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A comparison of three erosion control mulches on decommissioned forest road corridors in the northern Rocky Mountains, United States

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Abstract: This study tested the erosion mitigation effectiveness of agricultural straw and two wood-based mulches for four years on decommissioned forest roads. Plots were installed on the loosely consolidated, bare soil to measure sediment production, mulch cover, and plant regrowth. The experimental design was a repeated measures, randomized block on two soil types common in the northern Rocky Mountain area. The control produced the most sediment, while wood strands produced the least during the critical first winter following road decommissioning. Following the first year, there was no statistically significant difference in sediment production among the mulches or control. One year after the three mulches were applied, there was no statistical difference among mulch cover. Further, none of the mulches inhibited plant regrowth. The conservation implications of these research findings demonstrated that wood-based alternatives to agricultural straw were equally effective in reducing sediment production from originally bare, unvegetated soil strips resulting from forest road decommissioning. The amount of effective ground cover provided by mulch, plants, and litter appeared to be more important than the type of mulch.

Key words: erosion control—mulch—straw—wood shreds—wood strands

The US Forest Service has an inventoried road mileage of about 600,000 km (373,000 mi), ranging from paved two lane roads to native surface roads suitable for high-clearance vehicles only. These roads were built to provide commercial access for timber harvest activities and public access to recreational opportunities. With a deferred maintenance backlog of $3.3 billion (USDA Forest Service 2012), one solution is to decommission roads that are no longer needed or ones that are high risks to damage other forest resources. In 2012, the US Forest Service reported that 2,547 km (1,583 mi) of roads had been decommissioned (USDA Forest Service 2012). One popular decommissioning method is to recontour the former road bed to approximate the shape of the hillside prior to construction of the road. This method, hereafter referred to in this paper as road obliteration, results in corridors of loosely consolidated, bare soil until vegetation reestablishes a ground cover adequate to prevent water erosion. During this time, the bare corridors need protection from rain and snowmelt-induced erosion.

Erosion reduction agents work by absorbing the energy of falling raindrops, preventing surface sealing and thus increasing infiltration and reducing runoff (McGregor et al. 1998), by operating as roughness elements to slow the velocity of flowing water, and by trapping sediment due to the creation of mini-dams (Foltz and Dooley 2003). Agricultural straw is the most commonly used erosion mitigation material. In the past several years, managers have increasingly used wood-based mitigation material in lieu of agricultural straw. Two wood-based erosion reduction agents are wood strands and wood shreds. Both have been shown to be effective at the laboratory scale, but have not received sufficient testing at the field scale. Agricultural straw, wood strands, and wood shreds reduce erosion by similar mechanisms. The major difference among agricultural straw, wood strands, and wood shreds has been hypothesized to be in how long they persist and whether they inhibit plant regrowth.

The US Forest Service Rocky Mountain Research Station conducted a four-year study of agricultural straw, wood strands, and wood shreds on decommissioned road corridors. The objectives were (1) to compare the sediment production from agricultural straw, wood strands, and wood shreds to that of a control, (2) to determine the mitigation potential of each of the three mulches compared to that of a control, (3) to determine how each mulch and mulch plus plant and litter cover changed with time, and (4) to investigate the impact of mulches on plant regeneration.

In a forest setting, agricultural straw is a nonnative material and may disrupt the natural habitat by introducing nonnative vegetation (Robichaud et al. 2000). Kruse et al. (2004) reported that nonnative species were more prevalent on burned areas treated with certified weed-free straw than those left untreated on the Six Rivers National Forest in California. Chemical residues from agricultural pesticides and herbicides have been found in otherwise pristine watersheds where straw was used for erosion control (Seattle Public Utilities, personal communication). Fine dust from shattered agricultural straw is a respiratory irritant and source of allergens to workers who spread straw by hand or machine (Kullman et al. 2002). In agricultural settings, straw cover persists for one to two years until the next crop emerges and provides ground cover. In forest settings, it often takes three to five years before sufficient ground cover is reestablished following a disturbance. Forest managers need an erosion control mulch that persists for this three- to five-year period.

A wood-based erosion control mulch does not have many of the drawbacks associated with straw. Wood strands are a manufactured material made from wood veneer waste known as fish tails. The wood strands are cut to length and width in a machine resembling a paper shredder. The resulting material has repeatable length, width, and thickness.

Wood strands have been tested for erosion reduction in small-scale, laboratory settings. Foltz and Dooley (2003) reported that agri-

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cultural straw; a wide, 16 mm (0.63 in) wood strand material; and a narrow, 4 mm (0.16 in) wood strand material were all equally effective in reducing sediment production from a high intensity simulated rainfall. Yanosek et al. (2006) found no statistical difference in erosion control effectiveness on a gravelly sand and a sandy loam soil. They reported that the optimal wood strand cover was 50%.

Wood shreds, another wood-based erosion control mulch, are produced in tub grinders by shredding on-site woody materials such as limbs and small-diameter trees. The typical grinding operation produces a mixture that contains a large portion of fine material less than 25 mm (1 in) in length (Foltz and Copeland 2009; Foltz and Wagenbrenner 2010) that has little effect on erosion prevention and is likely to be washed away in the first few runoff events.

Wood shreds have also been tested for erosion reduction in small-scale, laboratory settings. Foltz and Copeland (2009) tested wood shreds on two soil types (gravelly sand and sandy loam) at four covers (0%, 30%, 50%, and 70%) on a 30% slope using high intensity simulated rainfall plus overland flow. The recommended cover for the fine grain soil was 50% and was 70% for the coarse grain soil.

