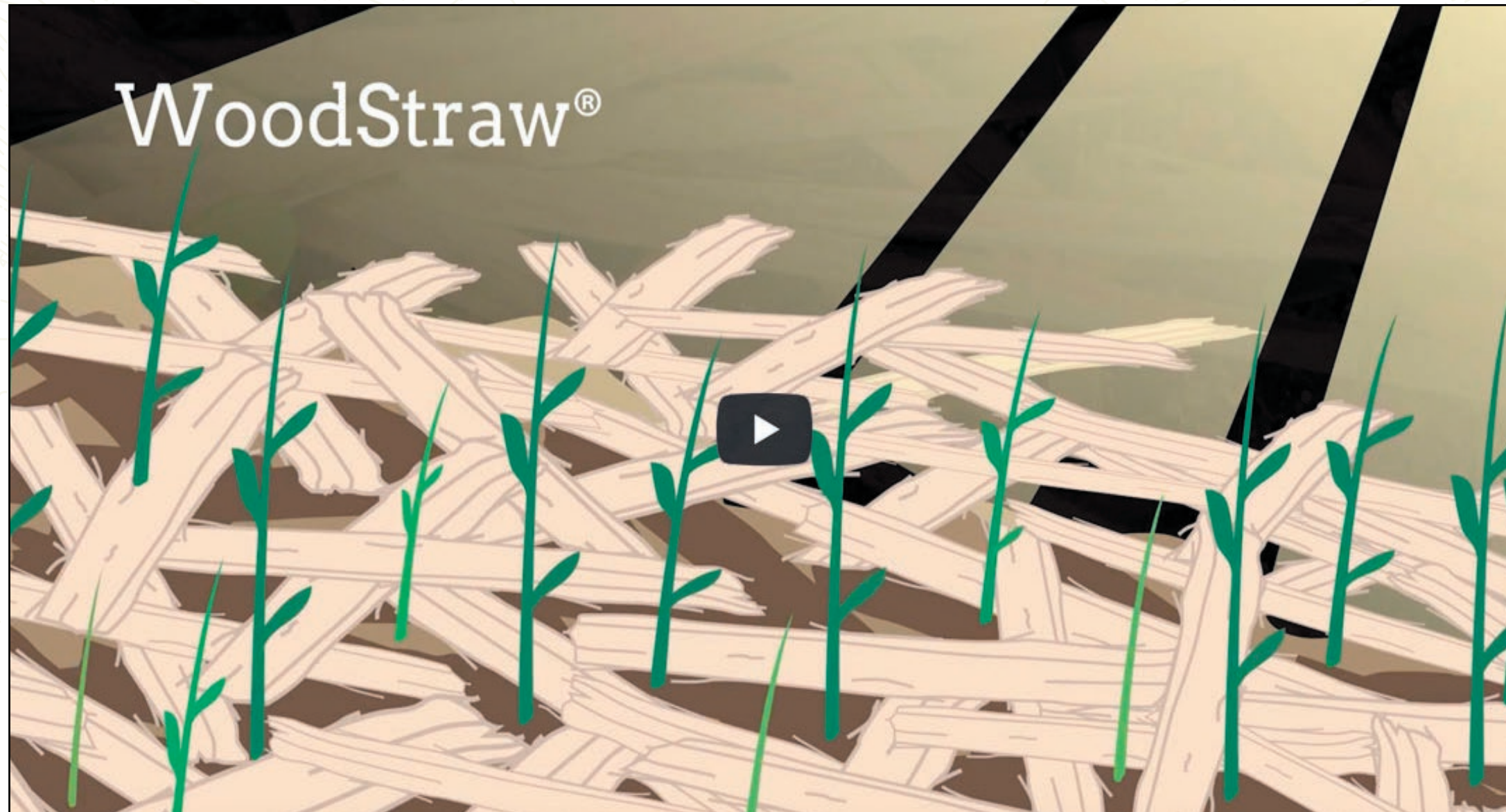




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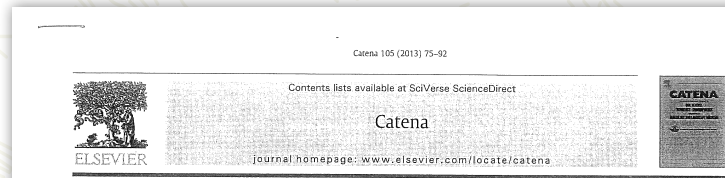
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Catena Study



