Reduction of Surface Fuel Should be a Forest Service Priority

Prepared for the Forsythe II Monitoring Group

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Summary

Surface fuels are the grasses, shrubs and woody debris that carry wildfire across the landscape. The more surface fuels, the greater the fire danger. If the surface fuels are tall enough, and in the forest, they become ladder fuels that can carry the fire into the crowns where the canopy will carry the fire.

Forest Service (FS) treatments that prioritize surface fuels can be effective in changing fire behavior (Cascade Complex 2003) but treatments that don't, may be counterproductive (Fourmile Canyon). The Forsythe treatments focus on removing trees not surface fuels. They remove downed debris created during the treatments (activity fuels) but not existing debris or ladder fuels. To make matters worse, lop and scatter slash treatments may add excess surface fuel.

Treatments must include plans for follow-up treatments and be iterative over many years. Most treatments will need follow-up action to burn piles, thin regenerating dog-hair growth, conduct prescribed burns, plant new trees of preferred species, etc. If follow-up treatments are not conducted, the initial treatments may do more harm than good. Unfortunately, the local FS has a poor record of following up on treatments and current plans do not have a specific plan for re-treatment nor do they identify a budget.

Although the Forsythe Decision Notice (DN) calls for "slash created by these treatments to be piled and burned, chipped, masticated, and/or removed offsite", chipping and mastication will not be used and lop and scatter will be.

But surface fuel is more than fuel for fire, woody debris helps a forest in terms of nutrient cycling, wildlife habitat, moisture retention in the forest and potential productivity of the forest. Therefore, a balance between fire hazard and these other values needs to be maintained. What range of surface fuel provides this balance?

Woody debris is measured in tons per acre and categorized as fine (FWD) (<3"), small (3"-6") and coarse (CWD) (>6"). Measurements of existing surface fuels in forests similar to Forsythe suggest about 10-30 tons/acre is normal and models recommend similar amounts as an optimum balance between fire risk and a healthy surface environment.

The Forest Service should prioritize surface fuel over tree-removal treatments (surface fuels first, then ladder fuels, and crown fuels last), complete follow-up treatments in a timely manner, and establish and enforce strict parameters for residual surface fuels.

The Monitoring Group should help define the appropriate range of surface fuels to balance wildfire risks with soil and wildlife considerations, help with guiding and compliance language for contracts, and design monitoring protocols for verification (CFRI?).

1. What are Surface fuels?

Wildfire is carried across the forested landscape either near the ground surface or in the forest canopy. Fuel models are used in fire behavior prediction models and describe the predominant type of surface fuel that would carry fire across an area. Fuel models are broken down by type: grass (GR), grass-shrub (GS), shrub (SH), timber litter (TL), timber-understory with grass or shrub (TU), and slash or blowdown (SB). Fuel types that are represented across the

Forsythe II project area are shown in Table 1 below (adapted from Table 11 Forsythe II EA P73, *italicized from Scott and Burgan* 2005).

Fuel Model	Represented Vegetation Type	Percent Project Area	Fuel Load
GR2	Meadows	7%	Low load, Dry-Climate grass *Moderately coarse continuous grass, average depth about 1 foot. Spread rate high; flame length moderate.*
GS1	Dry-Climate grasses and shrubs	<6%	Low to Moderate fuel load *Shrubs are about 1 foot high, low grass load. Spread rate moderate; flame length low.*
GS2		<6%	*Shrubs are 1 to 3 feet high, moderate grass load. Spread rate high; flame length moderate.*
TU5	Douglas fir and mixed conifer	14%	Very High Load, Dry Timber-Shrub *Fuelbed is high load conifer litter with shrub understory. Spread rate moderate; flame length moderate.*
TL3	Lodgepole pine	34%	Moderate Load Conifer Litter *Fuelbed does not include coarse fuels. Spread rate very low; flame length low.*
TL5	Mixed conifer w/ dead and down woody material	<6%	High Load Conifer Litter *Fuelbed does not include coarse fuels.Light slash or mortality fuel. Spread rate low; flame length low.*
TL6	Aspen	10%	Moderate Load Broadleaf Litter *Less compact. Spread rate moderate; flame length low.*
TL8	Ponderosa pine and mixed conifer	27%	Long-Needle Litter *Moderate load and compactness may include small amount of herbaceous load. Spread rate moderate; flame length low.*
SB1	Rx Burn units with Lop & Scatter	<1%	Low Load Activity Fuel *Fine fuel load is 10 to 20 tons/acre, weighted toward fuels 1 to 3 inches diameter class, depth is less than 1 foot. Spread rate moderate; flame length low.*
SB2	Slash, Lop and Scatter		*Activity Fuel. Fine fuel load is 7 to 12 tons/acre, evenly distributed across 0 to 0.25, 0.25 to 1, and 1 to 3 inch diameter classes, depth is about 1 foot. Spread rate moderate; flame length moderate.*
SB3	Slash, Lop and Scatter		*Activity Fuel. Fine fuel load is 7 to 12 tons/acre, weighted toward 0 to 0.25 inch diameter class, depth is more than 1 foot. Spread rate high; flame length high.*

“Reducing the fuel loadings, fuel continuity, and the availability of ladder fuels keeps fire confined to the ground, reduces fire intensity, and reduces firebrands, all of which increase the ability to control fires and improve firefighter safety.” Basin Creek Hazardous Fuels Reduction FEIS P3.42

“Describing and quantifying wildland fuelbeds are difficult because of the highly variable distribution and arrangement of fuel particles in space, and the dynamic changes in particle characteristics over time. The spatial and temporal variability of fuels directly influences fire behaviour, controls fire effects, confounds fuel sampling, confuses mapping efforts and complicates fuel description and classification. Fuel moistures, particle densities and, most importantly, component loadings are highly variable across space, and they can also be highly variable within individual fuel particles. This variability is scale dependent with variability of smaller fuel particles distributed over smaller scales than large fuels (e.g. twigs vary at smaller scales than logs). Moreover, a single high wind or heavy snow event can dramatically increase surface litter and woody fuel loadings and change the entire structure of the fuelbed in a short time.” Keane 2013

