Castle Rock Fire Straw Monitoring Report

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Introduction

On August 16, 2007 a lightning storm crossing the Sawtooth National Forest ignited a fire near Castle Rock Peak, southwest of Ketchum, Idaho. The fire escaped initial attack efforts and burned into dense Douglas fir, grass, and sagebrush and by the third day was 600 acres.

The California Interagency Incident Management Team 3 assumed command of the incident on Monday, August 20. During the course of the incident, the city of Ketchum, Idaho, as well as portions of the Sun Valley Ski Resort were threatened. Evacuations in parts of Ketchum were put into effect and an area closure on the forest put into place. The fire was 100% contained on Tuesday, September 4, 2007 after burning 48,520 acres on the Sawtooth National Forest, and lands managed by the Bureau of Land Management and the Idaho Department of Lands.

In June 2008 approximately 188 acres of agricultural and 195 acres of wood straw mulch were treated via aerial application in seven treatment units ranging in elevation from 5,880 ft. to 8,520 ft (Figure 1). Treatments were intended to protect life and property downhill of burned slopes by reducing the potential for erosion, sedimentation, and debris flow initiation. Mulching would reduce downstream peak flows by absorbing and slowly releasing overland runoff which was likely to increase due to reduced soil cover and hydrophobic soil

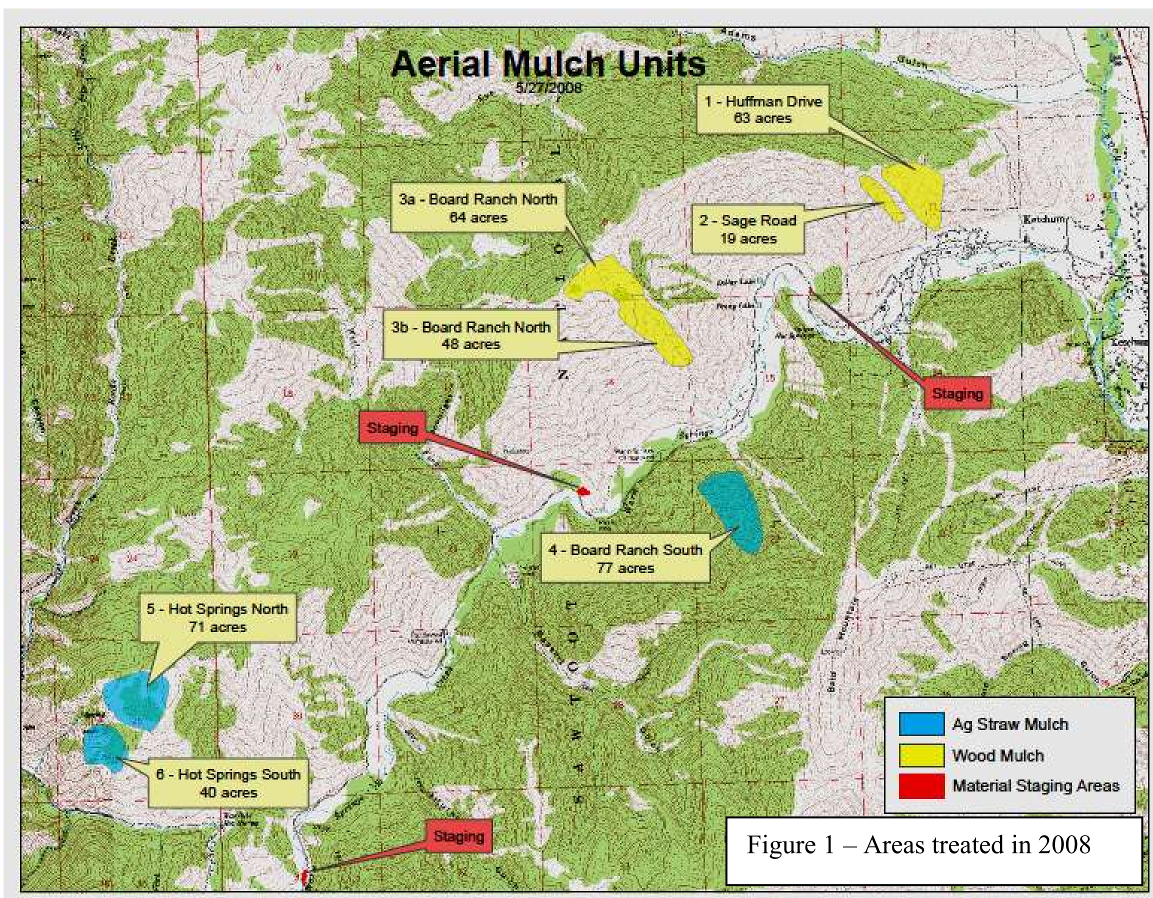

Figure 1 – Areas treated in 2008

conditions. Mulching would also help to protect the native seedbeds and retain moisture on the burned slopes to facilitate faster vegetative recovery of the treatment areas. Mulching treatments in the headwaters location would protect larger areas downslope from cumulative runoff and sedimentation.

Figure 2 – Homes below a burned micro-drainage

Field reviews after the BAER assessment by John Thornton (hydrologist Boise NF) and Pete Robichaud indicated that wood mulch was the best treatment above homes (Figure 2) because proposed units were prone to wind erosion and had no surface vegetation to breakup wind velocities or capture lighter windblown agricultural mulch. Wood straw was less prone to wind erosion than agricultural straw. In wind tunnel testing, wood strand mulch resisted wind velocities of up to 40 mi h^{-1} (18 m s^{-1}) while wheat straw mulch moved at 15 mi h^{-1} (6.5 m s^{-1}) (Copeland et. al. 2006). Heavier wood straw would also provide ground cover and hillslope protection for a longer period than agricultural straw. Although the cost of wood straw is significantly higher ($4,000 vs. $1,400/acre) than agricultural straw, it would likely remain on site longer and provide for a more effective ground cover helping to minimize downslope hazards to the high value properties at risk.

