Timber Losses from West Fork Complex Fire in Southwest Colorado

Laren Cyphers
Kurt Mackes
Kevin Duda

Abstract

This article provides an assessment of fire effects on timber burned in the West Fork Complex fire area, located in the San Juan Mountains of Colorado. The West Fork Complex fire burned 109,615 acres in 2013, and suppression costs alone totaled $33.2 million. Much of the fire occurred in spruce–fir forests that were previously affected by spruce beetle (*Dendroctonus rufipennis*). Several timber sales were actively occurring within the fire footprint, and more were anticipated to begin in subsequent years. To provide a more accurate valuation estimate, base log stumpage data from 2003 through 2017 were included in this study to show high degrees of variation over time. With base log stumpage values determined, estimates of total hundred cubic feet of each significant species were calculated using geospatial and forest inventory analysis data. This study determined the timber value loss resulting from the coupled disturbance events of the spruce beetle epidemic and a wildland fire to be $19,083,102. This estimate will allow for a more accurate valuation of the actual damage resulting from the West Fork Complex fire. This study may also be useful in supporting the literary basis for salvage and fuels management after a beetle outbreak to prevent such timber value losses from occurring.

The West Fork Complex fire, located in southwest Colorado, started on June 5, 2013, burned 109,632 acres, and was considered fully contained and smoldering by July 19, 2013 (US Department of Agriculture Forest Service [USDAFS] 2014). This fire burned primarily in the Weminuche Wilderness and surrounding Rio Grande National Forest located in the San Juan Mountains of Colorado (Fig. 1). Suppression efforts alone cost $33.2 million, not including the additional costs associated with effects on watersheds, local businesses, and timber value. Much of the fire occurred in spruce–fir forests that were previously affected by spruce beetle (*Dendroctonus rufipennis*). Mortality reached up to 80 percent of trees in some stands, leaving a dense network of ladder fuels (USDAFS 2014). The Burned-Area Report (USDAFS 2013) for the fire estimates that approximately 88 percent of the burned area was comprised of contiguous areas of beetle-killed trees in the ''dead and gray'' stage.

Several timber sales were actively occurring within the fire footprint, with more anticipated to begin in subsequent years. All harvestable acres within the fire footprint were in the Rio Grande National Forest. According to USDAFS personnel on the Divide Ranger District, Engelmann spruce (*Pices engelmannii*) was the primary species sold in this area, with occasional sales of aspen (*Populus tremuloides*) and other mixed conifers, including Douglas-fir (*Pseudotsuga mezsiesii*), subalpine fir (*Abies lasiocarpa*), and white fir (*Abies concolor*). Neither the Burned-Area Report nor the Programmatic/Cost Fire Review of the West Fork Complex fire mentioned timber value losses resulting from the fire, and this study seeks to estimate them.

Prior literature addresses primarily insect outbreaks following a fire event (Mazza 2007, Lowell et al. 2010). Timber value losses resulting from a high-intensity fire in a heavily beetle-killed forest is not well documented. Nonetheless, references in literature suggest that the rate of timber deterioration associated with a fire depends on the forest health prior to it, past management activities, severity of the burn, season the fire occurred, moisture conditions on site, and tree diameter (Mazza 2007, Lowell et al. 2010). Factors that affect the value of beetle-killed trees include species, size and quality, stand density, accessibility and terrain, logging method, available wood markets, type of

The authors are, respectively, MS Graduate, Dept. of Forest Sci. (larencyphers@gmail.com [corresponding author]), and Assistant Professor, Dept. of Forest and Rangeland Stewardship (kurt.mackes@colostate.edu), Colorado State Univ., Fort Collins; and Supervisory Forester, Region 2, Divide Ranger District, US Forest Serv., Del Norte, Colorado (kduda@fs.fed.us). This paper was received for publication in October 2017. Article no. 17-00062.