2. **Not all FS treatments are the same.**

    a. **Treatments that prioritize removal of surface and ladder fuels are more effective in reducing burn severity and crown fire occurrence.**

Forest Service treatments in the Forsythe projects have prioritized tree removal instead of surface fuel reduction. Trees are removed in order to: promote aspen stands, restore meadows, change stage structure, restore historical stand structure, reduce densities, open canopies, protect defensible space, reduce wildfire potential and severity, increase resistance and resiliency, and mimic natural disturbances. Although prescribed burning does directly address surface fuel accumulation and will be conducted on over 900 acres in Forsythe, it will only be in 2 units and will consume almost entirely grass. None of the existing surface fuel accumulations in the Forsythe forest will be addressed, nor are there defined plans for prescribed burns in the other Forsythe units.

“Surface fuel is the primary fuel model in Colorado front range wildfires and should be the primary focus of treatment actions”. (RMRS-GTR-289 August 2012)

“The implications of these simulations are … (that) not every fuel reduction treatment will reduce fire problems. Treatments should be planned using principles of firesafe forests: treat surface fuels, ladder fuels, and although thinning of the crown may be desirable, leave large trees. Those treatments that focused on smaller trees and ladder fuels were effective, and prescribed fire alone was effective, too.” Agee and Skinner 2005

<u>Lessons from the Fourmile Canyon Fire</u> Graham et al 2012
“No evidence was found that the progression of the Fourmile Canyon Fire was altered by the presence of fuel treatments and the treated areas were probably of limited value to suppression efforts on September 6 (Figure 32). In some cases, because there were large amounts of surface fuels present in the fuel treatments, they appeared to be ineffective in changing fire behavior.

Moreover, it was suggested that the large amount of surface fuels present in many of the treated areas was because they had not been maintained (Boulder Incident Management Team 2010)." P56

"In some cases, treated stands appeared to burn more intensely than adjacent untreated stands, perhaps because of additional surface fuels present as a result of the thinning and higher wind speeds that can occur in open forests compared to those with denser canopies." RMRS-GTR-289 August 2012 P57

"Within the Fourmile Canyon Fire perimeter, evidence of reduced fire extent and intensity due to treatment was not apparent and the ability of suppression response to utilize existing treatments to stop fire spread was not clearly documented. This review suggests that strategic fuel planning and implementation, <u>especially surface fuel management,</u> is needed on the Front Range." RMRS-GTR-289 August 2012 P77

"The efficacy of fuel treatments to produce desired outcomes depends on how the live and dead vegetation are treated (e.g., vegetation cut, piled, burned, masticated), time since treatment, and how the treated areas are dispersed, shaped, and arranged across the landscape. Wildland fuel treatments have been documented and studied for 80-plus years (Weaver 1943, Pollet and Omi 2002, Graham and others 2004, Agee and Skinner 2005, Finney and others 2005, Cram and others 2006, Hunter and others 2007, Graham and others 2009, Hudak and others 2011). A large proportion of this evidence applies directly to the ponderosa pine and mixed conifer forests of the Colorado Front Range and the Fourmile Canyon area. <u>This body of knowledge unequivocally demonstrates that changes in fire behavior and subsequent effects are most dependent on changes in surface fuels. In fact, very effective fuel treatment in many studies consists solely of prescribed burning with no overstory tree removal</u> (e.g., Hayman Fire, Finney and others 2003)." RMRS-GTR-289 August 2012 P21

"The most effective strategy for reducing crown fire occurrence and burn severity is to (1) reduce surface fuels, (2) remove ladder fuels, (3) increase canopy base heights, (4) and lastly, reduce canopy continuity and density." RMRS-GTR-289 August 2012 P22

<u>Lessons from the Warm Lake/ Cascade Complex of Wildfires in Central Idaho</u> Graham et al 2009

"Surface fuels, ladder fuels, and crown fuels (in this order of importance) determine both fire intensity and burn severity and strongly contribute to fire resilient forests (Agee and others 2002; Graham and others 2004). With this in mind, the first fuel treatments executed in the basin were aimed at <u>reducing amounts, distribution, and juxtaposition of surface and ladder fuels.</u>" RMRS-GTR-229. 2009 P6

"Similar to the prescribed fires, these mechanical treatments cleaned the forest floor and removed ladder fuels. In addition, the spacing between tree boles was increased to approximately 10 to 15 ft, thereby increasing the distance between tree canopies. The lower limbs of the residual trees were pruned to a height of 5 ft, further reducing the ladder fuels. The unwanted trees were cut (slashed), <u>as was the material on the forest floor (up to 12 inches in diameter)</u>, into lengths that could be hand-piled. All of the cut material was piled and the covered piles were burned either in the late fall or early spring. Because of the urban setting, the burning piles were attended to ensure that the majority (>80%) of the material was consumed to leave a clean and well-kept look to the forest floor (fig. 8)." RMRS-GTR-229. 2009 P7

"Not only did the presence of (this type of) fuel treatments directly impact the survivability of the many structures located within the basin, but they also influenced fire suppression strategies and the location of the Incident Command Post (Bull and others 2007)". RMRS-GTR-229. 2009 P26

"The way the North Fork and Monumental Fires interacted with fuel treatments, roads, and associated suppression efforts reinforce that treatment location and juxtaposition and the **treatment of surface fuels, ladder fuels, and crown fuels (in this order of importance)** are major determinants of both wildfire intensity and burn severity." RMRS-GTR-229. 2009 P33

"Some effective fuelbreaks had only surface fuels and ladder fuels treated, with residual canopy cover exceeding 60–70%. Even though canopy bulk density was insignificantly reduced, fire severity was significantly reduced, suggesting that reductions in canopy bulk density are not always needed to reduce wildfire severity." Agee and Skinner 2005 P91

b. Treatments without follow-up treatments can do more harm than good. Some treatments should not be undertaken if follow-up treatments cannot be completed.