Mulch was applied on slopes between 0 and 60 percent in forest ecotypes, where needle cast was not expected and in non-forested ecotypes where wind erosion was a concern. Wood mulch was applied at uniform cover of 50 percent of the surface area of any treatment unit at approximately 0.5 inches to 0.75 inches thickness or 3 to 4 shafts deep. The length of wood mulch was between 2.5 to 6.5 inches. The width was no more than 3/16 of an inch and thickness of no more than 1/10 inch.

Agricultural straw was applied at a uniform cover of 70 percent of the surface area of any treatment unit at approximately 0.25 inches or 3 to 4 straw shafts deep but not to exceed 2 inches in depth. All straw had to conform to Idaho State Department of Agriculture (ISDA) certified noxious weed free standards. In addition all straw had to be free of to Bromus tectorum, commonly referred to as “cheatgrass”. Since cheatgrass is not considered a noxious weed by Idaho, the Forest Service completed additional testing by obtaining 1 liter samples from 10 randomly selected bales from each 30 bale stack or lot prior to loading and shipping from the field. Samples were submitted to a local lab that followed Association of Official Seed Analysts (AOSA) testing protocols.

All mulch from any 30 bale stack or lot was rejected if the respective sample tests positive for noxious weeds. When lab testing determines a core sample to be certified noxious weed free, the sample was analyzed for viable Bromus tectorum seeds using a standard 200 seed viability TZ test. All mulch from any 30 bale stack or lot will be rejected if more than 50 percent of the 200 count viability test results in viable Bromus tectorum seed.

The rate of application was determined by six contract inspectors who had been trained in the principles of BAER treatments and the contractor. Inspectors were located in safe locations within each treated unit while the mulch was applied. After multiple drops, inspectors would walk through the unit to evaluate the amount and depth of applied mulch. Inspectors would also establish several transects within each treated area. To determine ground cover, surveyors would complete a 100 pace transect reaching down at the toe of their boot and identifying whether live vegetation, litter/duff, straw, or rock (>3/4") was encountered. Results were summarized to determine the composition and percent ground cover for each transect. Photo points were also established at the beginning and end of each transect looking into each transect. An ocular estimate of ground cover using the same categories was also made for the overall treatment area.