Forest Prod. J. 69(4):272–277.
doi:10.13073/FPJ-D-17-00062

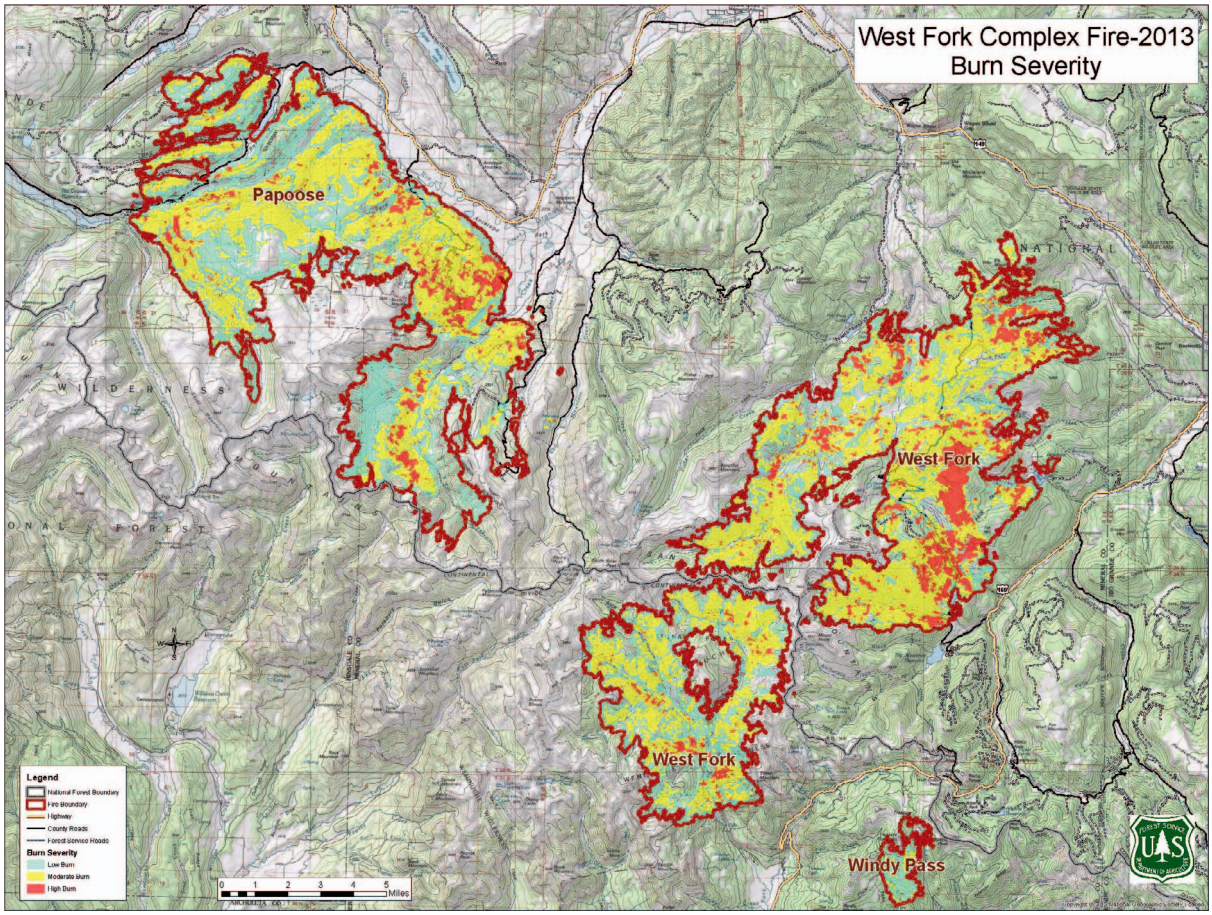

Figure 1.—Fire footprint and burn severity map of the 2013 West Fork Complex fire. Map provided by the US Department of Agriculture Forest Service.

timber sale, and conditions of the timber sale (Mackes et al. 2010).

