Research Report

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The effects of straw mulching on post-wildfire vegetation recovery in southeastern British Columbia

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Abstract

Following the severe wildfire season of 2007 in southeastern British Columbia, straw mulching was used to stabilize soil on burned hillslopes and to reduce the risk of debris flows and flooding after the fires. The effects of the straw mulch on vegetation recovery and the introduction of invasive species were studied in two elevation classes over 2 years following the fires. The study measured percent of live vegetation cover including native, non-native, and invasive species in mulched and untreated control plots in high-severity burns. Total percent vegetation cover was not significantly different between treatments in either elevation class. A slightly slower rate of vegetation growth in mulched sites may suggest that mulch inhibits growth. Invasive species were present prior to mulching in both elevation classes. In the low-elevation class, the invasive species cover increased in both treated and control plots and in both years of the study. High-elevation plots showed a decrease in invasive species in the second year. Non-native species introduced with the mulch did not increase after the first year in either elevation class. This study shows that the use of straw mulch as an erosion control treatment has minimal effects on vegetation growth, but considerable effort should be taken to access mulch that does not contain seed to prevent the introduction of invasive species.

KEYWORDS: *invasive species; southeastern British Columbia; straw mulching; vegetation recovery; wildfire.*

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Introduction

In 2003, drought conditions in southern British Columbia lead to extremely dry fuel and soil conditions. Intense fires resulted in large, severely burnt areas where there was complete consumption of forest floor and ground vegetation. The numerous severe erosion events that followed the fires (Jordan and Covert 2009) led to the development of a risk assessment and erosion mitigation procedure for British Columbia based on methods used by the U.S. Forest Service (Jordan et al. 2006).

The loss of vegetation cover and the changes that occur to the soil as a result of high-severity burns can lead to significant increases in the intensity and frequency of erosion events after wildfire (Gartner et al. 2005; Curran et al. 2006; Scott et al. 2009). The aerial application of mulch on severely burned hillslopes is a common and successful technique used in the United States to reduce soil erosion after wildfire. The mulch provides an immediate, protective soil cover that reduces raindrop impact, prevents soil sealing, promotes infiltration, and slows runoff (MacDonald and Robichaud 2007; Robichaud et al. 2009). Straw mulch is relatively inexpensive compared to other mulch types, and often readily available (Groen and Woods 2000; Robichaud et al. 2000); however, straw is lightweight and can be blown by the wind, resulting in uneven distribution. It also has the potential to contain non-native and invasive plant seeds (Robichaud et al. 2009). Other mulches, such as wood shreds, hydro-mulch, wood pellets, and wood chips, are more expensive to apply and have varying success at erosion control, but are less likely to contain weed seed or be windblown.

There is limited research on the ecological impacts of straw mulch and how it affects the re-establishment of native vegetation and tree seedlings in the United States (Kruse et al. 2004; Beyers et al. 2006; Robichaud et al. 2009). According to many agricultural studies, straw mulch helps vegetation growth and plant yield by creating more favourable growing conditions such as weed suppression, moderated soil temperatures, increased soil moisture by reducing losses to evaporation, reduced soil compaction from raindrop impact, and increased nutrient availability (Moody et al. 1963; Bhatt and Khera 2006). These are all desirable secondary benefits; however, little research has examined these effects in forested environments.

As the use of straw mulching after wildfires in British Columbia continues, there will be a need for information on not only the effects on erosion response, but also the ecological response of vegetation to mulching.

Where mulching studies have been done in forested environments, findings suggest that mulching may slow natural regeneration as well as increase the potential for invasive species introduction. A study of post-fire revegetation after mulching in northern California in 1999 showed significantly greater numbers of non-native plant species in plots treated with straw mulch, indicating that the straw may suppress natural vegetation and introduce weed species. Researchers found no significant increase in vegetative cover in treated plots compared to untreated plots, and significantly fewer conifer seedlings in mulched sites (Kruse et al. 2004). Similarly, Beyers et al. (2006) found that sites in Arizona and California treated with thick mats of mulches had slower vegetation recovery than sites treated with wood pellets or hydro-mulch. Robichaud et al. (2009) suggested that vegetation cover was slightly lower in mulched sites than in untreated sites, and that vegetation recovery was better in evenly distributed mulch than where mulch was clumped.