As part of the initial BAER request, funding was secured to conduct monitoring of the straw mulch application. The purpose of the monitoring was to determine if objectives had been met for the application and effectiveness of the overall treatment. The primary indicators are an estimate of ground cover resulting from aerial application and condition of straw mulch for mitigating raindrop impact erosion and overland flow.

Methods

Field surveys of treated areas were conducted in on August 17-19, 2009 to review application and recovery 14 months after treatment. Two person crews resurveyed transects in each unit established during implementation. A total of 21 transects (Board Ranch North – 4, Board Ranch South – 2, Sage Road – 3, Huffman Drive – 4, Hot Springs North – 3, and Hot Springs South – 4) were sampled.

For each site ground cover was collected using the same technique during project implementation (i.e. 100 pace transects categorizing cover according to live vegetation, straw, etc.). Photos were also retaken in each transect and within each treated unit. Results were summarized to determine the composition and percent ground cover for each transect. A series of questions were also answered within each treated area that addressed how well the treatment met the overall objectives. Questions focused on: (1) How well the straw mulch minimized overland flow and erosion; (2) How much regrowth had taken place; and (3) How thick and dispersed was the overall application?

Results

Condition of treatment 14 months after application

Of the 21 treated sites monitored 10 (48%) still had relatively good straw coverage 14 months after application. All of these sites were treated with wood straw except for one in the lower portion of Board Ranch South. Only a few sites in the Hot Springs North unit had excessive clumping that inhibited growth of grasses and forbs (Figure 3). These sites were some of the first areas flown in 2008 and the helicopter pilots were still adjusting their drop heights and airspeeds. So it was not surprising some clumping of agricultural straw occurred. As the helicopter drops progressed through the project the contractor adjusted their straw preparation and application techniques resulting in very little clumping of remaining units. Only minor clumping was found in the wood straw units due in part to excellent preparation (i.e. ramming and dropping wood straw bales with a fork lift) of the wood straw before it was loaded into cargo nets.

Figure 3 - Heavy Straw in portion of Hot Springs North unit in 2008

Originally there was good coverage of agricultural straw after it was applied. However, very few sites in 2009 still retained this coverage (Figures 4 and 5). Straw that remained mainly occurred in lower or mid slope areas of each unit, or behind large rocks, trees, low lying shrubs or in shallow depressions protected from the wind. It is unknown how long the agricultural straw remained in place. But clearly this material did not provide ground cover for the desired length of time. All of the treated hillslopes were subjected to