Initial deterioration of beetle-killed trees, where the sapwood drops below its fiber saturation point causing differential shrinkage, is made obvious by seasoning checks found on the surface of a tree (Vaughn et al. 2018). Seasoning checks tend to reduce the grade (quality) of lumber processed from the timber, but the lumber is still usable for lower grades, and yield is often not reduced after initial checking occurs (Lowell et al. 2010, Vaughn et al. 2018). The spruce beetle, like the mountain pine beetle (*Dendroctonus ponderosae*), attacks the phloem layer of the tree, minimally affecting the stem wood, but often leads to blue stain, seasoning checks, and further wood deterioration (Mackes et al. 2010). Wood moisture content decreases rapidly after the death of a tree, causing wood to check within 1 to 3 years post death (Mackes et al. 2010). A historic study of Engelmann spruce deterioration after a spruce beetle outbreak in Colorado observed season checking taking place in trees with green needles still attached, suggesting this defect can occur within the first year after a tree is attacked (Mielke 1950). These season checks are of concern primarily if the timber will be salvaged and cut for lumber (Mielke 1950). Blue stain in dead spruce has no effect on the integrity of the wood, but solely on the aesthetics; although it reduces the grade based on visual grade standards, in some cases it can still be sold at a premium (Mackes et al. 2010).

Standing dead trees eventually fall as a result of basal decay and windthrow. The potential to use those fallen dead trees decreases rapidly as the rate of decay progresses (Cahill 1980, Lewis and Hartley 2006). Although pine species must be salvaged as soon as possible after a disturbance, the literature suggests that Engelmann spruce can stand dead and remain merchantable after being killed by spruce beetle for more than 20 years, with most of the blowdown and losses in value taking place gradually over a number of years (Mielke 1950, Romme et al. 2006, Mackes et al. 2010, Vaughan et al. 2018). Relatively few trees had fallen within the first decade after an outbreak (Mielke 1950).

A recent field and sawmill study was conducted by Vaughan et al. (2018) on timber harvested from the Rio Grande National Forest to model seasoning check development in beetle-killed stands and to determine mortality effects on yield and grade of structural lumber. Time since death (TSD) of trees sampled ranged from 1 to 11 years, making the range in mortality years from 2004 to 2014. Overall, a decline in grade and increased check severity was found with increasing TSD of Colorado Engelmann spruce. However, this varied significantly depending on tree diameter. Small trees sampled, or those with a diameter of 8 to 11.9 inches, did not develop additional checks beyond the first year; medium trees, or those with a diameter of 12 to 16.9 inches, continued to check for several years; and large trees, or those with a diameter of 17 inches or larger,

developed deepening checks for the length of the study and likely beyond. The study concludes that the sooner salvage can occur, the better, but offers some priorities based on higher risk of deterioration (Fig. 2).

According to USDAFS aerial data, the spruce beetle epidemic on the Rio Grande began between 2004 and 2005 and continued to climb until the year of the fire (Fig. 3). This means the TSD of a given tree could be anywhere from 1 to 10 years, roughly the same time frame as the study conducted by Vaughn et al. (2018). Based on the findings of Vaughan et al. (2018), beetle-killed trees in West Fork stands likely exhibited limited deterioration, still being actively salvaged and suitable for products. However, their condition dramatically affected how they were affected by fire.

Generally, if a stand is in good health prior to a fire, the outer bark of a tree can scorch, but the interior wood will retain some commercial value if harvested in a timely manner (Mazza 2007). The length of time that the tree retains value is dependent on the species and the desired end use. The literature suggests that a fire-killed tree that was previously healthy will retain value for 3 to 5 years (Mazza 2007). If a live tree is severely damaged by a fire but not killed during the event, it will likely die 2 to 3 years after the fire event (Mazza 2007, Lowell et al. 2010). However, it is unclear based on literature what the anticipated timeline is for further timber deterioration resulting from high-intensity wildfire when a high percentage of the trees are already dead prior to the event, as was the case in the West Fork Complex fire.