Agricultural straw as a water erosion mitigation agent has been studied at the field scale in forest settings for effectiveness in reducing sediment production following wildfires. Dean (2001) studied the effectiveness of agricultural straw plus seeding on 23% to 24% slopes following the 2000 Cerro Grande Fire in New Mexico. She concluded that agricultural straw applied at an initial cover of 76% plus seeding on a sandy loam to loam soil reduced sediment production by 85% over a two-year period after the fire. Wagenbrenner et al. (2006) also studied agricultural straw as an erosion mitigation agent following the 2000 Bobcat Fire in Colorado. For a four-year period following the fire, the agricultural straw reduced sediment production by 79% compared to the untreated, bare plots.

Research on the impact of mulches on plant regrowth has found mixed results. In a study of agricultural straw mulch, Kruse et al. (2004) studied the impact of straw mulch on ecological recovery following wildfires. They postulated that straw mulch could suppress regeneration by blocking sunlight to emerging seedlings, preventing contact between newly arrived seeds and the soil surface, or reducing soil nitrogen availability as the straw mulch decomposed. Their study found that there was little evidence that mulching facilitated recovery of the native plant community. Dodson and Peterson (2010) acknowledged similar mechanisms to inhibit plant regeneration, but offered that mulches could be particularly beneficial on dry sites by retaining soil moisture and cited Bautista et al. (1996, 2009), Badia and Marti (2000), and Peterson et al. (2009) as studies that concluded straw mulch increased plant growth. In their study of agricultural straw mulch impacts on plant regeneration following a wildfire in Washington, Dodson and Peterson (2010) concluded that mulch cover was positively associated with plant cover, plant species richness, and conifer seedling densities when mulch cover in the second year did not exceed 40%. When mulch cover exceeded 70%, they observed that vegetation recovery was negatively impacted by the mulch cover. While these studies were conducted using agricultural straw as the erosion control mulch, similar concerns have been raised about the use of wood-based mulch.

Material and Methods

The study was conducted at two locations, one with a fine-grained soil and one with a coarse-grained soil, to represent typical soil and habitat conditions in the western United States. The fine-grained location on the Payette National Forest in Idaho will be referred to as Mud Creek. The long-term annual precipitation was 1,081 mm y^{-1} (42.5 in yr^{-1}) with an average 92-day growing season. The gravelly loamy sand soils (Typic Cryopsamment) with a mean soil particle diameter of 1.35 mm (0.053 in) were derived from Columbia River basalt and Idaho Batholith granite parent material. Subalpine fir/pachistima habitat dominates the Mud Creek watershed (USDA Forest Service 2003). The test sections of decommissioned road were at an elevation of 1,360 m (4,460 ft) with aspects ranging from 84° to 125°.

The coarse-grained location on the Kaniksu National Forest in Washington will be referred to as Willow Creek. The long-term average annual precipitation was 1,349 mm y^{-1} (53 in yr^{-1}) with an average 102-day growing season. The loamy sand soils (Typic Vitrandept) with a mean soil particle diameter of 0.32 mm (0.013 in) were derived from glacial till and heavily influenced by volcanic ash. Western red cedar and subalpine fir habitat types dominate the watershed. The study sites were at an elevation of 1,230 m (4,030 ft) with an aspect range of 104 to 112 degrees (USDA Forest Service 2004).

Road Obliteration Methods. In June 2005, a hydraulic excavator obliterated 3.0 km (1.9 miles) of the Mud Creek road to reduce sediment delivery to fish bearing waters and to provide wildlife security. A newer, higher standard road was built on the opposite side of Mud Creek, making this segment of the road redundant.

At the time of the obliteration, the native surface road had minor traffic levels and was open for use by high-clearance vehicles only. A mixture of native and nonnative grasses established from previous applications of erosion control efforts covered approximately 80% to 90% of road surface.

The obliteration technique was full bench recontour with native mulch and soil and vegetation transplants. To obliterate the road, the excavator first broke up the road to the depth of compaction with the use of the bucket. Road fill material was then pulled onto the former running surface, conserving some of the vegetation and live soil to transplant on to the recontoured road prism. Natural mulch and coarse woody debris within reach of the excavator was also placed on the road prism to achieve an approximate 50% to 80% ground cover. Areas that did not have enough native material to achieve the percentage cover were mulched with certified weed free straw. Exposed soil was seeded at an approximate rate of 25 live seeds per square foot.

A hydraulic excavator also obliterated the 16 km (10 mi) long Willow Creek road to improve grizzly bear habitat and reduce sediment delivery to fish bearing waters. Constructed in the early 1980's for a timber sale, the road provided access to several million board feet of timber. It remained in use until 1996 when it was closed with a guardrail to limit motor vehicle use in a grizzly bear recovery area. Between 1996 and 2005, the road experienced a few landslides, making it essentially undrivable. At the time of obliteration, the native surface road had 2.5 to 3.6 m (8 to 12 ft) tall thinleaf alder (*Alnus incana* [L.] Moench) and a forb dominated understory. Canopy and ground cover on both the running surface and the fill slope were 60% to 80%.

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The operator ripped the road prism down at least 0.6 m (2 ft), then pulled the fill material onto the former running surface and sloped the former road prism to match the natural terrain. The operator used the bucket to move clumps of vegetation from the adjacent area on to the treated road prism in an effort to accelerate natural revegetation. All exposed soils were mulched with certified weed free straw and or native slash and then seeded with a site-specific mix. In areas away from the streams and seeps, soils were fertilized.