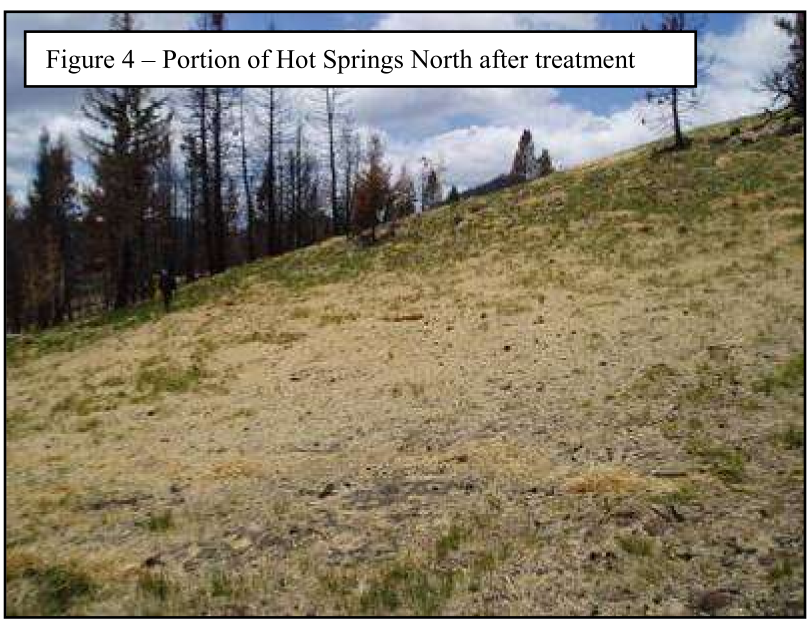

Figure 4 – Portion of Hot Springs North after treatment

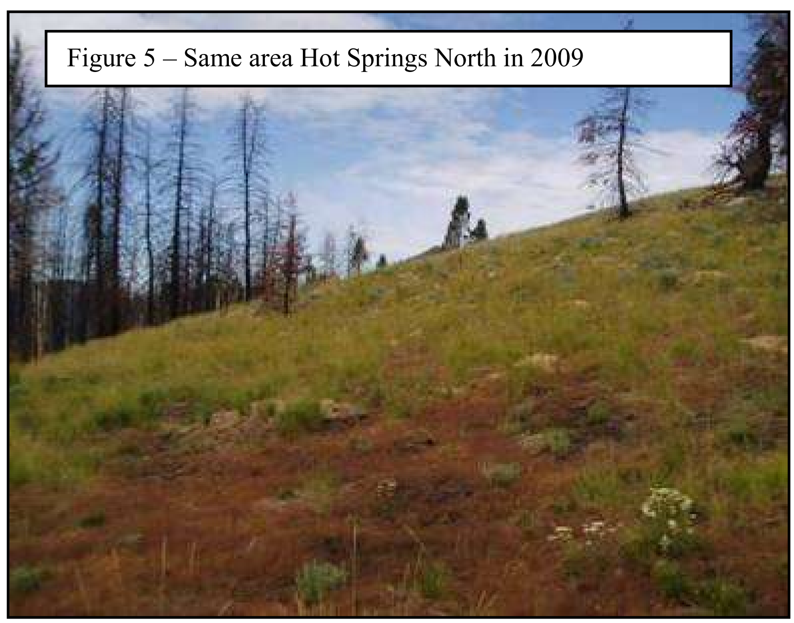

Figure 5 – Same area Hot Springs North in 2009

periodic high winds so clearly the lightweight agricultural straw lacked the needed stability to stay in place. As mentioned previously, wind tunnel testing showed that wheat straw mulch moved at 15 mi h^{-1} (6.5 m s^{-1}) vs. 40 mi h^{-1} (18 m s^{-1}) for wood strand mulch (Copeland et. al. 2006).

Ground Cover

Ground cover present 14 months after treatment varied greatly from site to site. Eight sites (38%) had more, 12 sites (57%) had less, and one site (5%) had the same ground cover compared to surveys completed in 2008 (Tables 1 and 2). Sites where ground cover increased were due to more vegetative recovery and litter/duff from sagebrush or dead cheatgrass than straw mulch. Straw mulch actually decreased by 25% (11 to 41% range) at sites where overall ground cover was higher. This loss of straw mulch is similar to sites where overall ground cover also decreased due to less cover from vegetation and litter/duff.

Eleven of the 12 transects where wood straw was applied had less mulch over the monitored timeframe (Figures 6 and 7). Wood mulch sites averaged a 19.8% (1 to 56% range) decrease in straw than the previous year. All nine transects where agricultural straw was applied also had less mulch. Agricultural mulch sites averaged a 30.7% (5 to 58% range) decrease in straw than what was present after application in 2008. Decreases were due to agricultural and some wood straw being moved by wind especially near ridges, wood or wheat strands settling or decaying to less than the required thickness to be included as ground cover, the original transect line being missed and not resurveyed, and/or observer variability in how ground cover was classified.