Post-fire mulching for runoff and erosion mitigation Part I: Effectiveness at reducing hillslope erosion rates

Peter R. Robichaud*, Sarah A. Lewis, Joseph W. Wagenbrenner, Louise E. Ashmun, Robert E. Brown

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Wildfire is often the cause of large landscape changes within and downstream of the burned area. Increases in post-fire runoff and erosion, and subsequent increases in flooding, debris flows, and sedimentation are well documented (Bento-Gonçalves et al., 2012; Kunze and Stednick, 2006; Lane et al., 2006; Moody and Martin, 2009; Moody et al., 2008a,b; Nyman et al., 2011; Shakesly and Doerr, 2006; Silins et al., 2009).

In areas where wildfire conditions will be aggravated by drought, earlier spring snow melt, and other effects of climate change, the number and severity of wildfires is likely to increase (Brown et al., 2004; Flannigan et al., 2000; Miller et al., 2009; Westering et al., 2006). In addition, the number of people living in and around forested areas continues to increase. This adds human life and safety, infrastructure, buildings, and roads to the natural and cultural resources (e.g. drinking water quality, aquatic habitat, and historically significant sites) at risk from the secondary effects of wildfire (Stewart et al., 2003; Theobald and Romme, 2007). Consequently, post-fire management efforts may include the use of mitigation treatments to reduce increases in runoff

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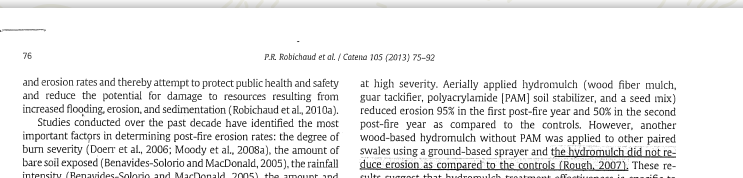
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USDA Nitrogen Study

Post-Fire Erosion Control Mulches Alter Belowground Processes and Nitrate Reductase Activity of a Perennial Forb, Heartleaf Arnica (*Arnica cordifolia*)

Erin M. Berryman, Penelope Morgan, Peter R. Robichaud, and Deborah Page-Dumroese

Abstract

Four years post-wildfire, we measured soil and plant properties on hillslopes treated with two different mulches (agricultural wheat straw and wood strands) and a control (unmulched, but burned). Soil total N was about 40% higher and microbial respiration of a standard wood substrate was nearly twice as high in the mulched plots compared to the unmulched plots. Greater respiration was tied to increased substrate moisture underneath mulch compared to bare soil. Nitrate reductase activity of a common forb (*Arnica cordifolia*) was about 30% higher on the wood strand plots than either the wheat straw or the unmulched plots. Mulch applications after wildfire may enhance N availability by increasing soil moisture, promoting microbial N mineralization, or by increasing biological nitrogen fixation. Because inference is limited for this case study, we call for additional replicated experiments investigating effects of mulch treatments on soil carbon and nitrogen cycling with links to plant regeneration.

Keywords: soil rehabilitation, restoration, fire effects, respiration, nitrogen

Berryman, Erin M.; Morgan, Penelope; Robichaud, Peter R.; Page-Dumroese, Deborah. 2014. Post-fire erosion control mulches alter belowground processes and nitrate reductase activity of a perennial forb, heartleaf arnica (*Arnica cordifolia*). Res. Note RMRS-RN-69. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 10 p.