The silvicultural characteristics of Engelmann spruce, coupled with massive beetle damage, made the trees in the West Fork Complex vulnerable to timber value loss. Engelmann spruce exhibits thin, loose bark with persistent dead lower limbs, making the species susceptible to severe injury from fire (Alexander and Shepperd 1984, Lowell et al. 2010). Lowell et al. (2010) also writes of Engelmann's thin-barked nature as encouraging rapid and uneven drying after death, thereby increasing losses from seasoning checks and potential for fire injury. Insect activity loosens the bark of trees, which also increases the rate of drying in sapwood (Lowell et al. 2010). During a site visit in July 2016, it was clear that the insect mortality followed by the severe fire significantly reduced the amount and value of usable wood in this area (Fig. 4). This reduction in harvestable timber is

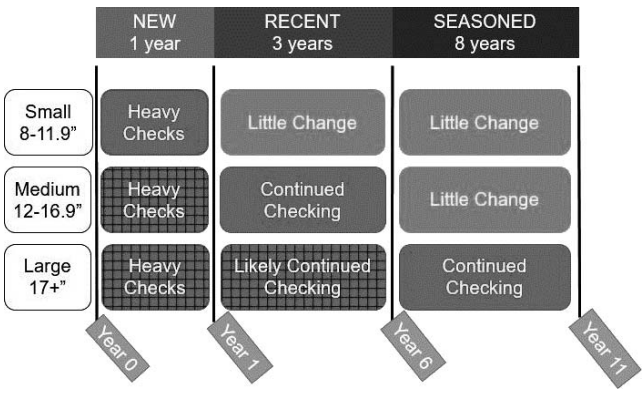

Figure 2.—Timeline of season checking after beetle attack on Engelmann spruce in the Rio Grande National Forest. Hatched squares indicate priority cells for a management response and timber recovery. "Likely Continued Checking" indicates a nonsignificant change. Graphic from Vaughn et al. (2018).

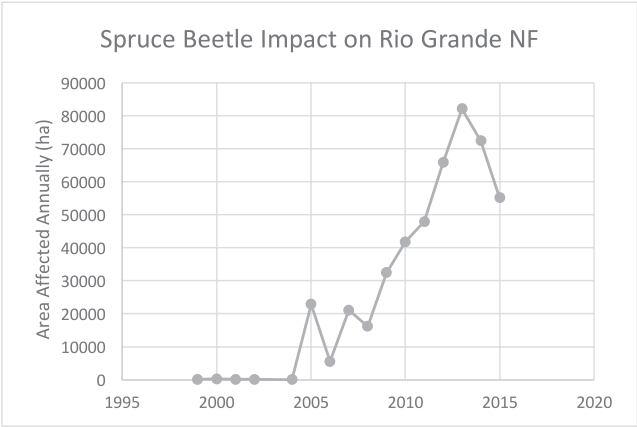

Figure 3.—Timeline of spruce beetle attack in the Rio Grande National Forest based on aerial data from the US Department of Agriculture Forest Service.

also seen in ongoing timber sale data provided by the USDAFS (Table 1). Of the ongoing timber sales in the fire footprint, five of the six sales were more than 50 percent burned. Three of the timber sales were almost completely burned and required a replacement volume or were not advertised, making it safe to assume that the timber on those sites could yield little to no volume or value. In one case, the purchaser terminated the sale after 74 percent of the site was burned. It follows from this timber sale data, literature, and the condition of Engelmann spruce observed at the sites that there was little opportunity to harvest beetle-killed trees after the fire. There are no plans for future timber salvage operation in the West Fork Complex fire footprint primarily because there is no timber suitable for use.

The focus of this study was to determine the value of timber consumed in the West Fork Complex fire. Estimates were based on stumpage values at the time of the fire. These cost estimates allow for a more accurate valuation of the actual costs resulting from the West Fork Complex fire. This study may also be useful in supporting the literary basis for salvage and fuels management after beetle outbreak to prevent such timber value losses from reoccurring.

Methodology

Log stumpage prices provided by the USDAFS 2013 Transaction Evidence Appraisal Bulletin for Engelmann spruce in the Southwest Intermountain region of Colorado were advertised at $55.13 per hundred cubic feet (CCF); Douglas-fir was advertised at $8.89/CCF; true firs at $40.32/CCF; and aspen at $2.82/CCF. Standard USDAFS appraisals are considered appropriate estimates when determining valuation of timber following a disturbance event, as discussed in a recent USDAFS guide on fire damage and cost recovery procedure handbook (Moore 2015). To provide a more accurate valuation estimate, log stumpage data from 2003 through 2017 were included in this study to show high degrees of variation over time. Estimates of total CCF for each significant species that could potentially have been harvested in the fire area were calculated using geospatial and forest inventory analysis (FIA) data.