Past Forsythe Forest Service treatments have increased openings and wind exposure which caused blowdown and created jackpot fuels. Slash piles have been left too long and lop and scatter slash treatments have added jackpot fuels. Excessive thinning opens the canopy too much and results in doghair thickets of saplings that serve as ladder fuels and must be retreated.

"The lesson here is that treatment without regard to residual fuel and forest structure, may exacerbate fire severity rather than ameliorate it." Agee and Skinner 2005 P91

"This study provides strong quantitative evidence that thinning alone does not reduce wildfire severity but that thinning followed by prescribed burning is effective at mitigating wildfire severity in dry western forests. Can. J. For. Res. Vol. 40, 2010 Abstract

"Crowns of trees removed during treatments may contribute to surface fuel loadings and may have a large impact on fire behavior if left untreated. Graham et. al. (1999) point out that logging slash has been responsible for extreme fire behavior in the past and contributed to the fires in the Inland and Pacific Northwest forests in the late 1800s and early 1900s. Thinning also has the potential to exacerbate ground and surface fire behavior by increasing surface wind exposure and increasing solar radiation, thereby lowering fuel moisture and increasing fine fuels (Graham et.al. 1999; Pollet and Omi 2000). However, these fires would occur as ground and surface fires, which can often be suppressed using direct attack. <u>In order for fuel treatments such as thinning to be effective, activity generated slash needs to be eliminated to reduce surface fuel loading</u>." Basin Creek Hazardous Fuels Reduction FEIS P3.39

"Finney et. al. (undated) also found that in the case of the Hayman Fire, relatively recent fuel treatments were more effective than older units in slowing fire and decreasing fire severity, indicating that treatments may only be effective a short time into the future." Basin Creek Hazardous Fuels Reduction FEIS P3.39

"If fuel treatments are small and scattered, or a long time has elapsed since treatment (generally 10– 15 years or more), they will be less effective in fragmenting the landscape fuel loads, and their efficacy at the stand level can be overwhelmed by intense fires burning in adjacent areas." Agee and Skinner 2005 P92

c. **Manual Vs Mechanical**

Mechanical Treatment Areas
"Again, there are tradeoffs as the sole use of chainsaws for implementation creates more slash (including logs and limbs) across the landscape to be disposed of at a later time. In some areas, large logs may be left on the site. In comparison, use of mechanical harvesting equipment, in which trees are skidded to a central location, provides a greater opportunity for material to be taken off the landscape, leaving only limbs in slash piles to be disposed of later." Forsythe II EA P33

"There was a question about whether a large amount of surface fuels presents more of a fire risk than a small amount of surface fuels. In areas where there are larger diameter trees, there will be more residual surface fuels, which presents a higher fire risk in the short term. Manual treatments will also result in more residual surface fuels in comparison to mechanical treatments." MMG Field Trip 10/18/19 Unit 5/7 P1

Note that, according to the EA, both manual and mechanical treatments leave material "to be disposed of later". Mechanical treatments may remove the large boles, but they leave the limbs, slash and the fine and coarse woody fuels that pose wildfire danger. Proposing that mechanical treatments are preferable because they leave less slash is a false choice. The FS must control slash levels after treatment regardless whether it is mechanical or manual.

3. **Slash Treatment**

"Slash created by these treatments may be piled and burned, chipped, masticated, and/or removed offsite. The treatments may produce 12,000-18,500 hand piles and 200-700 machine piles. Where mechanized equipment is used, forest products will most likely be removed in the form of logs, chips, or firewood. After work is completed, firewood may be removed from the manual treatment units." Forsythe II DN July 2017 P7

a. **Chipping and/or Mastication**

Although called for in the DN, chipping and mastication will not be used in the Forsythe II project per Kevin Zimlinghaus.

b. **Remove off site** – only in mechanical treatments

c. Pile and Burn

"Construct a minimum of a 6 foot wide control line, down to bare mineral soil, around each machine pile to create separation between piled material and surrounding slash mat."

Why would there be a surrounding slash mat?

d. Lop and Scatter

Lop and scattering slash directly adds fuel to the ground surface. The amount this raises the fire danger is sensitive to the size of the slash as well as its depth and time left on the ground: the finer the surface fuel, the greater the spread rate and flame length. The fuel models in Table 1 (above) include categories for slash or blowdown (SB) and describe changes in fire behavior as slash is increased.

Note that in the SB2 model, where the fine fuel load is 7 to 12 tons/acre, evenly distributed across size classes (0-¼", ¼-1", and 1-3"), and to a depth of about 1 foot, the spread rate and flame length are both predicted to be moderate.

In the SB3 model the density remains the same (fine fuel load is 7 to 12 tons/acre), but the size class is smaller (weighted toward the 0-¼" diameter class) and the depth is increased to more than 1 foot. In this case both the spread rate and flame length are high. (Scott and Burgan 2003)

Another example of the fire danger from increasing amounts of slash comes from a fuel model preceding Scott and Burgan: Rothermel GTR INT-143 June 1983. (An excerpted, adapted form of this model is presented in Appendix A for reference.) This model also created categories for logging slash.

If the Slash is fresh (0-3 years or so) and not overly compacted.

1. Slash is not continuous. Needle litter or small amounts of grass or shrubs must be present to help carry the fire, but primary carrier is still slash. Live fuels are absent or do not play a significant role in fire behavior. The slash depth is about 1 ft.

Model 11: Fires are fairly active in the slash and herbaceous material intermixed with the slash. The spacing of the rather light fuel load, shading from overstory, or the aging of the fine fuels can contribute to limiting the fire potential. Light partial cuts or thinning operations in mixed conifer stands, hardwood stands, and southern pine harvests are considered. Clearcut operations generally produce more slash than represented here. The less-than-3-inch material load is less than 12 tons per acre. The greater-than-3-inch material is represented by not more than 10 pieces, 4 inches in diameter, along a 50-ft transect.