Table 1—Average soil characteristics under the two mulch treatments and the unmulched control 4 years following wildfire and mulch application on the School Fire, eastern Washington.

Site treatment	pH	Organic Matter	Carbon		Nitrogen
			Percent	g m ⁻²	
Wheat straw	6.6 (0.18) ^a	7.5 (1.8)	3.07 (0.91)	0.184 (0.036) ^a	
Wood strands	6.4 (0.03)	8.3 (0.4)	3.40 (0.27)	0.224 (0.020) ^a	
Burned control	6.8 (0.13)	5.7 (0.1)	2.39 (0.12)	0.158 (0.011) ^b	

^aValues in parentheses are standard error of the mean. Different letters within a single column indicate significantly different treatment effects ($P < 0.01$; $n = 3$ composite samples).

the amount of N added by mulch may have exceeded that lost during the fire. Original aerial mulch application rates for the School Fire are estimated at 2.2 Mg ha⁻¹ for wheat straw and 4.5 Mg ha⁻¹ for wood straw, which would have potentially added 1.89 and 0.75 g N m⁻² to the soil surface. Comparatively, forest floor N loss from burned forests in the Inland Northwest may range from 7.7 to 20.9 g N m⁻² (Page-Dumroese and Jurgensen 2006), suggesting that organic N delivered via mulch may offset 10 to 25% of wildfire losses from the forest floor. However, this effect depends strongly on mulch decomposition and incorporation rates of N into the mineral soil. Future work needs to characterize decomposition rates of mulch in order to understand the potential contribution of mulch-derived N to mineral soil N. Replacing fire-induced losses of organic N via mulch may increase substrate for N mineralization, aiding forest productivity, influencing plant regeneration and ecosystem recovery (Pastor et al. 1984; Chapin and Matson 2011). The fate of mulch-delivered N in post-fire ecosystems needs to be fully assessed, together with the erosional mitigation impact of mulching on post-fire N retention and potential effects of mulch on BNF inputs.

Mulch cover reduces soil water evaporation and affects soil aggregate stability and porosity, thereby changing nutrient and water relations within the soil profile (Mulumba and Lal 2008). By increasing substrate moisture at a time when it would otherwise be low (typical of late summers in the Inland Northwest), surface mulch applications create an environment that promotes soil microbial activity, thereby altering long-term soil sustainability through the breakdown of OM, nutrient flux control, soil C sequestration, decomposition, mineralization, and immobilization (Nannipieri et al. 2003). Microbial turnover of soil C, measured as respiration from buried loblolly pine stakes, strongly co-varied with stake moisture content (Figure 1, Table 2). All stakes with moisture contents in the top 50th percentile were harvested from mulched areas rather than from the control. Thus, lower moisture in the control plots probably restricted microbial respiration there. Our results suggest that by altering the soil environment surrounding microorganisms, surface mulch applications may alter soil nutrient transformations with potential feedbacks to vegetation. Future work should resolve mulch effects on soil temperature as well as moisture effects in areas with different climate regimes.

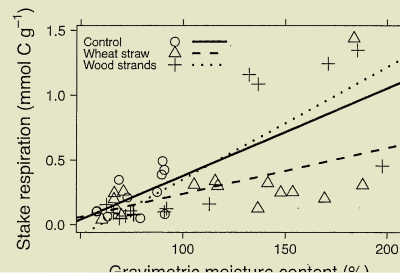


Figure 1—Stake respiration (mmol C g⁻¹) as related to stake moisture content (% w/w) at the time of stake retrieval 17 June 2009, with least squares linear regression lines for each mulched hillslope.