Geospatial data was acquired from the Divide Ranger District of the USDAFS. Harvestable acres in the West Fork Complex fire burn area were determined using ArcMap. All

Figure 4.—A site visit to the fire footprint showed the impact on timber in an area previously affected by spruce beetle. Photos by Laren Cyphers.

harvestable tree species with significant acreage were included in the study: aspen, Douglas-fir, Engelmann spruce, and true fir. Less than 1 percent of the burn area was covered by either cottonwood or blue spruce, which were not considered significant or included in the study. The parameters of acres that were considered harvestable included those that were on slopes less than 40 percent, outside wilderness areas, roadless areas, or other areas deemed unavailable for harvest by the Rio Grande National Forest's Land and Resource Management Plan, within the West Fork Complex fire footprint, and forested by aspen, Douglas-fir, Engelmann spruce, or true fir. It is important to note that acres deemed ''harvestable'' in this study were not necessarily part of an ongoing or future timber sale. Instead, harvestable acres include those that had the potential for inclusion in a timber sale or thinning operation prior to the fire. Acres that burned in the San Juan National Forest were not included in this study because they were primarily located in wilderness areas.

Total harvestable acreages for each significant tree species were calculated individually, as was a total for harvestable acres in the fire footprint. Average CF/acre for each species was determined using FIA data found through the publicly available EValidator program (USDAFS 2019). The program was run using an average net volume of sawlog portion of sawtimber trees on forestland per area of forestland from 2003 to 2012. The sampling error percentages of average CF/acre, according to the EValidator program, ranged from 7.53 to 15.65 percent. FIA data were also used to find the average percentage of Engelmann spruce and true fir included in the spruce–fir forest cover on the Rio Grande; this was necessary to accurately determine estimated total CCF and stumpage value loss of both species, as GIS data provided numbers only for the spruce–fir forest cover type. The sampling error percent for this data was higher, generally ranging between 14.33 and 33.7 percent, with a sampling error of 65.78 percent for white fir estimates.

The total harvestable acres for each species was multiplied with the average CF/acre of that species on the Rio Grande National Forest, producing an estimate of total harvestable CCF for each species within the fire footprint. Total harvestable CCF estimates were multiplied with the USDAFS appraised log stumpage prices to find the total stumpage value loss resulting from the West Fork Complex fire at the time of the fire. Final calculations were reviewed and verified by the supervisory forester of the Rio Grande National Forest.

Table 1.—Summary of ongoing timber sales in fire footprint in 2013. Data from US Department of Agriculture Forest Service records.

Timber sale	Acres	Volume (CCF)	% burned	Postfire action
Gold Nugget	180	2,801	98	Replacement volume
Last Chance	256	4,737	30	Replacement volume and harvest unburned
Antlered	172	1,947	74	Purchaser termination
Copperhead	317	2,801	51	Harvest unburned
Rhino	318	2,795	97	Not advertised
Overlook	402	3,426	100	Not advertised

Results and Discussion

Table 2 summarizes the timber value loss by species for the West Fork Complex fire. The total forested harvestable acres in the West Fork Complex fire footprint were determined to be about 20,850 acres. The majority of these acres, or about 85 percent, were forested by Engelmann spruce, which accounted for 98 percent of the timber value loss resulting from the fire. Total stumpage value loss for aspen, Douglas-fir, Engelmann spruce, and true fir totaled $15.1 million using appraisal values at the time of the fire, with Engelmann spruce accounting for $14.8 million of the total estimate.