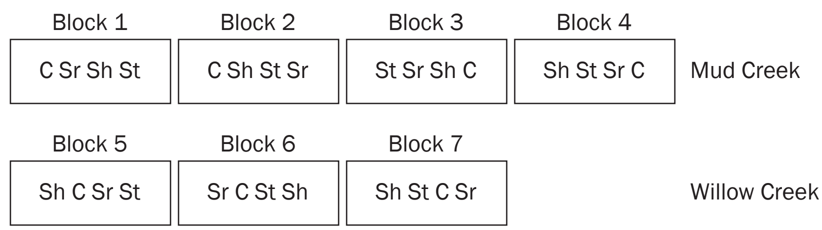
The obliteration methods described above result in a bare, loosely compacted strip of soil with seed and fertilizer covered by straw and native mulch. The seeding and fertilizing and application of straw and native slash are intended to accelerate plant regrowth, thus reducing sedimentation. However, not all sections of a road to be decommissioned have sufficient native mulch to place on the bare soil. With limited budgets, not all decommissioned roads receive seed and fertilizer. It is in these instances that agricultural straw and the wood-based alternatives have the greatest application. Therefore, to eliminate confounding of the study results by the sedimentation reducing efforts applied to the majority of the two decommissioned roads, test sections were ripped and recontoured as described above but no plant material, straw mulch, seed, or fertilizer was applied. Elimination of these treatments allowed the study to meet the objectives.

Experimental Design. The three water erosion mitigation materials were compared to control treatments using a repeated measures, randomized block experimental design as illustrated in figure 1. The repeated measures consisted of both ground cover and sediment mass produced by runoff. Measurements at the end of the snowmelt season, either May or June, and again at the end of the summer thunderstorm season, September, were taken. The randomized blocks consisted of four blocks at Mud Creek and three blocks at Willow Creek. Within each block, treatments of control, agricultural straw, wood strands, or wood shreds were randomly assigned.

Sediment Collection Methods. Each sediment collection plot of approximately 64 m^2 (690 ft^2) area consisted of 16 gauge galvanized sheet metal borders on three sides. The plots were located with the long dimension, ~10 m (~33 ft), parallel to the former road centerline. Flow paths were typically 6.4 m (21 ft) in length. Borders on the sides parallel to the flow path were driven into the soil to a depth of 50 mm (2 in) with 75 mm (3 in) remaining above the soil. Sheet metal borders in the shape of a "V" were installed on the downhill side of the plot and conveyed runoff and sediment to a buried sediment collection tank. The uphill side was left open to receive overland flow from the undisturbed forest. All plots were installed and treatments applied within a month following road obliteration. The target cover was 60% for agricultural straw and 50% for both wood strands and wood shreds.

Figure 1

Experimental design showing blocks at Mud Creek and Willow Creek. C represents control plots, Sr represents straw plots, Sh represents shred plots, and St represents strand plots.



A tipping bucket rain gauge was installed at each location to measure summer rainfall. Precipitation for the entire study period was characterized using nearby USDA Natural Resources Conservation Service Snowpack Telemetry (SNOTEL) sites. The West Branch SNOTEL site was 4.6 km (2.9 mi) west and 330 m (1,100 ft) higher in elevation than the Mud Creek site. The Bunchgrass SNOTEL site was 13 km (8 mi) southwest and 296 m (970 ft) higher in elevation than the Willow Creek site.

During semiannual sediment cleanout periods in either May to June or September, sediment from the collection tanks was weighed on location, and samples were taken to determine water content in the lab. Water content samples were oven dried at 110°C (230°F) overnight. The wet mass of each collection tank was corrected for water content based on the sample from that individual tank. Soil loss per unit area from each plot was calculated by dividing the sediment mass by the plot area. Sediment *mitigation,* objective 2, for each plot was calculated using equation 1 below:

$$mitigation = \frac{(control - treatment)}{control} \times 100 , \qquad (1)$$

where *treatment* was the mass of sediment from the treatment plot and *control* was the mass of sediment from the control plot.

Mulch cover was determined within a few days of the sediment cleanout dates. Following application of the mulch material, seven randomly chosen locations were selected in each plot. The same locations within each plot were reassessed for subsequent cover measurements. Biannual photographs from each location were analyzed by placing a 48-point grid over the photograph and counting the number of hits for each type of ground cover. Grids for the photographs were chosen to represent a 28 by 20 cm (11 by 7.8 in) rectangle on the ground. Ground cover types were bare, mulch, rock, plant, or litter.

Statistical Methods. The sediment production from agricultural straw, wood strands, and wood shreds to that of a control, objective 1, was analyzed using a generalized linear mixed model. The treatments were fixed effects. Random effects were blocks and the treatment by block interaction. A Gaussian distribution was chosen for the distribution of the residuals. Repeated measures were time and the time by treatment interaction. An autoregressive, lag one distribution for the residuals was chosen. Least squares means were adjusted using the Tukey-Kramer Honest Significant Difference to determine paired differences. A 95% confidence level was used for both the mixed model and the Tukey-Kramer Honest Significant Difference adjustments. To achieve a normal distribution of the residuals, the fourth root of the sediment production values was required. This transformation allowed inclusion of 26 zero sediment values to be included, whereas a log transformation would not have.

Statistical analysis of how each mulch and mulch plus plant and litter cover changed over time, objective 3, and the impact of mulches on plant regeneration, objective 4, were performed separately using a general-

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Mulch	Mean (%)	CV (%)	Goal (%)	Statistically different from goal at $\alpha = 0.05$
Wood strands	48	8.2	50	No
Wood shreds	49	18	50	No
Agricultural straw	67	7.6	60	Yes

Table 1
Initial application rates for the mulches.

Note: CV = coefficient of variation.

Table 2
Average sediment production and mitigation for each mulch for the entire study period.