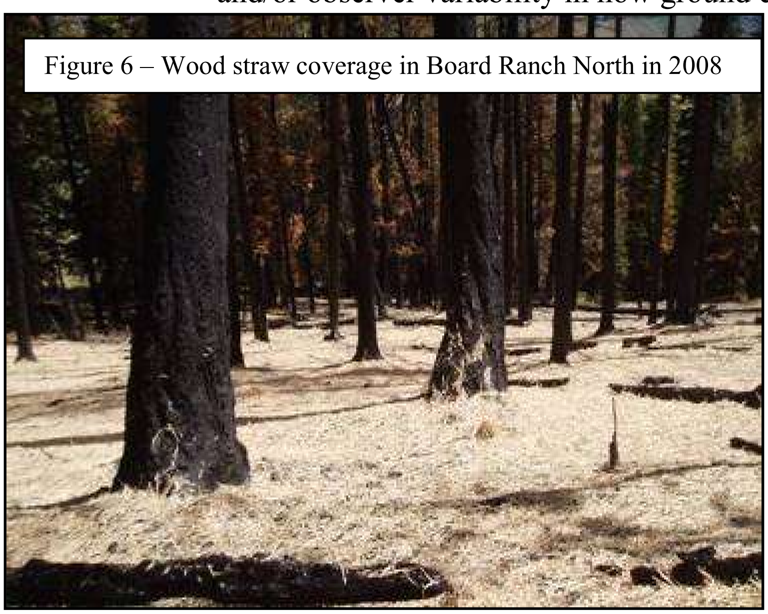

Figure 6 – Wood straw coverage in Board Ranch North in 2008

Figure 7 – Wood straw coverage in Board Ranch North in 2009

Although straw coverage decreased at most sites, it is still providing some ground cover and hillslope protection especially at the wood straw sites. Wood mulch ground cover averages 29.3% (0-39% range) and agricultural mulch averages 20.1% (14 to 44% range). Without mulch ground cover would only average 54% over all treated transects.

This would still be less than the 70% ground cover for south facing slopes before the fire. Straw mulch also helped retain higher soil moisture retention, which may have increased seed germination and recovery.

Table 1 - Percent ground cover within transects in areas treated with agricultural straw.

Unit	Transect	Year	Bare Ground	Rock	Straw	Litter/Duff	Live Vegetation	Total Ground Cover
Hot Springs South								
	T-1	2009	24	8	39	5	24	76
		2008	5	2	77	2	14	95
Change	--	--	**+19%**	**+6%**	**-38%**	**+3%**	**+10%**	**-19%**
	T-2	2009	36	0	11	17	36	64
		2008	13	0	69	4	14	87
Change	--	--	**+23%**	--	**-58%**	**+13%**	**+22%**	**-23%**
	T-5	2009	1	20	25	20	34	99
		2008	22	15	48	1	14	78
Change	--	--	**-21%**	**+5%**	**-23%**	**+19%**	**+20%**	**+21%**
	T-6	2009	18	24	12	9	37	82
		2008	28	9	48	2	13	72
Change	--	--	**-10%**	**+15%**	**-36%**	**+7%**	**+24%**	**+10%**
Hot Springs North								
	T-1	2009	39	7	0	8	46	61
		2008	32	1	30	7	30	68
Change	--	--	**+7%**	**+6%**	**-30%**	**+1%**	**+16%**	**-7%**
	T-2	2009	14	2	14	4	66	86
		2008	21	6	46	5	22	79
Change	--	--	**-7%**	**-4%**	**-32%**	**-1%**	**+44%**	**+7%**
	T-3	2009	22	4	30	12	32	78
		2008	19	7	35	7	32	81
Change	--	--	**+3%**	**-3%**	**-5%**	**+5%**	**--**	**-3%**
Board Ranch South								
	T-6	2009	2	16	16	0	66	98
		2008	33	18	50	2	0	70
Change	--	--	**-31%**	**-2%**	**-34%**	**-2%**	**+66%**	**+28%**
	T-7	2009	18	14	34	28	6	82
		2008	4	18	54	23	2	97
Change	--	--	**+14%**	**-4%**	**-20%**	**+5%**	**+4%**	**-15%**

Table 2 - Percent ground cover within transects in areas treated with wood straw.