These findings do not specifically account for any value or grade loss in Engelmann spruce resulting from the spruce beetle epidemic affecting the area, but losses associated with the epidemic are reflected in the stumpage values at the time of the fire. As seen in Figure 5, stumpage values for timber harvested in the Rio Grande National Forest have decreased significantly over the past decade or so, which is consistent with most timber markets in the United States. According to the Western Wood Products Association (2010), there was a mild recession in 2001, followed by a boom in forest products and housing markets from 2003 to 2005. The falloff in the US housing market began in 2006 and became a global financial crisis in 2009. During this crisis, ''virtually every western mill suffered curtailments and 30 large mills closed permanently'' (Keegan et al. 2011). The value of wood and paper products in the West dropped significantly, as did employment in this industry. The results of this study parallel these events and show some recovery from 2009 to 2013, followed by another sharp decrease in stumpage value around the time of the West Fork Complex fire in 2013.

Specifically, the variability and distinct decrease in Engelmann spruce Transaction Evidence Appraisal values around the time of the fire pose interesting discussion. This decline is likely the result of a number of factors: the sharp decline in lumber markets, an increase in salvaged material (beetle-killed timber), changes in appraisal methods for live versus dead timber in 2005, the splitting of appraisal zones in 2012, and the use of adjustments for sales with a high percentage of dead trees. However, the West Fork Complex fire decreased the volume of Engelmann spruce available in the ongoing contracts of several of the main purchasers in the area. In this way, the fire may have increased local

Table 2.—Summary of the timber value loss by species for the West Fork Complex fire.

Species[a]	Log stumpage adjusted base period price ($/CCF)	Average CCF/acre in Rio Grande National Forest	Stumpage value per acre ($)	Forested harvestable acres in burn area	Estimated value ($)
TAA	9.58	6.16395	59.05	1,447.12	85,453.36
TDF	8.89	14.1376	125.68	300.24	37,735.14
TES	55.13	16.7268	922.15	16,051.04576	14,801,447.51
TTF	40.32	1.9725	79.53	1,892.812	150,537.61
				Total estimated stumpage value	15,075,173.63

[a] TAA = aspen; TDF = Douglas-fir; TES = Engelmann spruce; TTF = true fir.