Mulch	Average sediment production (kg ha^{-1} y^{-1})	Cumulative sediment mitigation (%)
Control	490a	0
Wood shreds	280ab	43
Agricultural straw	210b	57
Wood strands	110b	76

Note: Means followed by a common letter are not significantly different at the 0.05 level.

ized linear mixed model with fixed, random, and repeated measures in the same manner as the sediment production analysis with the exception that no transformation of the cover was required.

Each ANOVA investigated the effect of treatments (wood strands, wood shreds, agricultural straw, and control), the effect of time (sediment cleanout intervals), and the interaction among treatments and time (how the treatments changed with time). Each of the main effects or interactions will be discussed only if they were statistically significant.

Results and Discussion

Treatments were applied at the Mud Creek plots on August 24, 2005, and at the Willow Creek plots on October 22, 2005. As shown in table 1, both the wood strands and wood shreds were not statistically different from the goal of 50% cover, while the agricultural straw was applied at a statistically greater cover than the desired 60%.

Average annual precipitation during the study period (August 2005 through September 2009) was 108% of normal at Mud Creek and 105% of normal at Willow Creek. Based on these values, the study period was a typical sequence of years for these two locations.

Sediment Production. There was a difference among the treatments in average sediment production for the entire four years of the study. Table 2 displays the average sediment production for each of the treatments. In decreasing order of sediment production, the treatments were control, wood shreds, agricultural straw, and wood strands. While the range of sediment production among the mulches was a factor of nearly 2.5:1, the number of plots combined with the runoff conditions in the current study was not sufficient to demonstrate any differences among the mulch treatments. This suggests that either there are, indeed, no differences among the mulch treatments or that more severe runoff conditions are needed to demonstrate any differences. The grouping of the wood shreds with the control suggests that sediment production from wood shred mulch was no better than that from a bare control.

Sediment production for all the treatments changed with time (figure 2). There were no differences among treatments at 0.8 years after the interval from treatment installation, but at 1.06 years, there was a difference between the control and the wood strands (indicated with an asterisk in figure 2b). Beyond the first year, there were no statistically significant sediment production differences.

The sediment production from the bare control plots averaged 490 kg ha^{-1} y^{-1} (0.22 tn ac^{-1} yr^{-1}) compared to 2,000 to 4,700 kg ha^{-1} y^{-1} (0.89 to 2.1 tn ac^{-1} yr^{-1}) reported by Dean (2001) and Wagenbrenner et al. (2006) for postfire erosion from bare plots. The bare strips of soil resulting from road decommissioning have an erosion potential of one-quarter to one-tenth that of postfire bare soil.

Sediment Mitigation Potential. Wood strands provided the highest cumulative sediment mitigation of 76% compared to the control. Agricultural straw was second at 56%, and wood shreds was third at 42%. Wood strands achieved this level of mitigation with an initial cover of 48%, while agricultural straw required an initial cover of 67%.

Both agricultural straw and wood shred mitigation on the decommissioned road corridors were less than that reported by Dean (2001) of 85% for a two-year period following a wildfire and that reported by Wagenbrenner et al. (2006) of 79% for the entire four-year period after a wildfire. Conversely, wood strands over the four-year period nearly equaled the Dean and Wagenbrenner two- and three-year periods.

The current study mitigation values for agricultural straw, wood strands, and wood shreds were less than those reported for single storm, laboratory scale studies (Foltz and Dooley 2003; Yanosek et al. 2006; Foltz and Copeland 2009; and Foltz and Wagenbrenner 2010). In these 1.5 m^2 (16 ft^2) scale studies using high intensity rainfall simulation, erosion mitigation results typically exceeded 80% reduction compared to a bare control. The combination of larger scale, multiple storms, and decline of mulch cover contributed to the lower observed mitigation effectiveness. While high intensity rainfall simulation can provide useful comparative mitigation effectiveness indications, the current study, Dean (2001), and Wagenbrenner et al. (2006) illustrate that actual field application values will be less by about half. Foltz and Copeland (2009) observed that the rainfall simulation studies suggested that the amount of mulch cover was more important than the type of cover. The longer term field-scale studies appear to confirm that observation.

Mulch and Mulch Plus Plant and Litter Cover Changes with Time. Mulch cover over the life of the study was different among the mulches. Wood strands and agricultural straw provided greater average mulch cover than did wood shreds (table 3). At the time of application, agricultural straw was statistically higher than either of the other two mulches (figure 3). Beyond one year, there was no statistical difference in cover among the three mulches.

Agricultural straw started at an initial cover of 67% compared to the two wood-based mulch covers of approximately 50%. The implication is that agricultural straw must have an initial application rate higher than that of either wood mulch to provide a similar lifetime cover. Another way to look