2. Slash generally covers the ground (heavier loadings than Model 11), though there may be some bare spots or areas of light coverage. Average slash depth is about 2 ft. Slash is not excessively compacted. Approximately one-half of the needles may still be on the branches but are not red. Live fuels are absent, or are not expected to affect fire behavior.

Model 12: Rapidly spreading fires with high intensities capable of generating firebrands can occur. When fire starts, it is generally sustained until a fuel break or change in fuels is encountered. The visual impression is dominated by slash, much of it less than 3 inches in diameter. These fuels total less than 35 tons per acre and seem well distributed. Heavily thinned conifer stands, clearcuts, and medium or heavy partial cuts are represented. The greater-than-3-inch material is represented by encountering 11 pieces, 6 inches in diameter, along a 50-ft transect. GTR INT-143 June 1983

"In manual units, pile sound, existing and/or created slash material, 1" to 6" diameter and 2 feet or longer. Alternatively, any slash that must be moved more than 50 feet to meet minimum required pile size may be lopped and scattered to a maximum depth of 18". Lopped and scattered material is expected to be a rare occurrence and most likely occur in very open grown areas where a few trees are required to be cut to meet spacing specifications, but not enough trees are cut to produce enough slash to create a minimum sized pile." Forsythe II DN July 2017 P39

"All thinning slash shall be less than 18" in height, placing it on or near the ground surface, and not covering more than 25% of the surface area per acre. Slash that is lopped and scattered shall be distributed to avoid continuous ground coverage. The desired pattern is patchy, mosaic, and discontinuous. Cut material shall not lean against an uncut tree, log or any obstacle. It shall be secure and not able to roll down the hill. CU 6 (northern portion of unit), 8, 9, 13." Contract – draft Forsythe II Phase I P9-11

Although the DN calls for Lop and Scatter to be rare, the contract speaks as if it's common practice. Eighteen inches of slash is equal to how many tons/acre? We saw examples of this thick, lop and scatter treatment on a field trip (Unit 5 Oct. 18, 2019). Animals (including humans) are reluctant to walk through the resulting mat of thick slash material. And, if the unit is not scheduled for a prescribed burn, this excessive mat of fuel will pose a wildfire danger for years. Unit 5/7 are not scheduled for Rx Burn yet Lop and Scatter was used. See photo in Google Drive slash photos.

"There was a concern that the woody debris left on the ground as a result of the lop-and-scatter technique serves as surface fuels and poses a fire risk. Others said the woody debris left from the lop- and-scatter does create a fire risk in the short-term until the needles fall off the debris. In two to three years, there will be a negligible difference in the fire risk. The lop-and-scatter debris is a better alternative than keeping the regenerating conifers on the landscape. The USFS also uses lop-and-scatter as a part of the design criteria to benefit wildlife. There is a balance between fire and wildlife considerations. Some participants said they would like to know the amount of surface fuels needed to benefit wildlife and the amount of surface fuels that significantly increase fire risk." MMG Field Trip 10/18/19 Unit 5/7 P1

This seems to be a false choice, the FS can both remove the regenerating dog-hair and minimize use of lop and scatter.

e. Broadcast Burn

Broadcast or prescribed burn is planned for 945 acres in Forsythe II. "Broadcast burning would be the option for reducing the surface fuels, but because of private property intermix, broadcast burning is only feasible near Gross Reservoir." EA P79. Although all MMG parties agree on the need for prescribed burns to control surface fuels, it is also recognized that CWD increases after a burn and will need to be treated again in follow-up treatments (see 4.d. below).

4. What is the right amount of surface fuel?

To minimize the risk of wildfire, the FS should require the minimum amount of surface fuels remain to support wildlife, moisture retention and nutrient cycles.

"The lower limit of the optimum range is determined by the ecological benefits of CWD, including wildlife habitat and site productivity, and the upper limit by excessive fire hazard." Brown et al 2003

"The role of CWD in site protection can be significant or minor depending on site conditions. On steep slopes, CWD helps protect soils from erosion due to surface runoff. It disrupts flow near the ground, creates shade for seedlings, and reduces trampling by livestock, wildlife, and people." Brown et al 2003

a. Impact on Wildfire

"Fuel loadings are usually measured in tons per acre and define the amount of fuel available for burning in a given area. There are three categories of fuels that affect fire behavior; 1) fine fuels such as grass or forbs, 2) small woody fuels less than three inches in diameter and 3) large (coarse) woody fuels greater than three inches in diameter. Fine fuels are the major contributors to fire spread, carrying the ignition and flaming front of a fire (Rothermel 1983). Without these fine fuels, many fires will not get large. However, eliminating fine fuels (litter, duff, and grasses) is neither possible nor desirable. Small woody fuels influence a fire's rate of spread and fire intensity, and small woody fuels lose their moisture faster, start easier, and burn more readily than large woody fuels" (Agee 1993).

"Under a frequent fire regime, it is possible to maintain fine fuels at lower levels and various patch sizes than under a less frequent fire regime, but fine fuels will always exist. Aside from eliminating the fine fuels that contribute to fire spread, only the total amount and arrangement can be modified to benefit fire control efforts. From a firefighter's perspective, it is better to construct fireline through 2 inches of this small material to reach mineral soil (therefore stopping fire spread) than to dig through 10 inches of fine fuels because fireline construction will progress faster and the fire could potentially be contained at a smaller size."
"Large woody fuels (greater than 3" diameter) remain burning after the fire front has passed (Andrews 1986) and contribute to fire intensity. Large woody fuels also contribute to the development of large fires and high fire severity (Brown et al 2001)." Brown et al 2003

b. Impact on Nutrient Cycling

"Even in a mechanical treatment, the crews have to leave some surface fuels on the ground for nutrient cycling. Surface fuels create microsites for forests to establish themselves. The surface fuels hold soils from wind erosion. In narrow patchcuts, like the one of Unit 10 east, there are fewer concerns about nutrient cycling because needles from nearby trees will fall into the area. <u>For wider patchcuts, placing surface fuels is necessary to provide nutrients.</u> Surface fuels also allow for the use of prescribed burns." MMG Meeting notes 10/18/19.