Based on post-fire risk assessments of fires in 2007, straw mulch was applied to severely burned slopes for erosion control for the first time in British Columbia.[1,2] As the use of straw mulching after wildfires in British Columbia continues, there will be a need for information on not only the effects on erosion response, but also the ecological response of vegetation to mulching. The objectives of this study were to determine how the straw mulch affected the regeneration of native,

1 Jordan P.J., D. Gluns, A. Covert, and M. Curran. 2007. Sitkum Creek fire, 2007, N70347 post-wildfire risk analysis. B.C. Ministry of Forests and Range, Forest Science Section, Southern Interior Forest Region, Nelson B.C. Prepared for B.C. Ministry of Forests and Range, Southeast Fire Centre, Southern Interior Forest Region, and Kootenay Lake Forest District. Unpublished report.

2 Nicol, D.R., Geotech Engineering Ltd. 2007. Springer Creek fire number 50372 post-wildfire risk analysis. Prepared for B.C. Ministry of Forests and Range, Southeast Fire Centre. Unpublished report.

TABLE 1. Site characteristics of study fires

	Pend d'Oreille	Springer	Sitkum
Nearest town	Trail	Village of Slocan	Nelson
Mean annual precipitation (mm)[a]	880	971	1289
Slope of plot area (%)	35–90	40–64	31–38
Aspect (°)	SW–SE	NW–SW	NE–SE
Elevation of plot area (m)	1145, 1330	1465–1560	1700
Rock type[b]	Mudstone, siltstone, shale/ undivided sedimentary	Granodioritic intrusive rock	Granodioritic intrusive rock
Soil texture	FSL, SL	LS	LS/SL
Soil group[c]	Orthic Dystric Brunisol	Orthic Humo-Ferric Podzol	Orthic Humo-Ferric Podzol
Biogeoclimatic zones[d]	ICHdw1, mw2	ICHmw2,ESSFwc1	ESSFwc4
Mulched/control plots (#)	4/4	3/4	2/2
Date of mulch application	October18, 2007	August 29, 2007	October 12, 2007
Elevation class	Low	High	High

[a] (Mount 2007)
[b] (Massey 2005)
[c] (Jungen 1980)
[d] (Braumandl and Curran 1992)

non-native, and invasive vegetation in two elevation classes for 2 years following the fires.

Study area and plot layout

Study sites for this project were selected from three large fires that burned in southern British Columbia in 2007: Springer (SP), Sitkum (SK), and Pend d'Oreille (PO). Operational aerial mulch was recommended and applied to slopes on the Sitkum and Springer burns with high erosion risk to residential areas or highways.[3,4] No high-risk slopes were identified at the Pend d'Oreille burn, and it was not operationally mulched for erosion control,[5] but several research plots were established for research purposes. Table 1 shows the different fires and their site characteristics.

A total of 31 siltfence plots (3 × 15 m) were located at the three fires for a separate study to determine the effects of different mulch treatments on sediment yield. All of the plots were located in areas with high vegetation where the forest canopy was completely burned and the forest floor consumed, leaving little to no forest floor or vegetation, based on the severity classifications used in British Columbia (Curran et al. 2006). Plots were located in areas of previously mature standing timber on relatively straight slopes with the following features: similar slope gradient; minimal bedrock or boulder cover; no gullies or rills that could concentrate drainage; no excessive soil disturbance such as skid trails; and soil that was not so stony that it would prevent siltfence installation. Plots were established in groups of two to four, and mulch treatments were randomly assigned to half of the plots. The other half remained as replicated control plots. For this study, 19 of the total plots (9 control and 10 straw mulch) were selected to determine the effects of agricultural straw mulch on vegetation recovery. The low-elevation class had four replicates in both the control and treatments. The high-elevation class had five treated and six control replicates. The low replication rate was a result of stratifying the plots into the two elevation classes after realizing the influence of different elevation on the vegetation growth rates. The effects of elevation are described in the results section.

Mulched plots at the Springer and Pend d'Oreille burns were treated by hand with annual fall rye straw

3 Jordan et al., 2007.
4 Nicol, 2007.
5 Alcock, J. 2007. Pend d'Oreille wildfire N50523 post-wildfire risk analysis final report. Prepared for B.C. Ministry of Forests and Range, Southeast Fire Centre, and Arrow Boundary Forest District. Unpublished report.

(*Secale cereale*) grown in Oliver, British Columbia. The plots on the Sitkum burn were established in areas that was aerially mulched from a helicopter with wheat straw (*Triticum aestivum*) sourced from Olds, Alberta. One of the control plots at Sitkum was covered with a cloth prior to mulch application, and the cloth was removed after the treatment was completed. The other control plot was located in an untreated area adjacent to a treated plot. The Springer plots were established in August 2007; the Pend d'Oreille and Sitkum plots were installed in October 2007.