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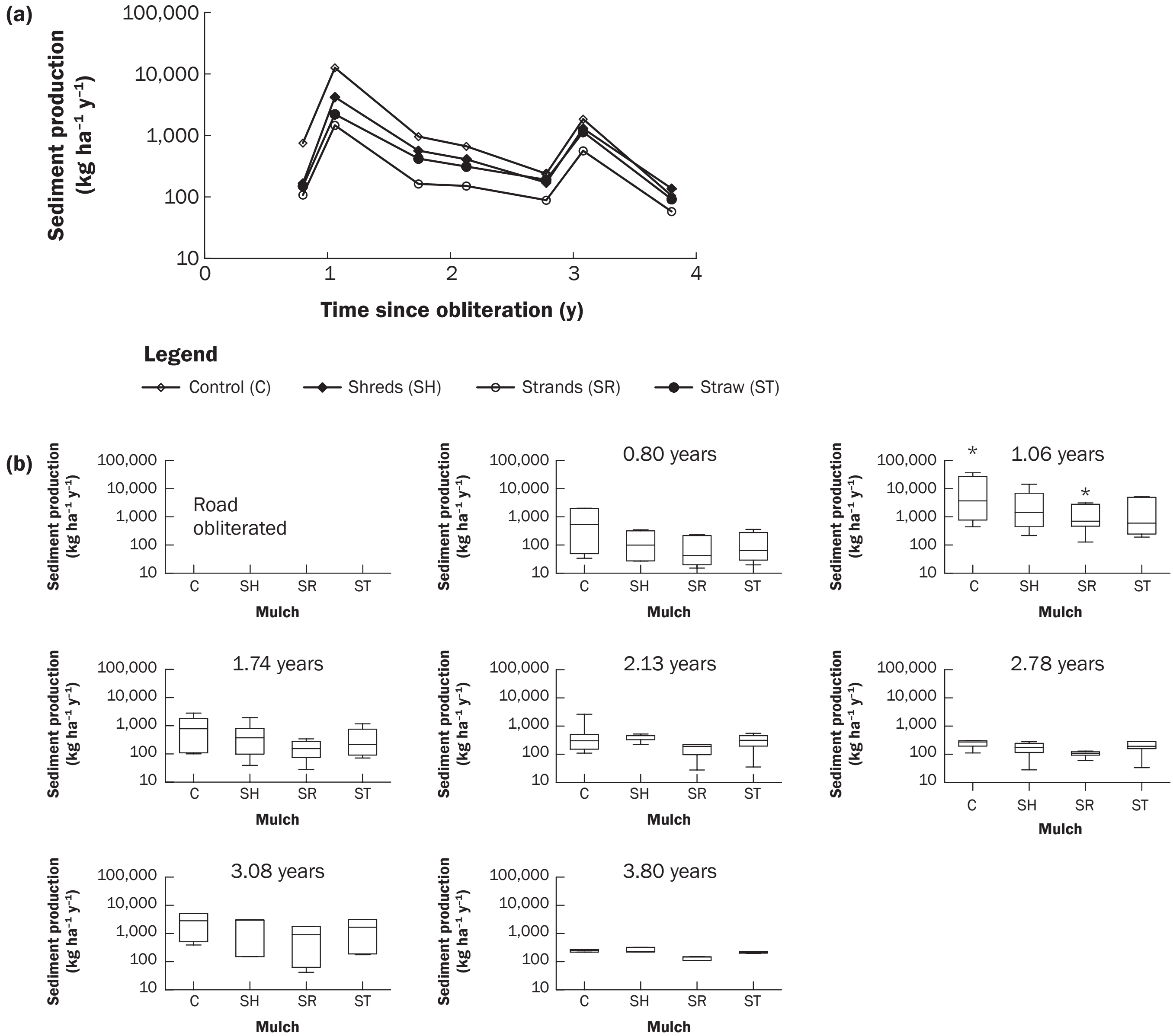
Figure 2

(a) Annual sediment production over time. (b) Individual box plots are shown to illustrate the range of measurements. Box plots have an upper horizontal line for the maximum observation. The top of box is the 75th percentile. The horizontal line in the box is the median observation. The bottom of the box is the 25th percentile. The lower horizontal line is the minimum observation. Statistically significant pairs are marked by an asterisk (*).



at this is that 50% cover of wood-based mulch provided the same lifetime cover as 67% cover of agricultural straw. Erosion mitigation users need to take this higher initial application rate for the agricultural straw into account when comparing the economics of the various mulch products.

The time required for each mulch cover to be reduced by half, a measure of the persistence of the mulch, is shown in table 3. There was no difference between wood shreds and agricultural straw with each having a half-life of 1.5 years. The wood strands were more persistent with a half-life of 2.3 years, which implies a 50% longer life than either the wood strands or agricultural straw.

The exponential models of mulch cover decline predict that one year after application agricultural straw and wood shreds would have 63% of the initial cover while the longer-lasting and slower-decomposing wood strands would retain 74% of the initial cover. This difference in cover grows larger with time. For example, at the end of 4 years, the corresponding values would be 16% of the initial cover for agricultural straw or wood shreds and 30% of the initial cover for wood strands. For applications where treatment longevity is important, wood strands would be preferred. Such applications could be short growing season locations with thin, rocky soils or soils impacted by high severity fires. In the current study where plant regrowth in two growing seasons was sufficient, the benefits of a long-persisting treatment were less important.

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Figure 3

(a) Mulch cover over time. (b) Individual box plots are shown to illustrate the range of measurements. Box plots have an upper horizontal line for the maximum observation. The top of box is the 75th percentile. The horizontal line in the box is the median observation. The bottom of the box is the 25th percentile. The lower horizontal line is the minimum observation. Outliers are indicated with a dagger (†). Statistically significant pairs have one, two, or three asterisks (*, **, or ***).