"In thinning units, the proposed activities have low potential to detrimentally impact long term nutrient cycling processes because many trees would remain following treatment, providing material for recruitment of large downed wood, fine slash, or needle cast. Recruitment of material for decomposition is expected to occur naturally over time in these activity areas. The potential for nutrient cycling impacts in patchcut or clearcut areas is higher because more vegetative material is removed. However, provided retention of <u>adequate amounts</u> of large downed wood and fine slash occurs, effects to long term nutrient cycling would be low." EA P101

"However, where ground cover or slash is sparse, it is important to scatter material to provide protective ground cover for erosion control and fine slash for nutrient cycling." EA Manual Treatments P102

How are contractors to know when there are "adequate amounts" or when ground cover is "sparse"?

"The effects of slash disposal activities on soil resources could be beneficial or harmful, depending on the amount, size, and spatial distribution of material retained."

Potential Positive and Negative Effects on Soil Processes/Functions

- Erosion Control – Retention of slash/chips/chunks may benefit soil resources by providing protective ground cover.
- Soil Nutrient status – Microbes decomposing this wood (chips and chunks) could immobilize nitrogen and reduce soil nutrient availability to a small degree. When the wood becomes mostly decomposed, it would begin to release nitrogen and increase soil nutrient availability.
- Soil carbon – Slight increase in soil carbon over time
- Soil physical properties – Increased soil moisture retention and decreased diurnal and seasonal soil temperature fluctuations. Heavy equipment used for chipping or mastication may compact the soil.
- Soil biota – Woody debris provides habitat for soil insects and microbes and addition of carbon from woody debris would lead to an increase in soil biota, especially fungal species that are the primary wood decomposers.
- Fire risk or behavior – Under certain conditions, slash and chipped/masticated materials may smolder, resulting in a longer residence of fire at the soil surface." EA P103

As discussed above, this last bullet from the Forsythe II Environmental Assessment clearly understates the contribution of slash to fire behavior.

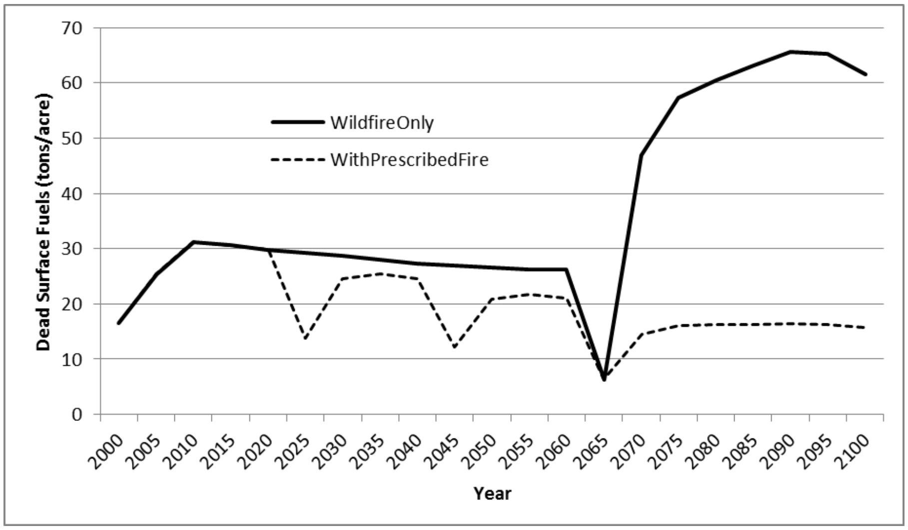
c. Impact on Wildlife

"Coarse woody debris contributes to biodiversity by being part of the life cycle of soil mites, insects, reptiles, amphibians, mammals, and birds (Brown 2000). Invertebrates such as bark beetles, wood borers, carpenter ants, and wasps utilize CWD for food and protection. Mammals, reptiles, and amphibians mostly utilize downed logs for purposes such as feeding, reproduction, and shelter (Harmon and others 1986). As more downed CWD accumulates in the forest, activity of small mammals such as voles increases (Ucitel 1999). A 15 to 20 percent coverage of downed CWD was recommended by Carey and Johnson (1995) for favoring small animal communities." Brown et al. 2003

"In treatment units where slash is piled by hand, leave an average of 2 piles per acre for wildlife habitat, including any piles remaining from previous vegetation treatment, distributed randomly throughout the unit." Contract – draft Forsythe II Phase I P9

d. Typical Surface Fuel Loadings

"The surface fuel load in tons per acre is an indicator for fuel managers because generally, the more there is, the greater the fuel hazard. Figure 1 shows total weight of woody fuels summed over all size classes. To wildlife and vegetation managers, this fuel is considered down woody debris and that is often a valuable resource. The Wildfire only scenario shows consistently high fuel loads while the With prescribed fire scenario shows that surface fuels are reduced by the prescribed fires. In general, however, the reductions are short lived as the trees killed by the prescribed fires create surface dead material soon after each prescribed fire." FFE-FVS June 2015 P5



A 15 percent coverage of CWD is equivalent to (assuming wood densities typical of ponderosa pine and lodgepole pine) Brown et al 2003
15 tons per acre of 3" diameter pieces
32 tons per acre of 6" diameter pieces
64 tons per acre of 12" diameter pieces

"In ponderosa pine stands having <0.5 inch of duff (averaged 2.4 tons per acre), large woody fuels averaged less than 1 ton per acre. The shallow duff indicated a fire history characteristic of the understory fire regime.
In stands having > 0.5 inch of duff (averaged 11 tons per acre), indicating a long period without fire, large woody fuels averaged 23 tons per acre." Brown et al 2003