Plots were divided into two elevation classes for the analysis. The 11 plots at Sitkum and Springer were grouped together into the high-elevation class because of their similar elevation, soil, and rock type; the eight plots at Pend d'Oreille were analyzed separately in the low-elevation class. Table 2 provides a summary of the grouping of plots into the two classes and their different plot characteristics, including the initial mulch cover and the subsequent vegetation cover in the following two years of the study.

Methods

Mulch was applied to achieve approximately the recommended 60–70% cover for erosion control (Robichaud et al. 2009); however, measured cover was higher on several of the plots.

Percent cover was measured immediately after the plots were installed in 2007, and again at the peak of the growing season in August 2008 and July 2009. The total

TABLE 2. Plot characteristics for low- and high-elevation study sites

Fire	Treatment	Biogeoclimatic label	Slope (%)	Aspect	Elevation (m)	Mulch cover 2007 (%)	Vegetative cover 2008 (%)	Vegetative cover 2009 (%)
LOW-ELEVATION STUDY SITES								
PO	Control	ICH mw2	40	S	1330	0	16	82
PO	Control	ICH mw2	35	SW	1330	0	18	50
PO	Control	ICH dw	73	SE	1145	0	25	97
PO	Control	ICH dw1	90	SW	1145	0	16	77
PO	Mulch	ICH mw2	40	S	1330	82	51	49
PO	Mulch	ICH mw	35	SW	1330	89	17	46
PO	Mulch	ICH dw1	70	SE	1145	79	30	67
PO	Mulch	ICH dw1	80	SW	1145	65	21	69
HIGH-ELEVATION STUDY SITES								
SK	Control	ESSFwc4	31	E	1700	0	17	55
SK	Control	ESSFwc4	38	SE	1700	0	2	8
SP	Control	ESSFwc1	42	SW	1540	0	2	2
SP	Control	ESSFwc1	40	SW	1540	0	7	35
SP	Control	ICH mw2	55	W	1500	0	45	90
SP	Control	ICH mw2	64	NW	1490	0	6	16
SK	Mulch	ESSFwc4	31	E	1700	64	19	36
SK	Mulch	ESSFwc4	38	SE	1700	69	7	13
SP	Mulch	ESSFwc1	45	W	1540	73	18	51
SP	Mulch	ESSFwc1	40	SW	1540	80	3	36
SP	Mulch	ICH mw2	60	NW	1500	70	12	23

ground cover was tallied at 100 points on a 10 cm grid, covering a total of 1 m^2 on each siltfence plot. Ground cover was categorized into rock, wood, straw, herbs and shrubs, litter, ash, moss, or mineral soil. Herb and shrub and moss cover were combined to calculate the total percent cover of vegetation for each year (Table 2). Species distribution was estimated on the larger siltfence plots; percent vegetation cover on the smaller plot was multiplied by the percent distribution of the plant species on the larger plot and then used to estimate the percent cover of native, non-native, and invasive species on each siltfence plot. In this study, non-native refers to domestic species such as annual fall rye and wheat that sprouted from the seeds of the straw.

Regression analysis was used to compare and identify correlation between site factors (slope, aspect, elevation, percent mulch cover, soil type, nutrient content) and total vegetation cover. This was done using the analysis of variance (ANOVA) output from the Data Analysis Tool pack in Microsoft Office Excel 2007 (Microsoft Corporation).

A split-plot design with ANOVA was used for each site to compare means between treatments and years and to determine whether there was an interaction between treatment and year at a probability of 0.05. The analysis was done using JMP statistical software (SAS Institute Version 5.1 1989).

Results

The strongest correlation of site factors was a negative relationship between elevation and the total amount of vegetation cover (ANOVA; $R^2 = 0.51$, $Prob > F = 0.001$; Figure 1). Soil texture and nutrient content were also correlated in a similar way to elevation. These factors as well as growing condition and rock type were justification for dividing the plots into the different elevation classes for the final analysis (Tables 1 and 2). Springer and Sitkum plots were combined into the high-elevation class and the Pend d'Oreille plots were analyzed separately in the low-elevation class.

Mean vegetation cover

The photos in Figures 2–5 show the change in vegetation cover on a mulched and a control plot in both the high- and low-elevation classes in (a) 2007, (b) 2008, and (c) 2009. On all plots across both sites, there was no vegetation cover in 2007 (Figures 2a–5a). The 2008 data in Tables 3, 4, and 5 indicate not only the mean vegetation cover, but also change in cover between 2007 and 2008.