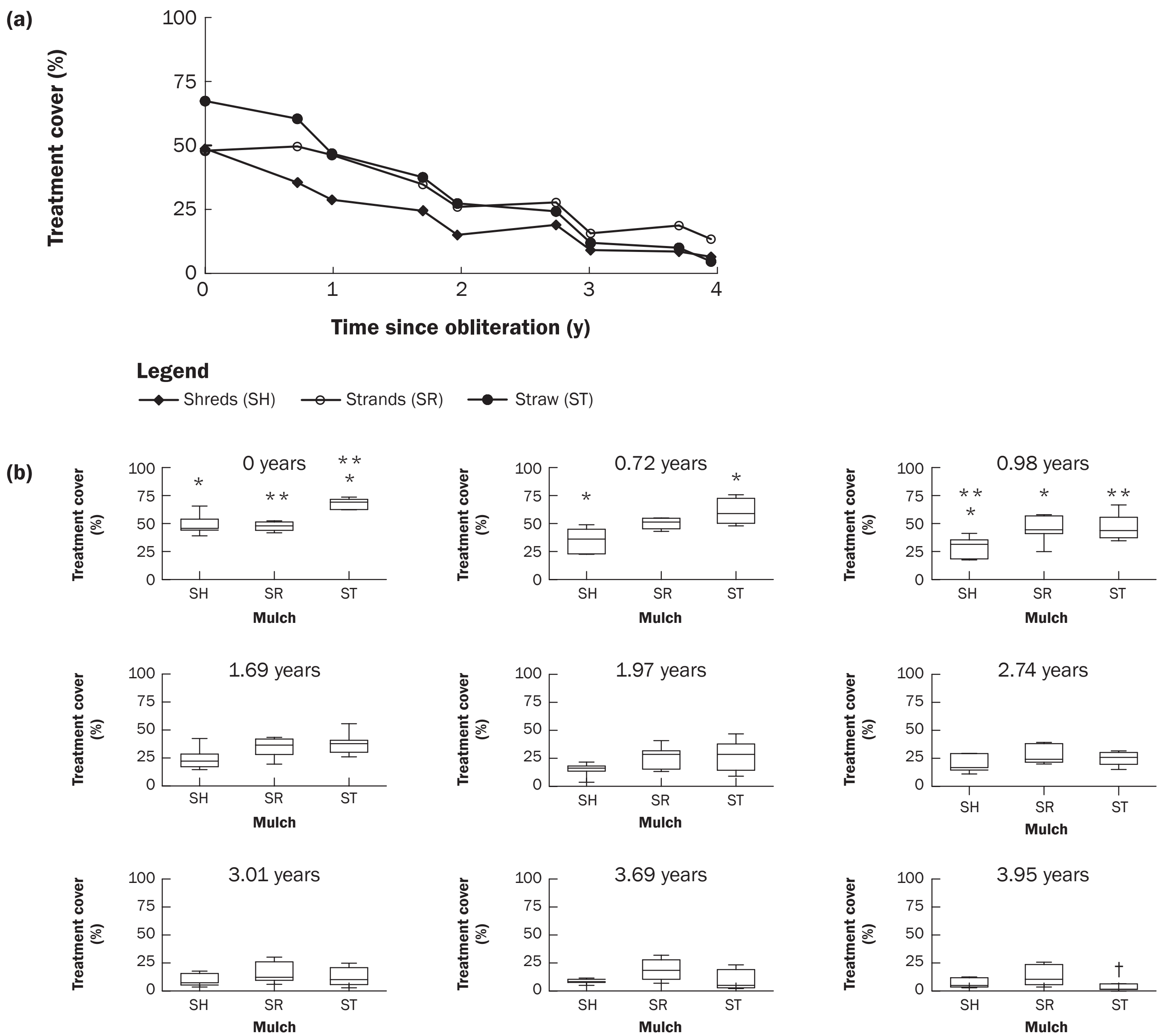

Table 3

Initial mulch cover, average effective mulch cover, and mulch half-life.

Mulch	Initial mulch cover (%)	Average mulch cover (%)	Half-life (y)
Wood shreds	48.8	21.7a	1.5
Agricultural straw	67.4	32.3b	1.5
Wood strands	47.9	31.1b	2.3

Note: Means followed by a common letter are not significantly different at the 0.05 level.

Mulch plus plant and litter is effective ground cover. This effective ground cover provides protection to the bare soil during the first few years after a disturbance until plant regrowth becomes established. There was a difference in effective ground cover among control, wood shreds, agricultural straw, and wood strands (figure 4).

It took slightly more than one year for the effective ground cover of all treatments com-