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Wind Study

A Wood-Strand Material for Wind Erosion Control: Effects on Total Sediment Loss, PM₁₀ Vertical Flux, and PM₁₀ Loss

N. S. Copeland* USDA-FS
B. S. Sharratt USDA-ARS
J. Q. Wu Washington State University
R. B. Foltz USDA-FS
J. H. Dooley Forest Concepts, LLC

Fugitive dust from eroding land poses risks to environmental quality and human health, and thus, is regulated nationally based on ambient air quality standards for particulate matter with mean aerodynamic diameter $\leq 10 \mu\text{m}$ (PM₁₀) established in the Clean Air Act. Agricultural straw has been widely used for rainfall-induced erosion control; however, its performance for wind erosion mitigation has been less studied, in part because straw is mobile at moderate wind velocities. A wood-based long-strand material has been developed for rainfall-induced erosion control and has shown operational promise for control of wind-induced erosion and dust emissions from disturbed sites. The purpose of this study was to evaluate the efficacy of both agricultural straw and wood-strand materials in controlling wind erosion and fugitive dust emissions under laboratory conditions. Wind tunnel tests were conducted to compare wood strands of several geometries to agricultural wheat straw and bare soil in terms of total sediment loss, PM₁₀ vertical flux, and PM₁₀ loss. Results indicate that the types of wood strands tested are stable at wind speeds of up to 18 m s⁻¹, while wheat straw is only stable at speeds of up to 6.5 m s⁻¹. Wood strands reduced total sediment loss and PM₁₀ emissions by 90% as compared to bare soil across the range of wind speeds tested. Wheat straw did not reduce total sediment loss for the range of speeds tested, but did reduce PM₁₀ emissions by 75% compared to a bare soil at wind speeds of up to 11 m s⁻¹.

ARID conditions and persistent winds, characteristic of much of the western United States, promote conditions conducive to wind erosion. Wind-blown dust liberated from construction sites, burned areas, and agricultural fields is a widespread problem with both human health and environmental implications. In 1987 the United States Environmental Protection Agency (USEPA) began to regulate PM₁₀ as a criteria pollutant. Since then, numerous epidemiological studies have shown a strong correlation between incidence of respiratory ailments, such as asthma, and atmospheric PM₁₀ (Dockery and Pope, 1994; Koren, 1995; Peden, 2001). Based on these and other findings, National Ambient Air Quality Standards have been set regulating PM₁₀ on a 24-h basis (USEPA, 2006). Aside from the health issues directly related to particulate matter, PM₁₀ also represents the most chemically active portion of the soil, and thus has the potential to transport heavy metals, pesticides, and microbes (Garrison et al., 2003; Whicker et al., 2006a). In addition to these potentially harmful compounds, PM₁₀ may also transport nutrients necessary for plant growth, reducing soil productivity (Van Pelt and Zobeck, 2007).

Once fine-sized particles are in suspension, they can remain in the atmosphere for long periods of time before being redeposited. This long residence time allows impacts of particulate matter to be felt in areas distant from the actual dust source. For instance, suspended particulates originating from dust storms in the Columbia Plateau region of the U.S. Pacific Northwest have been shown to affect air quality in eastern Washington and the Idaho Panhandle, with ambient PM₁₀ concentrations exceeding air quality standards numerous times since monitoring began in 1985 (Sharratt and Lauer, 2006). Influxes of dust originating from events as far away as Asia have been measured on the Columbia Plateau (Vaughan et al., 2001) and it is estimated that hundreds of millions of tonnes of dust from Africa are deposited in the Caribbean each year (Moulin et al., 1997).

N.S. Copeland, USDA Forest Service Rocky Mountain Research Stn., Moscow, ID 83843, B.S. Sharratt, USDA Agricultural Research Service, Pullman, WA 99164, J.Q. Wu, Washington State Univ., Pullman, WA 99164, R.B. Foltz, USDA Forest Service Rocky Mountain Research Stn., Moscow, ID 83843, J.H. Dooley, Forest Concepts, LLC, Auburn, WA 98001. The use of trade or firm names in this paper is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Abbreviations: PM₁₀, particulate matter with mean aerodynamic diameter $\leq 10 \mu\text{m}$; SLR, soil loss ratio.