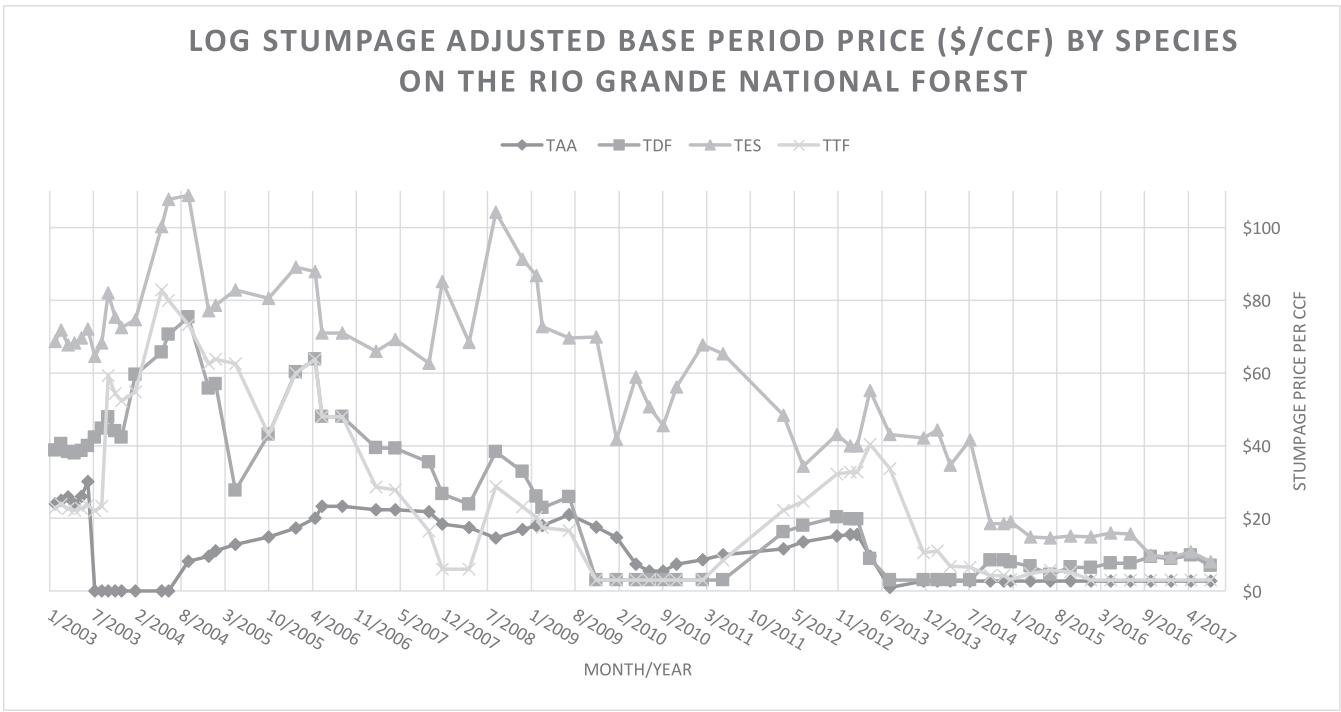

Figure 5.—Estimated log stumpage adjusted base period price ($/CCF) of the harvestable timber by species in the Rio Grande National Forest by year. TAA = aspen; TDF = Douglas-fir; TES = Engelmann spruce; TTF = true fir.

demand for timber, which may have slightly increased prices. Still, the volume offered and sold on the Rio Grande at the time of the fire was also increasing, making more volume available and perhaps tempering the market response. Based on the complexity and uncertainty of the factors listed above, it is unclear whether the fire affected timber prices, but it certainly decreased available volume to the local market area, causing long-term effects for the local mills. There is little discussion of this phenomena experienced by the dwindling timber market in Colorado and it could be the catalyst for future studies.

It is important to note that this study assumes that all trees in the harvestable burn area were of rotation age and on productive sites. Most of the spruce–fir cover type that was accessible had been previously harvested at least once, so the FIA data may be overestimating spruce–fir volume per acre. According to USDAFS personnel in the Divide Ranger District, most of the commercial aspen stands in the area net closer to 22 CCF/acre, compared with about 7 CCF/acre according to FIA data used. FIA data do not focus on commercial stands, so they are likely to be underestimating volume per acre of commercial aspen stands.

Regardless, losses calculated based on stumpage value give a conservative estimate of the overall effect on the Rio Grande National Forest and the local community. The timber value losses reported in this study do not consider timber loss effects on other important uses of the forest, such as watersheds, wildlife habitat, and recreation, nor do they consider the impact on the local forest products industry or the businesses and communities they support as identified by Lynch and Kelly (2006). The losses reported in this study generally reflect the loss to the timber harvesting program in the Rio Grande National Forest. Although the losses reported are thought to fairly reflect the value of the timber on the landscape that was lost at the time of the fire, the impact of this loss will be felt for a much longer time. Areas where aspen was present will regenerate relatively quickly. However, high-intensity fires in spruce–fir generally result in meadows for hundreds of years when aspen is not present (Battaglia and Shepperd 2007). As a result, about 85 percent of the harvestable land affected by the West Fork Complex fire will be lost to timber production for the foreseeable future.

Conclusion

The West Fork Complex fire burned primarily on national forest system lands with spruce–fir cover type heavily affected by spruce bark beetles, affecting just one small structure and causing no loss of human life. Because of forest conditions and high fire intensity, the timber burned in the fire was no longer suitable for use, and there are no plans to salvage timber in the fire area. The harvestable area consumed by the fire was determined to be 20,835 acres, and the stumpage value of timber found on these acres was an estimated $15.1 million at the time of the fire, about 98 percent of which was Engelmann spruce. This loss in stumpage value does not consider effects on other forest uses such as watershed, wildlife habitat, and recreation, nor does it consider the future impact on the Rio Grande National Forest timber program and the local businesses and communities that derive benefit from the timber. When coupled with suppression costs of $33.2 million, the true cost of the West Fork Complex fire exceeded $48 million, not including costs or losses associated with watershed damage, wildlife habitat damage, tourism, tax revenue, highway closures, law enforcement, and rehabilitation efforts; as such, the true cost may not be fully known for decades or perhaps centuries to come.

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