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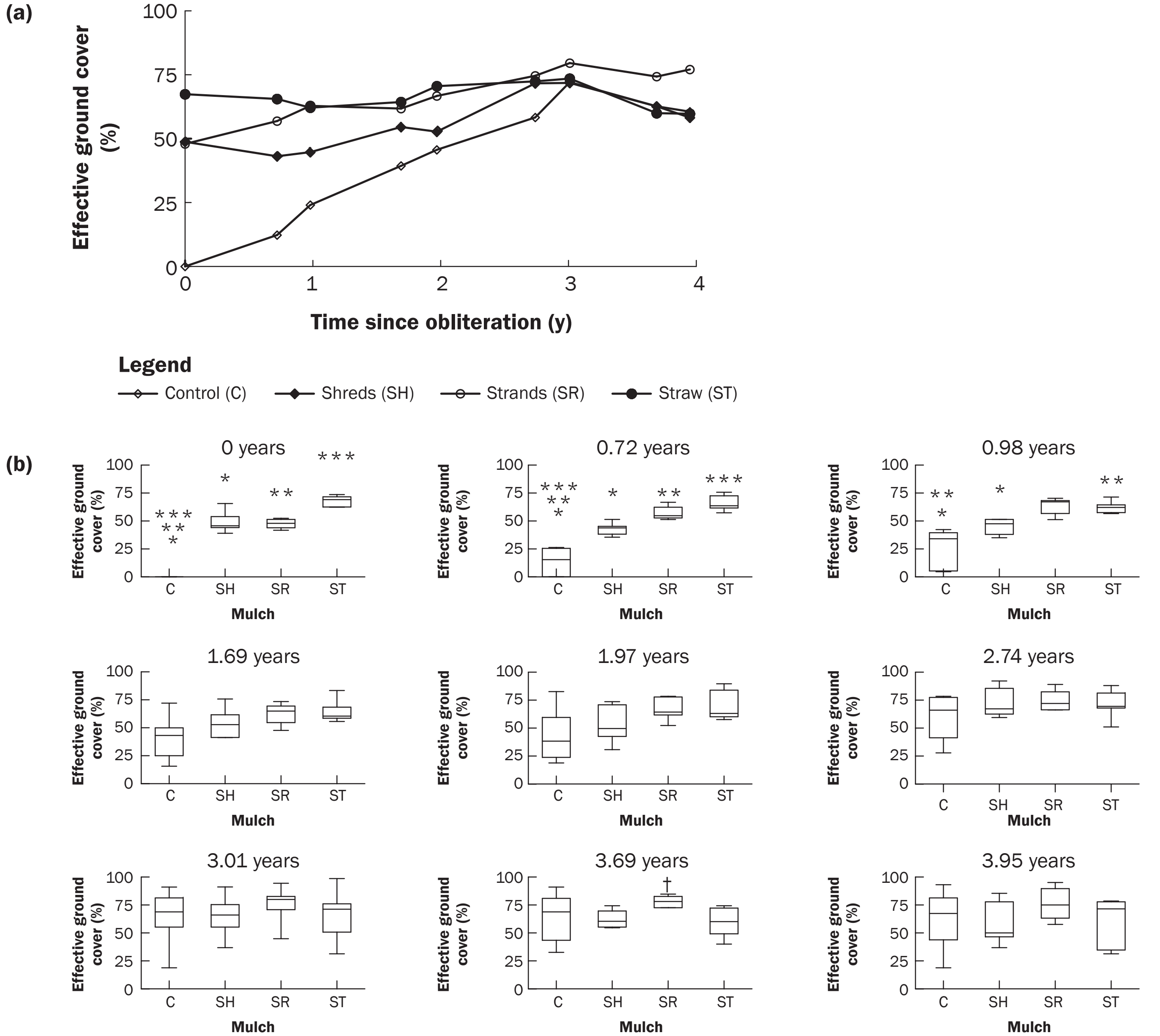
Figure 4

(a) Effective ground cover over time. (b) Individual box plots are shown to illustrate the range of measurements. Box plots have an upper horizontal line for the maximum observation. The top of box is the 75th percentile. The horizontal line in the box is the median observation. The bottom of the box is the 25th percentile. The lower horizontal line is the minimum observation. Outliers are indicated with a dagger (†). Statistically significant pairs have one, two, or three asterisks (*, **, or *).**



bined to reach 50% cover and another year to reach 70%. Effective ground cover never exceeded 75% during the four years of the study. A peak effective ground cover of 74% was attained after three years with effective ground cover declining slightly to 64% at the end of the study in year four.

Effective ground cover on the mulches and control did not change at the same rate. Up to 0.72 years after decommissioning, all of the mulches had significantly higher effective ground cover than the control. By 0.98 years, only wood strands and agricultural straw had significantly higher effective ground cover than the control. After two growing seasons (beyond 0.98 years), there was no difference among any of the mulches and the control. Beyond the second growing season, there were no statistical differences in effective ground cover and in sediment production. These observations suggest that an effective ground cover, plant plus litter plus mulch, of between 35% and 58% was needed to reduce sediment production from control and mulch plots to statistically indistinguishable values.

Impact of Mulches on Plant Regeneration. Plant cover, as represented by plant plus litter, was the same on the control plot as on each of the three sediment erosion treatments, i.e., there was no inhibition of plant regrowth by any of the three sediment erosion treatments. All four treatments began with no plant plus