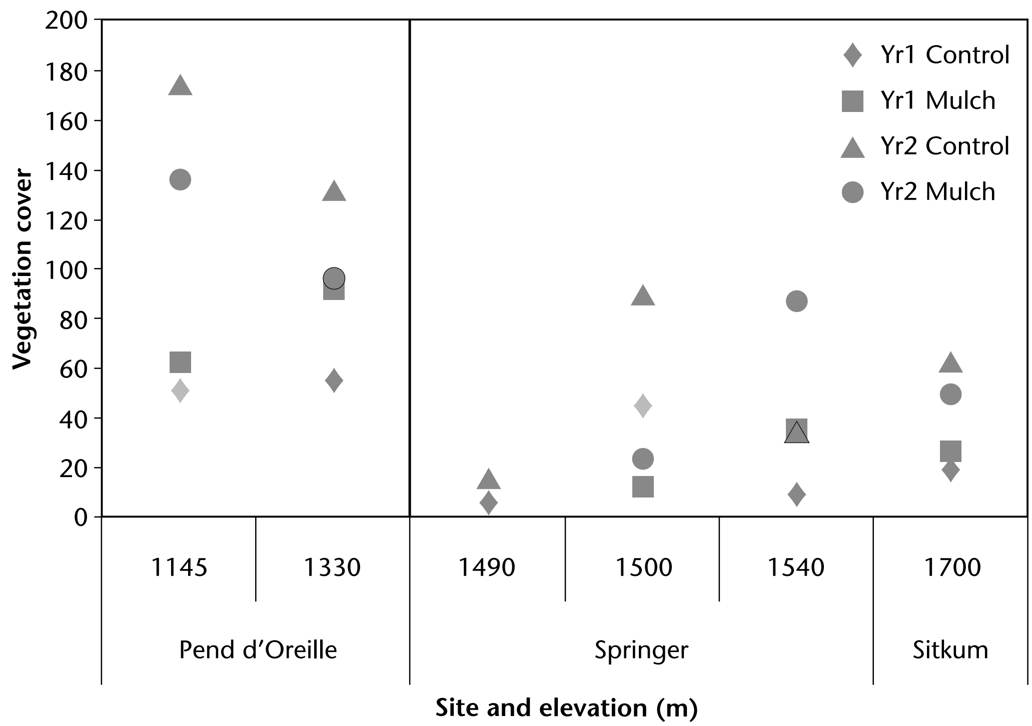

FIGURE 1. Correlation between elevation and vegetation cover. The vertical line distinguishes between the low-elevation (to the left) and high-elevation (to the right) site designation.

FIGURE 2. Low-elevation mulched plot: (a) in 2007, immediately after the fire and mulch application; (b) in 2008, with rye sprouts visible; and (c) in 2009, with natural vegetation cover. Note how the tall rye in 2008, which is past its prime, does not provide much living cover.

FIGURE 3. Low-elevation control plot: (a) in 2007, immediately after the fire; (b) in 2008, with natural revegetation; and (c) in 2009.

FIGURE 4. High-elevation mulched plot: (a) in 2007, immediately after the fire and mulch application; (b) in 2008; and (c) in 2009. The white square in (a) is the 1 m^2 ground cover grid used to measure vegetation cover.

FIGURE 5. High-elevation control plot: (a) in 2007, immediately after the fire; (b) in 2008; and (c) in 2009. Notice the increased amount of exposed rock caused by the erosion of ash and sediment.

TABLE 3. (a) Mean total vegetation cover (and standard deviation) on mulched and untreated sites in low- and high-elevation classes; (b) *Prob* > *F* for total vegetation between treatment and years for each site.

	(a) Mean vegetation cover (%)		
	2008	**2009**	**Change 2008–2009**
LOW-ELEVATION SITES			
Control	27 (9)	77 (20)	+50
Mulch	39 (17)	58 (12)	+19
Difference between treatments	12	31	
HIGH-ELEVATION SITES			
Control	13 (17)	34 (33)	+21
Mulch	15 (11)	32 (14)	+17
Difference between treatments	2	2	

	(b) Mean vegetation (%) *Prob* > *F*	
	Low elevation	**High elevation**
Treatment	0.544	0.965
Year	0.010	0.004
Treatment × year	0.15	0.67

TABLE 4. (a) Mean vegetation cover (and standard deviation) of invasive and native species on mulched and untreated sites in low- and high-elevation classes; (b) *Prob* > *F* for native and invasive species cover between treatment and years for each site.