Table 2—"Average quantities of large woody fuel (tons per acre) by ponderosa pine (PP), Douglas-fir (DF), and lodgepole pine (LP) cover types on the Bitterroot and Lolo National Forests inventoried by the forest survey and stand exam programs (Brown and See 1981). Number of plots is shown in parentheses." Brown et al 2003

	Bitterroot			Lolo		
Program	PP	DF	LP	PP	DF	LP
Forest survey	5.3	9.2	12.2	4.8	11.5	13.3
	(218)	(1,056)	(203)	(120)	(1,000)	(768)
Stand exam	11.3	21.1	25.9	10.4	11.9	15.8
	(1,685)	(7,158)	(1,152)	(665)	(4,233)	(1,591)

Table 3 - Default initial fuel loadings (tons/acre), by size class, based on the cover type of the stand. FFE-FVS June 2015 P26

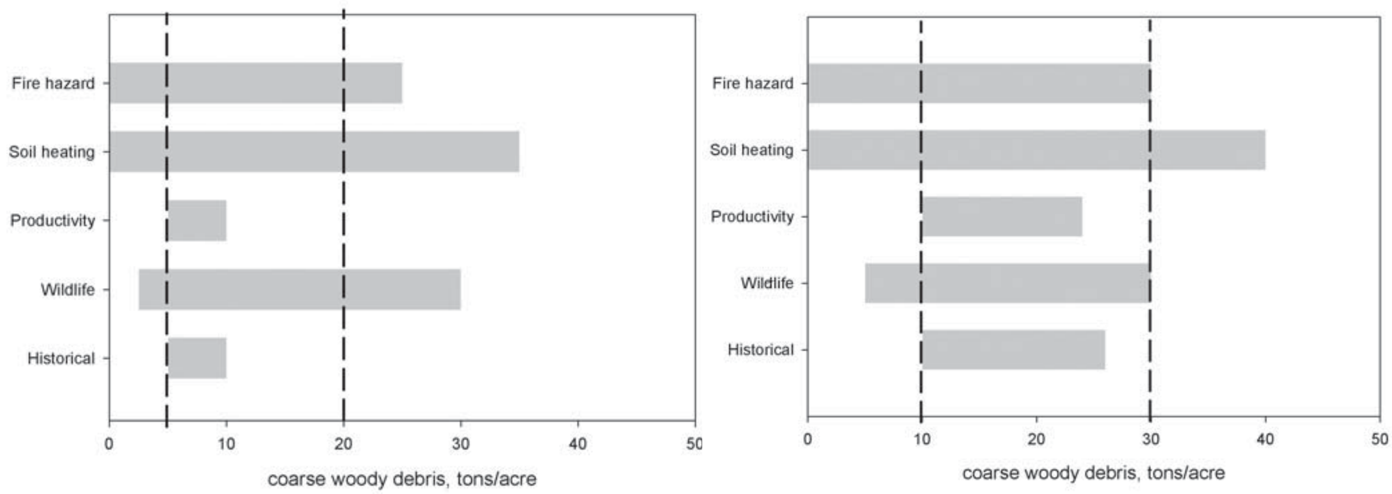
Species	<0.25”	0.25”-1”	1”-3”	3”-6”	6”-12”	>12”	Litter	Total	Duff	Total
Douglas -fir	0.9	0.9	1.6	3.5	3.5	0.0	0.6	11	10.0	21
Lodgepole	0.9	0.9	1.2	7.0	8.0	0.0	0.6	18.6	15.0	33.6
Ponderosa	0.7	0.7	1.6	2.5	2.5	0.0	1.4	9.4	5.0	14.4

The consensus of these studies suggest typical loadings of 10-30 tons/acre in Ponderosa pine, Douglas fir and Lodgepole.

e. Science Recommended Surface Fuel Loading

The (following) recommendations (CWD tons/acre) were based on studies in undisturbed mature stands where ectomycorrhizae populations were used to determine optimum amounts of organic material. USDA Forest Service Gen. Tech. Rep. Brown et al 2003

Figure 2—"Optimum ranges of coarse woody debris for providing acceptable risks of fire hazard and fire severity while providing desirable quantities for soil productivity, soil protection, and wildlife needs for (Left) warm dry forest types and (Right) cool and lower subalpine forest types. Dotted lines show a range that seems to best meet most resource needs: 5 to 20 tons per acre for the warm dry types and 10 to 30 tons per acre for other types.” Brown et al 2003



“The optimum quantity of CWD is about 5 to 20 tons per acre for warm dry ponderosa pine and Douglas-fir types and 10 to 30 tons per acre for cool Douglas-fir and lodgepole pine types and lower subalpine fir types. The recommended optimum ranges of CWD quantities should be modified by consideration of other factors such as quantity of small woody fuel, diameter of CWD, landscape level needs, and ecosystem restoration objectives. The CWD optimum quantities for acceptable fire hazard are appropriate when accompanied by small dead fuel loadings of about 5 tons per acre or less. Acceptable CWD quantities are less at higher small fuel loadings (greater than 8 to 10 tons per acre). Brown et al 2003

‘This suggests that where CWD comprises predominately 3- to 6-inch material, the optimum quantity is less, perhaps by 5 tons per acre or more, than for larger sized material. With this in mind, it seems reasonable to assume that high fire hazard ratings apply when 25 to 30 tons per acre of CWD largely comprises 3- to 6-inch material.”

If CWD = 3-6”, and small dead fuel = 5 t/a, then optimum = 10-30 t/a
If CWD = 3-6”, and small dead fuel = 8-10 t/a, then optimum = 5-25 t/a

How much fine woody debris is present after L&S treatments?
How much FWD is left after manual or mechanical treatments have made piles?