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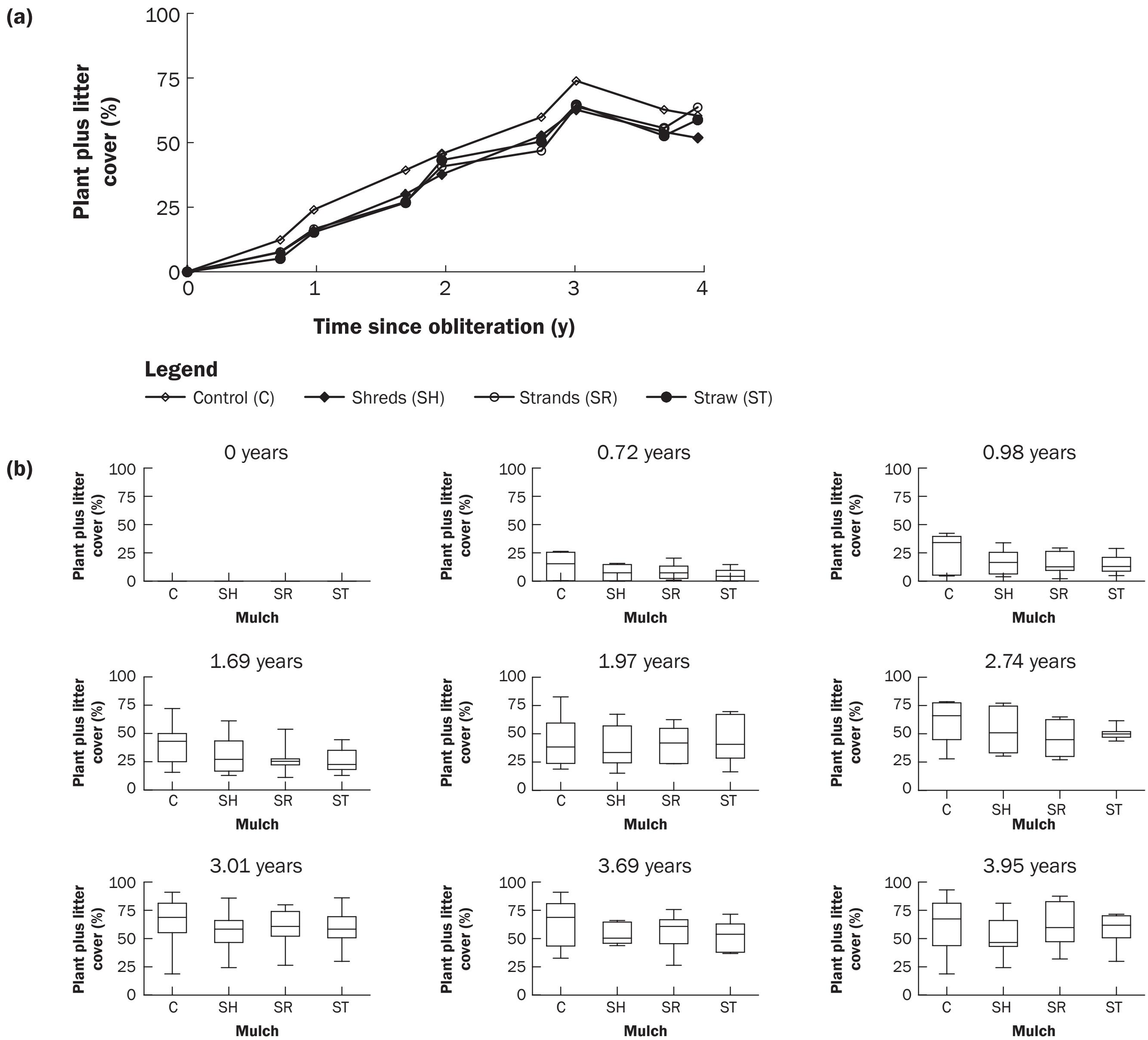
Figure 5

(a) Plant plus litter cover over time. (b) Individual box plots are shown to illustrate the range of measurements. Box plots have an upper horizontal line for the maximum observation. The top of box is the 75th percentile. The horizontal line in the box is the median observation. The bottom of the box is the 25th percentile. The lower horizontal line is the minimum observation.



litter cover. Figure 5 shows how plant plus litter cover for all the treatments changed over the course of the study.

Plant regrowth was not statistically different among the control and the treatment plots. All of them had plant growth at the same rate (approximately a 23% increase in vegetation cover per year) and peaked after three years (70%). This performance was consistent with the findings of Bautista et al. (1996, 2009), Badia and Marti (2000), Peterson et al. (2009), and Dodson and Peterson (2010), where each concluded that agricultural straw mulch increased plant growth after a wildfire. The present study extends these findings to wood shreds and wood strands.

Conservation Implication. Wood-based alternatives to agricultural straw are equally effective in reducing sediment production from originally bare, unvegetated soil strips that result from decommissioning forest roads. While wood strands demonstrated a slight advantage in persistence, the amount of effective ground cover provided by erosion reduction mulches and plant regrowth appeared to be more important than the type of mulch.

Summary and Conclusions

Agricultural straw is a widely used mulch for erosion mitigation. In forest settings, two wood-based alternatives are wood strands,

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an engineered product manufactured from veneer waste, and wood shreds, a product produced by a tub grinder. This four-year study of sediment production compared the effectiveness of these three mulches to a control with no erosion protection on the bare, loosely consolidated soil of a decommissioned road. Precipitation for the study period at the two locations was 105% to 108% above normal.

For the four years of the study, the average sediment production was greater on the bare control compared to the mulch treatments. There was no difference among the three mulch treatments due either to an insufficient number of plots for the amount and type of storms or because there was, indeed, no difference among the mulch treatments. Average sediment production from the wood shred mulch was not statistically different from the bare control. In the critical first year after the road decommissioning, only the wood strands had less sediment production than the control. After the first year, there were no statistically significant differences in sediment production.

Wood strands provided the highest average sediment mitigation compared to the control. They achieved this level of mitigation with 17 percentage points lower cover than the agricultural straw.

Beyond the first year, there was no statistical difference in mulch cover among wood shreds, agricultural straw, and wood strands, even though the agricultural straw started at 17 percentage points greater cover. Decline in mulch cover was similar for the agricultural straw and wood shreds with a half-life of 1.5 years. The wood strands were more persistent with a half-life of 2.3 years. The longer half-life of the wood strands could be valuable on disturbed sites that do not regenerate in less than two years. Short growing season and postfire sites are two examples where the longer half-life would be useful.

Effective ground cover, mulch cover plus plant and litter, reached 50% in slightly over a single growing season and reached 70% in an additional year. Although the controls initially had neither plant, litter, or mulch cover, in two growing seasons there was no difference in effective plant cover among the treatments and the control. Between 35% and 58% effective ground cover was needed to reduce sediment production from mulch and control plots to statistically indistinguishable values.

Plant regrowth was not impaired by any of the three mulches. Both the control and each of the three mulch treatments had plant growth rates of approximately 23% increase in vegetation cover per year.

The conservation implications of these research findings demonstrated that agricultural straw, wood shreds, and wood strands were equally effective in reducing erosion from the bare soil corridors that are a consequence of forest road decommissioning. In climates and soil types where revegetation occurs quickly, the type of mulch may be less important than the amount of ground cover provided by the mulch.

Disclaimer

The use of trade or firm names in this paper is for reader information and does not imply endorsement by the US Department of Agriculture of any product or service.

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