	(a) Invasive species cover (%)			Native species cover (%)		
	2008	**2009**	**Change 2008–2009**	**2008**	**2009**	**Change 2008–2009**
LOW-ELEVATION SITES						
Control	3.1 (2.8)	22 (24)	+19	23 (9.3)	55 (21)	+32
Mulch	7.6 (5.3)	27 (29)	+19	21 (9.7)	31 (17)	+10
Difference between treatments	4.5	5		2	24	
HIGH-ELEVATION SITES						
Control	0.5 (0.8)	0.0	−0.5	12 (16)	34 (33)	+22
Mulch	1.8 (1.6)	0.1 (0.3)	−1.7	7.3 (5.7)	29 (15)	+22
Difference between treatments	1.3	0.1		4.7	5	

	(b) Invasive species *Prob* > *F*		Native species *Prob* > *F*	
	Low elevation	**High elevation**	**Low elevation**	**High elevation**
Treatment	0.634	0.115	0.155	0.673
Year	0.101	0.011	0.021	0.002
Treatment × year	0.989	0.120	0.177	0.994

TABLE 5. (a) Mean non-native vegetation cover (and standard deviation) on mulched and untreated sites in low- and high-elevation classes; (b) *Prob* > *F* for total non-native vegetation between treatment and years for each site.

	(a) Mean non-native vegetation cover (%)		
	2008	**2009**	**Change 2008–2009**
LOW-ELEVATION SITES			
Control	0.0 (0)	0.0 (0)	0
Mulch	10 (4.5)	0.0 (0)	−10
Difference between treatments	10	0.0	
HIGH-ELEVATION SITES			
Control	0.3 (0.7)	0.5 (1.1)	+0.2
Mulch	5.5 (5.7)	2.9 (6.4)	−2.6
Difference between treatments	5.2	2.4	

	(b) Mean non-native vegetation *Prob* > *F*	
	Low elevation	**High elevation**
Treatment	0.004	0.113
Year	0.004	0.346
Treatment × year	0.004	0.305

In the first growing season after the fires, the photos show slightly more vegetation cover in the mulched plots compared to the control plots (Figures 2–5b). There is noticeably higher total vegetation cover in 2009 in the low-elevation class (Figures 2c and 3c), compared to the high-elevation class (Figures 4c and 5c).

In the low-elevation class, there was a significant increase in mean vegetation cover from 2008 to 2009 on both the untreated and mulched plots (Table 3a and b). In 2008, there was higher cover in the mulch plots than the control plots, but in 2009 the difference in cover was higher in the control plots (Table 3; Figures 2 and 3). Due to the high variability between the plots and the response in each treatment seen in Table 2, the difference in cover between treatments is not statistically significant (Table 3b).

In the high-elevation class, the difference in vegetation cover between years was highly significant, but the mulch had no effect on cover (Table 3). Figures 4 and 5 show an example of the increased growth between years for each treatment. Figure 6 shows the overall mean percent vegetation cover by year and treatment at each site.

Invasive and native species cover

Invasive species were more abundant and had faster growth rates in the low-elevation class than in the high elevation (Table 4a; Figure 6). Invasive species increased in cover from 2008 to 2009, but the mulch treatments made no difference in invasive cover (Table 4a and b).

In the high-elevation class, the few invasive species that were present on both treatments in 2008 were significantly lower in 2009, indicating that the growing conditions were unsuitable for invasive species at higher elevations (Table 4; Figure 6).

In both elevation classes, native species cover showed a significant increase between years but no difference between treatments.

Non-native species cover

The non-native portion of Figure 6 relates to the viable annual wheat or rye seed contained in the straw mulch that sprouted after mulching.

In the low-elevation class, there was a significant decrease in cover between years ($Prob > F = 0.004$; Table 5) as the annual rye died off or was out-competed by other species and did not reseed in 2009. By 2009, the non-native cover in the mulched plots decreased to zero. The significant difference between treatments ($Prob > F = 0.004$) was attributed to the absence of mulch, and therefore seed, on the control plots. The significant interaction between treatment and years