Unit	Transect	Year	Bare Ground	Rock	Straw	Litter/Duff	Live Vegetation	Total Ground Cover
Huffman Drive								
	H-1	2009	40	4	41	4	11	60
		2008	11	8	42	1	38	89
Change	--	--	**+29%**	**-4%**	**-1%**	**+3%**	**-27%**	**-19%**
	H-2	2009	40	11	25	19	5	60
		2008	11	1	58	0	30	89
Change	--	--	**-29%**	**-10%**	**-33%**	**+19%**	**-25%**	**-29%**

	H-3	2009	41	0	35	7	17	59
		2008	15	5	62	1	17	85
Change	--	--	**+26%**	**-5%**	**-27%**	**+6%**	**--**	**-26%**
	H-4	2009	22	20	34	12	12	78
		2008	36	1	45	1	17	64
Change	--	--	**-14%**	**+19%**	**-11%**	**+11%**	**-5%**	**+14%**
	H-5	2009	33	0	38	18	11	67
		2008	24	1	64	0	11	76
Change	--	--	**+9%**	**-1%**	**-26%**	**+18%**	**--**	**-9%**
Sage Road								
	S-1	2009	27	12	17	33	11	73
		2008	15	6	73	6	0	85
Change	--	--	**+12%**	**+6%**	**-56%**	**+27%**	**+11%**	**-12%**
	S-2	2009	14	0	27	47	12	86
		2008	25	0	68	1	6	75
Change	--	--	**-11%**	**--**	**-41%**	**+46%**	**+6%**	**+11%**
	S-3	2009	26	9	23	30	12	74
		2008	10	24	56	0	10	90
Change	--	--	**+16%**	**-15%**	**-33%**	**+30%**	**+2%**	**-16%**
Board Ranch North								
	BRNT-1	2009	12	16	44	16	12	88
		2008	21	1	57	12	0	79
Change	--	--	**-9%**	**+15%**	**-13%**	**+4%**	**+12%**	**+9%**
	BRNT-2	2009	33	6	36	10	15	67
		2008	10	51	14	8	17	90
Change	--	--	**+23%**	**-45%**	**+22%**	**+2%**	**-2%**	**-23%**
	BRNT-3	2009	26	12	14	38	10	74
		2008	41	16	25	4	14	59
Change	--	--	**-15%**	**-4%**	**-11%**	**+34%**	**-4%**	**+15%**
	BRNT-4	2009	26	17	18	9	30	74
		2008	26	22	26	8	18	74
Change	--	--	**--**	**-5%**	**-8%**	**+1%**	**+12%**	**--**

Rill erosion and debris flows

Five of the six treated hillslopes are on south facing aspects that were dominated by sagebrush, grasses, and pockets of conifers near ridges before the fire. Transects completed during the BAER assessments showed that portions of these non-forested slopes burned at high severity due to thick pockets of sagebrush increasing the fire's residence time at the soil's surface. The fire also removed all

Figure 8 – Vegetation in Huffman Drive unit 2 years after fire

vegetative ground cover leaving only coarse gravel-sized rock fragments in volcanic derived soils and coarse sand/small rock in Batholith derived soils.

Figure 9 – Rill erosion from untreated north facing slope.

Field reviews during project implementation in 2008 (9 months after the fire) and in 2009 (14 months after the fire) found very few visible signs of overland flow, rill erosion or debris flows on any south facing aspect. This may be due to several factors. First, none of the burned hillslopes were subjected to high intensity rains in 2008 when ground cover was still sparse and hydrophobicity was higher. Higher intensity rains (0.3-0.4"/hour) did not occur until the late May and June of 2009. By this time grasses and forbs had recovered on most of the south facing slopes leaving fewer areas of exposed soils to erode (Figure 8). Vegetative ground cover minimized rainsplash and sheet erosion by intercepting precipitation before it hit the soil's surface. Hydrophobic soils had also not reestablished by late spring allowing water infiltration into the soil.

Second, higher burn severities on south facing slopes may have not been as wide spread or lasted as long as the BAER assessment concluded. Sagebrush slopes typically have limited ground fuels and lower fire residence times to cause higher severities. It is possible transects completed during the rapid BAER assessment did not sample enough of the treated south facing slopes to characterize the variability in burn severities across the area. It is also possible that hydrophobic soils were shorted lived in the treated areas because vegetation quickly recovered one year after the fire. Benavides-Solorio and MacDonald (2001) found that plant roots increased soil water infiltration and helped to break down hydrophobic soils. Climate variations are more common on exposed south-facing, non-forested sites. Wetting-drying, freeze-thaw, are more prevalent as vegetation (or lack of) does not buffer or influence under canopy microclimate.