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Fugitive dust from eroding land poses risks to environmental quality and human health, and thus, is regulated nationally based on ambient air quality standards for particulate matter with mean aerodynamic diameter $\leq 10 \mu\text{m}$ (PM₁₀) established in the Clean Air Act. Agricultural straw has been widely used for rainfall-induced erosion control; however, its performance for wind erosion mitigation has been less studied, in part because straw is mobile at moderate wind velocities. A wood-based long-strand material has been developed for rainfall-induced erosion control and has shown operational promise for control of wind-induced erosion and dust emissions from disturbed sites. The purpose of this study was to evaluate the efficacy of both agricultural straw and wood-strand materials in controlling wind erosion and fugitive dust emissions under laboratory conditions. Wind tunnel tests were conducted to compare wood strands of several geometries to agricultural wheat straw and bare soil in terms of total sediment loss, PM₁₀ vertical flux, and PM₁₀ loss. Results indicate that the types of wood strands tested are stable at wind speeds of up to 18 m s⁻¹, while wheat straw is only stable at speeds of up to 6.5 m s⁻¹. Wood strands reduced total sediment loss and PM₁₀ emissions by 90% as compared to bare soil across the range of wind speeds tested. Wheat straw did not reduce total sediment loss for the range of speeds tested, but did reduce PM₁₀ emissions by 75% compared to a bare soil at wind speeds of up to 11 m s⁻¹.

ARID conditions and persistent winds, characteristic of much of the western United States, promote conditions conducive to wind erosion. Wind-blown dust liberated from construction sites, burned areas, and agricultural fields is a widespread problem with both human health and environmental implications. In 1987 the United States Environmental Protection Agency (USEPA) began to regulate PM₁₀ as a criteria pollutant. Since then, numerous epidemiological studies have shown a strong correlation between incidence of respiratory ailments, such as asthma, and atmospheric PM₁₀ (Dockery and Pope, 1994; Koren, 1995; Peden, 2001). Based on these and other findings, National Ambient Air Quality Standards have been set regulating PM₁₀ on a 24-h basis (USEPA, 2006). Aside from the health issues directly related to particulate matter, PM₁₀ also represents the most chemically active portion of the soil, and thus has the potential to transport heavy metals, pesticides, and microbes (Garrison et al., 2003; Whicker et al., 2006a). In addition to these potentially harmful compounds, PM₁₀ may also transport nutrients necessary for plant growth, reducing soil productivity (Van Pelt and Zobeck, 2007).

Once fine-sized particles are in suspension, they can remain in the atmosphere for long periods of time before being redeposited. This long residence time allows impacts of particulate matter to be felt in areas distant from the actual dust source. For instance, suspended particulates originating from dust storms in the Columbia Plateau region of the U.S. Pacific Northwest have been shown to affect air quality in eastern Washington and the Idaho Panhandle, with ambient PM₁₀ concentrations exceeding air quality standards numerous times since monitoring began in 1985 (Sharratt and Lauer, 2006). Influxes of dust originating from events as far away as Asia have been measured on the Columbia Plateau (Vaughan et al., 2001) and it is estimated that hundreds of millions of tonnes of dust from Africa are deposited in the Caribbean each year (Moulin et al., 1997).

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Abbreviations: PM₁₀, particulate matter with mean aerodynamic diameter $\leq 10 \mu\text{m}$; SLR, soil loss ratio.

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lower coverages than those tested in this study may also be effective. Wood strands may be less stable on the soil surface at a lower percent cover, however, as material stability is a function of cover due to material layering and interweaving. Layering increased with increasing percent cover because the wood strands laid on top of one another as more strands were applied. Layering thus increased both depth of cover and effective surface roughness. Layering also appeared to increase wood strand stability by promoting interweaving of the materials.