“Large, dead and down woody debris is a major component of Rocky Mountain forests. Graham et al (1994) conducted studies on coarse woody debris (woody residue larger than 3 inches in diameter) in the Rocky Mountains. They state that “Forested ecosystems evolved with a continual flux of coarse woody debris (CWD). The creation and accumulation of CWD depends on forest type, successional stage, insect and disease activity, weather events, fire-return intervals, decay rates, and timber management activities. During the last 100 years, the fire frequencies in all of the Rocky Mountain ecosystems have been greatly extended, potentially increasing CWD accumulations.” They maintain that CWD performs many physical, chemical and biological functions in forest ecosystems and make conservative recommendations by habitat type to ensure that enough organic matter is available after timber harvest to maintain long-term productivity. Their study included granitic and volcanic soils on the Beaverhead-Deerlodge National Forest, Butte and Jefferson ranger districts. They recommend 7-15 tons/acre in the Subalpine fir/whortleberry type, 11-23 tons/acre in the Subalpine fir/beargrass type, 4-9 tons/acre in the Douglas-fir/ninebark type, and 13-24 tons/acre in the Douglas-fir/pinegrass type.” Basin Creek Hazardous Fuels Reduction FEIS P3.13

“Treatment of Slash
There is a short-term increase in fire hazard following treatment and prior to slash disposal when fuels remain in the units and on the ground. Slash will be whole tree yarded to the landing and piled and burned. In Douglas-fir units, remaining debris will be jackpot burned, leaving 10-15 tons/acre on site for soil nutrient cycling and to mitigate erosion. In lodgepole pine units, remaining debris will be machine or handpiled and burned, leaving 10-15 tons/acre as well. This amount is below the recommendation by Brown et al (2001) to reduce fire hazard and increase the ability to safely and efficiently suppress fires. Fuel loadings within 200 feet of the forest boundary may be less than this recommendation; these areas will be handpiled and burned to provide added protection next to private residences.” Basin Creek Hazardous Fuels Reduction FEIS P3.49

“Fire hazard, including resistance-to-control and fire behavior, reach high ratings when large fuels exceed about 25 to 30 tons per acre in combination with small woody fuels of 5 tons per acre or less.”

f. Forsythe Surface Fuel Loading Criteria

“Slash take back will only be allowed on skid trails, in patchcut/clearcut units where it is needed to meet the coarse and fine woody debris retention criteria or other areas designated as adversely impacted by a USFS Soil Scientist/Hydrologist/COR/Sale Administrator, for soil stabilization, and to a maximum depth of 18 inches." Forsythe II DN July 2017 P35

Patchcut/Clearcut Areas P36
1. Retain coarse and fine woody debris (CWD and FWD) throughout clearcut/patchcut units to maintain long term soil productivity.
a. At least 8 tons/acre of Coarse Woody Debris (material >3" in diameter), with preference for large diameter material (boles)
b. At least 4 tons/acre of Fine Woody Debris (material <3" in diameter.)

"All thinning slash shall be less than 18" in height, placing it on or near the ground surface, and not covering more than 25% of the surface area per acre." Contract – draft Forsythe II Phase I P9-11

"In machine units, reasonably gather and place activity slash material, 1" to 6" diameter, into piles. If more than 50% of a treatment unit has continuous slash depth greater than 6" after initial treatment, additional piling will be required." Forsythe II DN July 2017 P38

The Forest Service doesn't appear to have a well-defined or consistent approach to surface fuels in the Forsythe projects: at least 4 tons/acre of FWD and no more than 18" slash depth over 25% of an acre.

5. **What can the FS do to address surface and ladder fuels?**
    a. **Prioritize surface and ladder fuel reduction over tree removal treatments.**

"The most effective strategy for reducing crown fire occurrence and burn severity is to (1) reduce surface fuels, (2) remove ladder fuels, (3) increase canopy base heights, (4) and lastly, reduce canopy continuity and density." Graham and Finney 2012

- Use treatment methods like those used by the Forest Service in the Warm Lake/ Cascade area before the Complex of Wildfires in Central Idaho in 2007.
- Require that manual teams remove (pile and burn) existing excess (to be defined) surface fuels where they find it. Not just the "activity" fuels created during tree removal treatments. This may also be a step toward preparing an area for follow-up prescribed burns.
- Anticipate and prepare for increased fuel loads. For example, in edge regions, next to treatments, where blowdown is expected and can be estimated, crews could remove (pile and burn) additional surface fuels so that over time, the blowdown doesn't create new regions of jackpot fuels.
- "A practical consideration for minimizing severe soil heating is to concentrate salvage activities in thickets of dead trees. If the thickets fall down naturally the CWD becomes concentrated. Burnout of large woody fuels is enhanced where the material is concentrated because of the interaction between adjacent burning pieces. Thus, salvage can be used to reduce and scatter the potential fuel concentrations." Brown et al 2003 P6

b. **Write into the contracts strict rules for the amount of surface and ladder fuels that can remain and enforce compliance, just as with the number, size and placement of slash piles.**

The monitoring group and FS can come to a consensus on an acceptable range of surface fuel and work together to write guiding contract language. After any treatment there should be a maximum surface fuel load and the COR should be tasked with enforcing compliance.

c. **Minimize the use of Lop and Scatter slash treatments.**

Only in Rx Burn units, or rarely and under agreed maximum depth.

d. **Create plans and schedules for conducting Prescribed Burns over as much of the landscape possible.**

e. **Follow-up or maintenance treatments, including prescribed burns, removal of doghair thickets, regen planting and burning of slash piles, must be planned and completed on a set schedule.**

Timetables and budgets should be described and identified.

f. **Delay treatments that will create new burn piles or unacceptable levels of slash until fuel backlogs can be reduced.**

6. **What is the role of the Monitoring Group?**

The DN includes a section describing implementation monitoring steps:

• Reevaluating the treatment areas every 10-15 years for the need to retreat.
• Taking photographs of the smoke column during burning operations to verify smoke dispersion, as necessary.
• Checking the receptors for smoke pooling near those areas, as necessary.