Figure 10 – Debris fans below untreated north facing slope.

Finally, surveys completed in August, 2009 found that wood straw generally provided better ground cover than agricultural straw because it was not as easily blown off the site. Wood mulch may have diminished rainsplash and sheet erosion in some locations where enough remained to increase ground cover when heavy rains arrived in 2009.

Rill erosion was only found within a few conifer stands on south facing slopes and more so on untreated north facing slopes that burned at a higher intensity and severity. These areas are characterized by high water repellency, limited ground cover, loss of litter/duff layer, and sparse overstory (Figure 9). Overland flow on north facing slopes from intense rainfalls of 2009 caused rill erosion that collected into smaller and larger channels. Since the terrain is very steep, debris torrents quickly gained momentum continuously scouring channels over several miles until they reached the valley floor creating multiple alluvial fans (Figure 10).

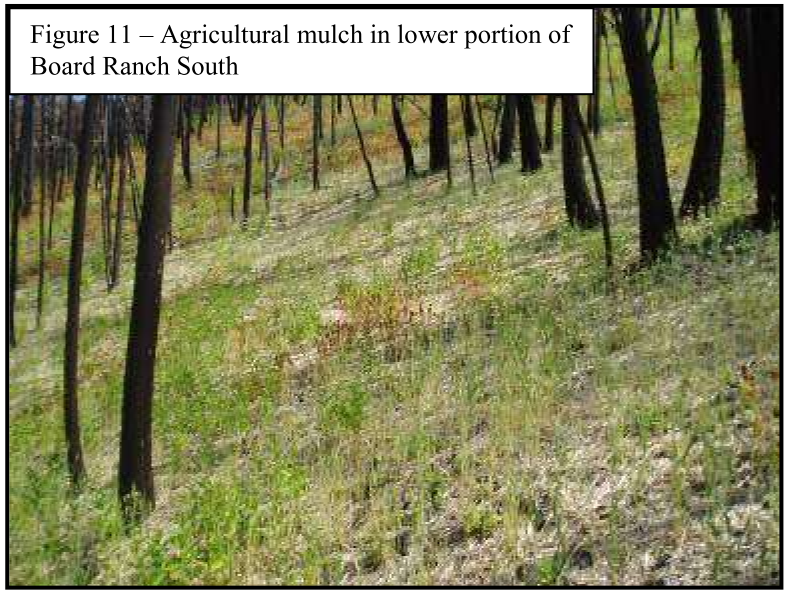
Figure 11 – Agricultural mulch in lower portion of Board Ranch South

Surprisingly very little rill erosion or channel scour was found within or below the "Board Ranch South" treatment unit. This may be due to increased ground cover provided by the agricultural straw. While much of the straw in the upper portion of this unit was sparse 14 months after application there was still good mulch coverage in the more protected middle and lower portions (Figure 11). Field observations found that mulch also created surface obstructions or small straw plies when heavy rains caused overland flow in 2009. These straw piles appear to have slowed runoff and minimized rill formation. Other studies (Foltz and Copeland 2009, Groenier and Showers 2004, Pannkuk and Robichaud 2003) have found similar results when long-stranded mulches were applied. The mulch coupled with the coarse rock content in the upper portions of the unit may have helped to minimize rilling. Several headwater channels with mulch ground cover showed only minor overland flow. While untreated hillslopes adjacent to the treated areas shows significantly more rill erosion (Figure 12) and channel scour resulting in a small debris flow.