Conclusions

Wheat straw was only stable at speeds of up to 6.5 m s⁻¹. Wood strands reduced total sediment loss and PM₁₀ emissions by 90% as compared to bare soil across the range of wind speeds tested. Wheat straw did not reduce total sediment loss for the range of speeds tested, but did reduce PM₁₀ emissions by 75% compared to a bare soil at wind speeds of up to 11 m s⁻¹.

Wood Strand Properties

Wood strands in the range of dimensions tested in this study were equally effective in reducing wind erosion, and were found considerably more stable than straw, especially at the 18 m s⁻¹ wind speed. Lack of differences in total sediment and PM₁₀ loss between 50 and 70% cover of the wood strands suggests that lower coverages than those tested in this study may also be effective. Wood strands may be less stable on the soil surface at a lower percent cover, however, as material stability is a function of cover due to material layering and interweaving. Layering increased with increasing percent cover because the wood strands laid on top of one another as more strands were applied. Layering thus increased both depth of cover and effective surface roughness. Layering also appeared to increase wood strand stability by promoting interweaving of the materials.

Conclusions

Wood strands were found to be a viable alternative to agricultural straw for wind erosion control. Wood strands reduced sediment loss and PM₁₀ emissions from bare soil surfaces at wind speeds of up to 18 m s⁻¹, whereas agricultural straw only reduced sediment loss at the lower, 11 m s⁻¹ wind speed tested. Wood strands were more stable at higher wind speeds than wheat straw. Wood strand effectiveness was not affected by the range of dimensional characteristics tested in this study. Additional testing of wood strands at lower coverage is needed to further investigate the cover-stability relationship of the wood strands. Wind tunnel testing with saltating agents used as abraders should also be of interest to explore the ability of the wood strands to prevent saltating grains from liberating erodible material from the soil surface. Further field-scale research may provide more insight into the erosion reduction efficacy of wood strands vs. agricultural straw, as microtopography will also play a role in the performance of cover elements in the field.

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Very important to get adequate cover for reducing sedimentation

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Tons per acre is not a proper method. A bale can weigh 20 lbs. or up to 85 lbs. depending on water content in the wood particles.



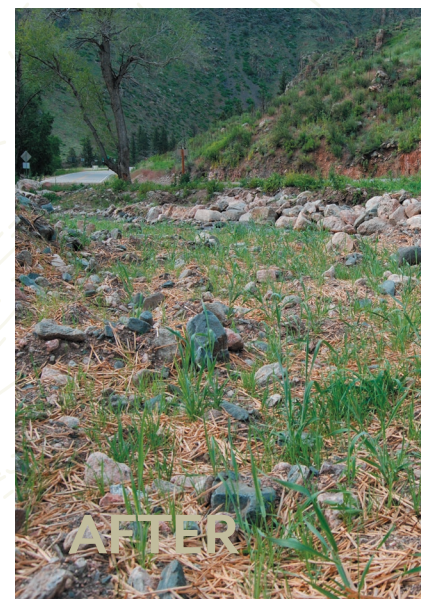
CDOT | Highway 40 – Before and After:



Seneca Channel – Before and After:



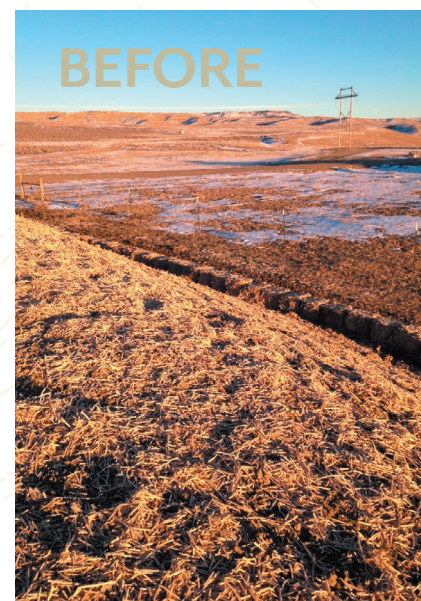
Skin Gulch – Before and After:



Black Forest – Before and After:



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