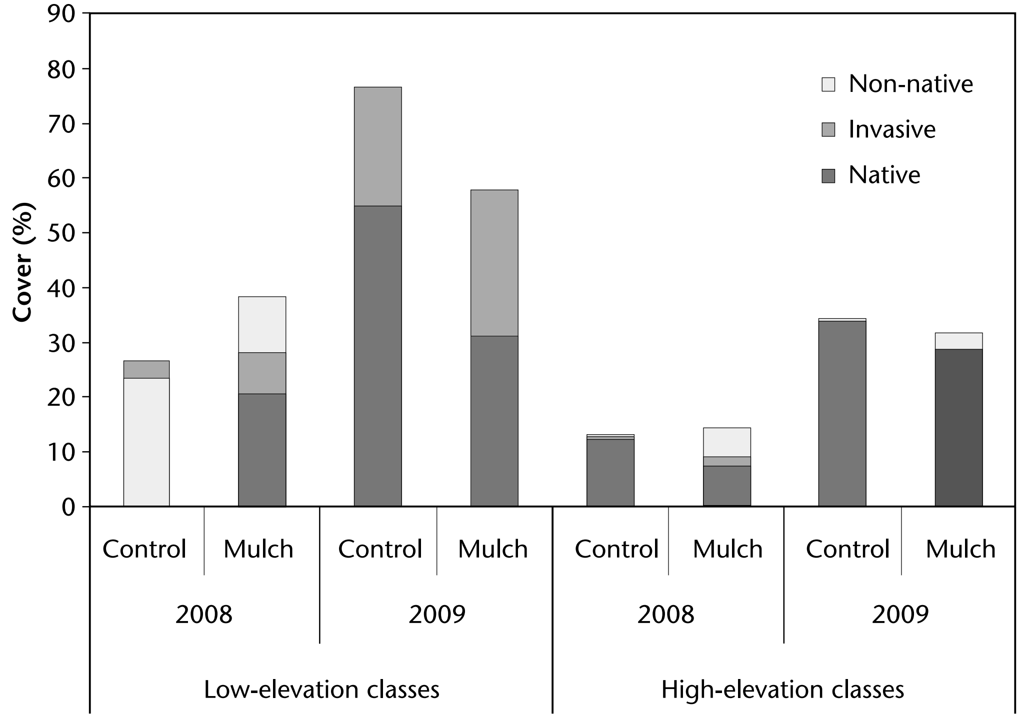

FIGURE 6. Mean total vegetation cover by treatment and the percent distribution of native, non-native, and invasive species in high- and low-elevation classes.

in the low-elevation class was attributed to the lack (0% cover) of non-native cover on the control plots.

In the high-elevation class, no significant difference was evident in non-native vegetation cover between treatments or years, which is likely due to seed from the adjacent mulched plots that blew into the control plots. Because of cooler temperatures and a shorter growing season, a small portion of the seed may have remained dormant until the 2009 growing season, resulting in the small non-native cover control plots in 2009.

Discussion

Effect of mulch on mean vegetation cover

The overall effect of the mulch did not cause a statistically significant difference in the amount of vegetation cover. Initial observations in 2008 showed higher vegetation cover on the mulch plots, which suggested that the mulch might promote growth and increase the speed of recovery. On the contrary, the vegetation cover on the mulch plots in the second year (2009) was less than on the control plots, which may be a result of mulch inhibiting plant growth. This trend was similar with the native vegetation cover. The mulch cover on several of the plots in this study was greater than the recommended 60–70% as shown in Table 2 and may inhibit growth of vegetation. Further monitoring is recommended to determine whether the mulch continues to inhibit growth into the future.

Effect of mulch on invasive and native species cover

This study shows no increase in invasive species cover due to the application of straw mulch. Monitoring done in 2008 at the Springer burn (high-elevation class) indicated that the majority of weeds found in the mulched area of the burn were agricultural and would not survive in forest conditions as they would be out-competed by the natural vegetation.[6] Other regional and provincially rated noxious weeds were only found along roads and old skid trails and not within the burn, which suggests that these species were present on the site before the fire. These findings were confirmed in the

[6] Herman, C. and L. Lacasse. 2008. Springer fire noxious weed recce report. Prepared for BC Ministry of Forests and Range, Arrow-Boundary District. Unpublished report.

high-elevation class at both Springer and Sitkum, where invasive species were minimal in the first year following the fire (2008) and declined further in 2009 (Figure 6).

In the low-elevation class, a substantial weed population exists, but it too appears to be caused by seed that was present on-site before mulching. Extensive invasive species populations were observed along roads and somewhat less in the burned areas. The Pend d'Oreille area has many forest roads and is accessed by miners, loggers, and recreationists. The high levels of human activity, low elevation, warm growing conditions, and pre-existing weed population contributed to the rapid rate of spread and growth of weeds on the site. The invasive species population may be a problem in the future; however, the mulch application did not have a significant influence on the invasive species population.

Effect of mulch on non-native vegetation

Agricultural species such as annual fall rye (Secale cereale) are recommended for erosion control by seeding on slopes prone to erosion because the extensive root system helps to restore soil structure and improves soil stabilization while giving way to native vegetation (B.C. Ministry of Forests 1997). The presence of viable seed heads in the rye straw used on the mulch plots was considered to be an added benefit, with the intent that the roots might also help break up any water-repellent layers and improve infiltration and soil stability while providing additional ground cover in the first year. The observed decrease in wheat and rye sprouts in the second year in both elevation classes indicates that these non-native species will not persist, nor will they out-compete native vegetation. The low percent cover indicates that little viable seed was left in the mulch, and the benefits it provided as ground cover were minimal.