More realistic goals with respect to surface fuels may include:

a. Help define the appropriate range of surface fuels to balance wildfire risks with soil and wildlife considerations.
b. Look to the FS to include surface fuel guiding and compliance language in contracts.
c. Work with CFRI to design and implement surface fuel measurement and monitoring protocols to verify contract compliance.
d. Because the CFRI can provide actual before-and-after measurements of surface fuel amounts, this is one of the few objective ways that we can monitor treatment implementation and effectiveness.
e. ?

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Appendix

Table excerpted and adapted from: How to Predict the Spread and Intensity of Forest and Range Fires Richard C. Rothermel General Technical Report INT-143 June 1983

Fuel Type	Fire Behavior Model
PRIMARY CARRIER OF THE FIRE IS LITTER BENEATH A TIMBER STAND. Spread rates are low-to-moderate; fireline intensity (flame length) may be low-to-high. A. Surface fuels are mostly foliage litter. Large fuels are scattered and lie on the foliage litter; that is, large fuels are not supported above the litter by their branches. Green fuels are scattered enough to be insignificant to fire behavior. 1. Dead foliage is tightly compacted, short needle (2 inches or less) conifer litter or hardwood litter.	8. Slow-burning ground fires with low flame heights are the rule, although the fire may encounter an occasional "jackpot" or heavy fuel concentration that can flare up. Only under severe weather conditions involving high temperatures, low humidities, and high winds do the fuels pose fire hazards. Closed canopy stands of short-needle conifers or hardwoods that have leafed out support fire in the compact litter layer. This layer is mainly needles, leaves, and some twigs since little undergrowth is present in the stand. Representative conifer types are white pines, lodgepole pine, spruce, fir, and larch.
2. Dead foliage litter is loosely compacted long needle pine or hardwoods.	9. Fires run through the surface litter faster than model 8 and have higher flame height. Both long-needle conifer and hardwood stands, especially the oak hickory types, are typical. Closed stands of long-needled pine like ponderosa, Jeffrey, and red pines or southern pine plantations are grouped in this model. Concentrations of dead-down woody material will contribute to possible torching out of trees, spotting, and crowning.
B. There is a significant amount of larger fuel. Larger fuel has attached branches and twigs, or has rotted enough that it is splintered and broken. The larger fuels are fairly well distributed over the area. Some green fuel may be present. The overall depth of the fuel is probably below the knees, but some fuel may be higher.	10. The fires burn in the surface and ground fuels with greater fire intensity than the other timber litter models. Dead down fuels include greater quantities of 3-inch or larger limbwood resulting from overmaturity or natural events that create a large load of dead material on the forest floor. Crowning out, spotting, and torching of individual trees is more frequent in this fuel situation, leading to potential fire control difficulties. Any forest type may be considered if heavy down material is present; for example, insect- or disease-ridden stands, wind-thrown stands, over mature stands with deadfall, and aged slash from light thinning or partial cutting.
PRIMARY CARRIER OF THE FIRE IS LOGGING SLASH. Spread rates are low-to-high, fireline intensities (flame lengths) are low-to-very high. Slash is from conifers. Needles have fallen and considerable vegetation (tall weeds and some shrubs) has overgrown the slash. A. Slash is aged and overgrown.	See model 10 above.

B. Slash is fresh (0-3 years or so) and not overly compacted. 1. Slash is not continuous. Needle litter or small amounts of grass or shrubs must be present to help carry the fire, but primary carrier is still slash. Live fuels are absent or do not play a significant role in fire behavior. The slash depth is about 1 ft.	11. Fires are fairly active in the slash and herbaceous material intermixed with the slash. The spacing of the rather light fuel load, shading from overstory, or the aging of the fine fuels can contribute to limiting the fire potential. Light partial cuts or thinning operations in mixed conifer stands, hardwood stands, and southern pine harvests are considered. Clearcut operations generally produce more slash than represented here. The less-than-3-inch material load is less than 12 tons per acre. The greater-than-3-inch material is represented by not more than 10 pieces, 4 inches in diameter, along a 50-ft transect.
2. Slash generally covers the ground (heavier loadings than Model 11), though there may be some bare spots or areas of light coverage. Average slash depth is about 2 ft. Slash is not excessively compacted. Approximately one-half of the needles may still be on the branches but are not red. Live fuels are absent, or are not expected to affect fire behavior.	12.-Rapidly spreading fires with high intensities capable of generating firebrands can occur. When fire starts, it is generally sustained until a fuel break or change in fuels is encountered. The visual impression is dominated by slash, much of it less than 3 inches in diameter. These fuels total less than 35 tons per acre and seem well distributed. Heavily thinned conifer stands, clearcuts, and medium or heavy partial cuts are represented. The greater-than-3-inch material is represented by encountering 11 pieces, 6 inches in diameter, along a 50-ft transect.
3. Slash is continuous or nearly so (heavier loadings than Model 12). Slash is not excessively compacted and has an average depth of 3 ft. Approximately one-half of the needles are still on the branches and are red, OR all the needles are on the branches but they are green. Live fuels are not expected to influence fire behavior.	13.-Fire is generally carried across the area by a continuous layer of slash. Large quantities of greater-than-3-inch material are present. Fires spread quickly through the fine fuels and intensity builds up more slowly as the large fuels start burning. Active flaming is sustained for long periods and firebrands of various sizes may be generated. These contribute to spotting problems as the weather conditions become more severe. Clearcuts and heavy partial cuts in mature and overmature stands are depicted where the slash load is dominated by the greater-than-3-inch material. The total load may exceed 200 tons per acre, but the less-than-3-inch fuel is generally only 10 percent of the total load. Situations where the slash still has "red" needles attached but the total load is lighter, more like model 12, can be represented because of the earlier high intensity and quicker area involvement.