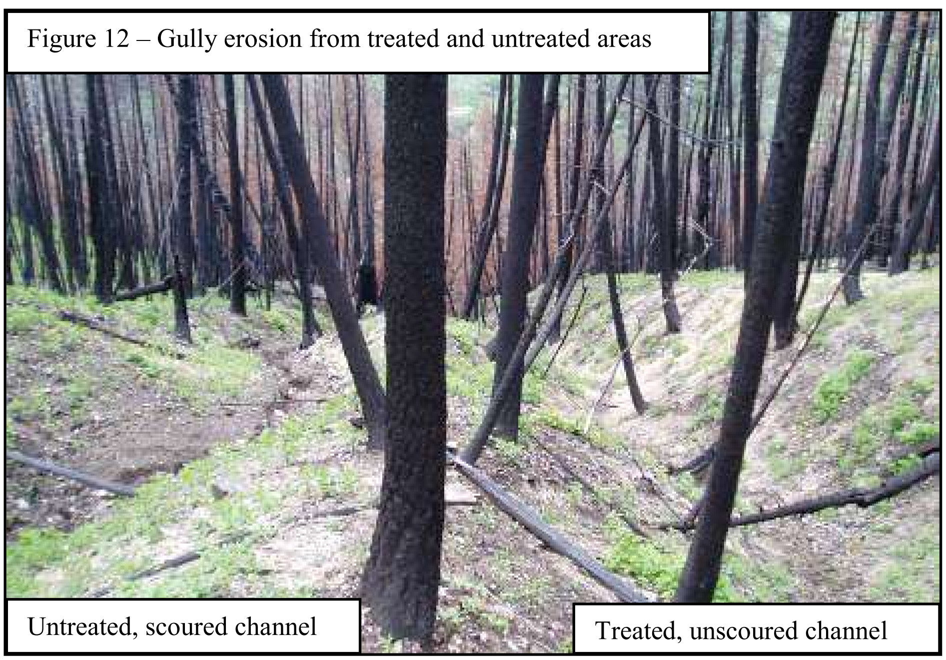

Figure 12 – Gully erosion from treated and untreated areas

Conclusions

Approximately half of the treated areas still had adequate straw coverage 14 months after application. Areas with the best remaining coverage were predominantly treated with wood straw except for a portion of the Board Ranch South treatment area. Very few sites in 2009 still retained agricultural straw. Straw that remained occurred mainly behind large rocks, trees, low lying shrubs, shallow depressions, or other protected areas of each unit. Sites where ground cover increased were due to more vegetative recovery and litter/duff from sagebrush or dead cheatgrass than straw mulch.

Almost all sites had less straw coverage, with wood mulch decreasing 19.8% and agricultural mulch decreasing 30.7%. Decreases were due to agricultural and some wood straw being moved by wind especially near ridges, wood or wheat strands settling or decaying to less than the required thickness to be counted as ground cover, some original transect lines being missed and not resurveyed, and/or observer variability.

Mulch did not reduce vegetative ground cover in any of the treated areas. Grass, forbs, and small woody species were able to easily grow through the wood and agricultural mulch. Only a few sites in the Hot Springs North unit had excessive clumping that inhibited regrowth of grasses and forbs.

It is difficult to determine how much mulch reduced runoff and rill erosion on south facing slopes since none of the burned hillslopes were subjected to high intensity rains in 2008 when ground cover was still sparse and hydrophobicity was higher. By the time heavy rains arrived in 2009 grasses and forbs had recovered on most of the south facing slopes leaving less exposed soils to erode. Mulch did appear to help minimize rill erosion and debris flow initiation on the north facing slope under 2-year storm 21 months after the fire because the straw coverage remained intact. This helped retain soils and enable regrowth of grasses and forbs.

Although straw coverage decreased at most sites, it is still providing some ground cover. This coverage has helped to protect hillslopes especially at the wood straw sites until enough revegetation took place. In hind sight, it would have been better to treat all areas with wood mulch since this product lasts much longer than agricultural straw. This is especially true on north facing slopes that burned hotter and still do not have adequate vegetative ground cover nearly two years after the fire. Costs would have been much higher (another $600,000) to complete the entire project with wood mulch. It would have also taken longer for the contractor to acquire enough mulch to treat the entire project area, potentially delaying the project by several weeks. However, these issues must be weighed against the values and post-fire risks that these treatments are intended to minimize. The BAER assessment concluded these risks were very high to life and property immediately downslope of the fire. So any additional protection would have been worth the higher costs. However, in areas were risks to life and property are lower less costly treatments should be considered.

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