Conclusions and recommendations

The use of straw mulch as an effective erosion control treatment after wildfire is likely to continue in British Columbia. While straw mulching is a successful, effective technique to reduce erosion during the first years after a fire, it also has the potential to introduce invasive species and reduce natural vegetation growth (Robichaud 2005). To achieve a net positive result without causing further damage to the landscape, it is important to use proper application techniques, and to monitor and study mulch applications not only for erosion control effectiveness, but also for the effects on ecology and vegetation dynamics.

To achieve a net positive result without causing further damage to the landscape, it is important to use proper application techniques, and to monitor and study mulch applications not only for erosion control effectiveness, but also for the effects on ecology and vegetation dynamics.

This study examined the effects of straw mulch application on the ecological response of vegetation growth in two elevation classes across three fires that burned in southeastern British Columbia in 2007. Over the period of this study, the mulch treatments had no significant effect on the amount of vegetation cover compared to untreated plots. There were no significant effects of invasive species that were introduced with the mulch; however, low-elevation plots showed significant increases in the weed population in both 2008 and 2009 as a result of a pre-existing population. In the high-elevation class, invasive species cover decreased in 2009, indicating unsuitable growing conditions for the persistence of those species. Non-native species introduced with the mulch did not persist beyond the second year and did not out-compete the native species in either elevation class.

Although there were no significant differences in total vegetation cover between treatments in either elevation class, a slightly slower rate of vegetation growth in mulched sites was observed. This difference suggests that mulch may inhibit growth (19% increase on mulch plots versus 50% increase in cover on control in the low-elevation class between 2008 and 2009) (Table 3). These observations are similar to other published and unpublished results suggesting that mulch may inhibit vegetation growth, especially in areas where application is too thick (Kruse et al. 2004; Beyers et al. 2006; Robichaud et al. 2009).

According to published and unpublished data from a simultaneous study at these sites, the application of mulch significantly reduced soil erosion from high-intensity rainfall after fires and caused minimal effect on the vegetation cover (good or bad). Based on these findings, the continued used of mulch to reduce erosion hazards after wildfire is recommended with a few important considerations.

- Lower-elevation, warm growing sites naturally have a higher risk of developing invasive species problems and need more intensive management and monitoring.
- Weed-free mulch should be selected for all erosion control applications.[7]
- Highly sensitive areas may justify the use of more expensive but completely seed-free types of mulch, such as wood shreds instead of agricultural straw, for erosion control in low elevation, productive growing sites that have any potential for weed invasions.
- Mulch sites should be monitored for weed invasions and the introduction of new non-native species.
- Straw mulch should be applied at the recommended rates to ensure native plant regeneration is not inhibited by the mulch, while maintaining sufficient cover for erosion control.

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References

B.C. Ministry of Forests. 1997. Soil rehabilitation guidebook. Forest Practices Code of British Columbia, Victoria, B.C. *http://www.for.gov.bc.ca/TASB/LEGSREGS/FPC/FPCGUIDE/soilreha/rehabtoc.htm* (Accessed February 2010).

Beyers, J.L., W. Christensen, P. Wohlgemuth, and K. Hubbert. 2006. Effects of post-fire mulch treatments of vegetation recovery in the southwestern US. Abstracts 91st Annual Meeting of the Ecological Society of America.

Bhatt, R. and K.L. Khera. 2006. Effect of tillage and mode of straw mulch application on soil erosion in submontaneous tract of Punjab, India. Soil and Tillage Research 88(1–2):107–115.

Braumandl, T.F. and M.P. Curran. 1992. A field guide for site identification and interpretation for the Nelson Forest Region. B.C. Ministry of Forests and Range, Victoria, B.C. Land Management Handbook No. 20.

Curran, M.P., B. Chapman, G.D. Hope, and D. Scott. 2006. Large-scale erosion and flooding after wildfires: Understanding the soil conditions. B.C. Ministry of Forests and Range, Research Branch, Victoria, B.C. Technical Report No. 030.

Gartner, J.E., S.H. Cannon, E.R. Rigio, N.K. Davis, C. Parrett, K.L. Pierce, M.G. Rupert, B.L. Thurston, M.J. Trebish, S.P. Garcia, and A.H. Rea. 2005. Compilation of data relating to the erosive response of 608 recently burned basins in the western United States. U.S. Geological Survey, Open-File Report 2005-1218. *http://pubs.usgs.gov/of/2005/1218/Report.html* (Accessed February 2010).

Groen, A.H. and S.W. Woods. 2008. Effectiveness of aerial seeding and straw mulch for reducing post-wildfire erosion, north-western Montana, USA. International Journal of Wildland Fire 17(5):559–571.

Jordan, P. and S.A. Covert. 2009. Debris flows and floods following the 2003 wildfires in southern British Columbia. Environmental and Engineering Geoscience 15(4):217–234.

Jordan, P., K. Turner, D. Nicol, and D. Boyer. 2006. Developing a risk analysis procedure for post-wildfire mass movement and flooding in British Columbia. In: 1st Specialty Conference on Disaster Mitigation. Canadian Society for Civil Engineering, Calgary, Alta. pp. 1–10.

Jungen, J.R. 1980. Soil resources of the Nelson Map Area (82F). B.C. Ministry of Environment, Resource Analysis Branch, Victoria, B.C. RAB Bulletin No. 20. Report No. 28.

Kruse, R., E. Bend, and P. Bierzychudek. 2004. Native plant regeneration and introduction of non-natives following post-fire rehabilitation with straw mulch and barley seeding. Forest Ecology and Management 196:299–310.

MacDonald, L.H. and P.R. Robichaud. 2007. JFSP Final report: Postfire erosion and the effectiveness of emergency rehabilitation treatments over time. Final Report to the Joint Fire Science Project, Boise, Idaho:

[7] At the time this paper was written, there was no certification process in Canada for weed-free straw; however, weed-free seed is available, and straw should be sourced from straw providers that use it.

03-2-3-22. *http://warnercnr.colostate.edu/~leemac/publications/JFSP_Final_Report.PDF* (Accessed February 2010).

Massey, N.W.D. 2005. Bedrock geology. B.C. Ministry of Enery, Mines and Petroleum Resources, BC Geological Survey Branch, Victoria, B.C. *https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=47075&recordSet=ISO19115* (Accessed February 2010).

Moody, J.E., J.N. Jones, and J.H. Lillard. 1963. Influence of straw mulch on soil moisture, soil temperature and the growth of corn. Soil Science Society of America Journal 27:700–703.

Mount, C. 2007. Ecological aquatic units of British Columbia: Rivers. B.C. Ministry of Environment, Ecosystems Branch, Victoria, B.C. *https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=52478&recordSet=ISO19115* (Accessed February 2010).

Robichaud, P.R., J.L. Beyers, and D.G. Neary. 2000. Evaluating the effectiveness of postfire rehabilitation treatments. U.S. Department of Agriculture Forest Service, Fort Collins, Colo. General Technical Report No. RMRS-GTR-63:85.

Robichaud, P.R. 2005. Measurement of post-fire hillslope erosion to evaluate and model rehabilitation treatment effectiveness and recovery. International Journal of Wildland Fire 14:475–485.

Robichaud, P.R., S.A. Lewis, R.E. Brown, and L.E. Ashmun. 2009. Emergency post-fire rehabilitation treatment effects on burned area ecology and long-term restoration. Fire Ecology 5(1):115–128.

Scott, D.H., M.P. Curran, P.R. Robichaud, and J.W. Wagengrenner. 2009. Soil erosion after forest fire. In: Fire effects on soils and restoration strategies after forest fires. Land Reconstruction and Management Series. A. Cerda and P.R. Robichaud (editors). Science Publishers, Enfield, N.H., pp. 177–195.

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Test Your Knowledge . . .

The effects of straw mulching on post-wildfire vegetation recovery in southeastern British Columbia

How well can you recall some of the main messages in the preceding Research Report?
Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. The invasive plant cover at the low elevation site in 2009 was:
   A) Highest in the mulch plots
   B) Not different between mulched and un-mulched plots
   C) Highest in the control sites
   D) Decreased significantly from 2008 in both treatments

2. Non –native plants that sprout from the seeds of the straw species:
   A) Provided significant amounts of additional ground cover, but outcompeted native vegetation
   B) Did not outcompete native vegetation, and provided significant additional ground cover
   C) Did not provide significant ground cover, and did not outcompete native vegetation
   D) Significantly increased in cover between 2008 and 2009

3. The use of straw mulch as an erosion control method:
   A) Significantly increased the rate of vegetation growth after fire
   B) Should be used with caution in areas that have high potential for weed infestations
   C) Caused significant increases in weed cover and inhibited native vegetation
   D) Should be monitored for weed infestations for several years following application

ANSWERS

1. B 2. C 3. B and D