Fire Severity in Fuel Treatments
American River Complex fire, Tahoe National Forest, California
June 21 - August 1, 2008

Hugh Safford
Regional Ecologist
USDA-Forest Service
Pacific Southwest Region
1323 Club Drive
Vallejo, CA 94592
707-562-8934
hughsafford@fs.fed.us
Contents

Contents and List of Figures 2
Executive Summary 3
Report Background 4
Fire and Land Use Background 4
Specific Findings from the Field Visits 8
Conclusions 20

Figures

Figure 1. Fire severity map with field site locations 5
Figure 2. Fire progression map 6
Figure 3. Daily max. temperatures and min. humidities 6
Figure 4. ERC values, 6-10 to 7-20, Foresthill RAWS station 7
Figure 5. Texas Hill Spring fuel treatment 9
Figure 6. Texas Hill Spring fuel treatment 10
Figure 7. Dawson Springs fuel treatment and neighboring spotted owl Protected Activity Center (PAC) 11
Figure 8. Dawson Springs spotted owl PAC 12
Figure 9. New York Canyon from Site 4 12
Figure 10. Whiskey Project ridgetop fuel treatment 13
Figure 11. Unburned area within fuel treatment 14
Figure 12. Tadpole spotted owl PAC 15
Figure 13. Tadpole masticated plantation 15
Figure 14. Whiskey 2 plantation 16
Figure 15. Whiskey 1 fuel treatment at onset of fire 17
Figure 16. Whiskey 1 fuel treatment postfire 18
Figure 17. Unburned thinned area, Humbug Ridge 19
Figure 18. Burned landing pile area, Humbug Ridge 19
Figure 19. Unburned masticated fuel treatment just outside the fire perimeter 21
Executive Summary

1. The American River Complex fire burned through extremely complex topography, under mostly moderate weather conditions and relatively high ambient and fuel moisture conditions. Overall fire severity was primarily low to moderate, with most of the high severity effects occurring on a single day when temperatures and wind speeds rose and humidity dropped.

2. The fire encountered a number of fuel treatments, principally pine plantations where shrubs has been masticated and mature forest stands where commercial thinning had been accomplished. Although there is no record of explicit reduction and removal of ladder and natural surface fuels in any of the forest thinning treatments, the Texas Hill fuel treatment supported very low levels of both and it appears that it may have been “informally” treated at some time.

3. Of three masticated plantations visited, one resisted fire on a day of moderate fire behavior, two were burned through with loss of the plantation on the day of severe fire weather. A fuel treatment which incorporated mastication also burned. Plantations with medium to high cover of live shrubs mostly survived fire.

4. Of the thinned forest stands visited, only one performed completely as designed. This was the Texas Hill fuel treatment, where it appeared that ladder and natural surface fuels had been reduced. Of the other treatments, the Whiskey 1 fuel treatment had had surface fuels piled but they were still on site when fire encountered the treatment. Although fire in this fuel treatment progressed largely as a surface fire, locally intense burning resulted in high canopy tree mortality.

5. Mastication is a cheaper alternative than complete removal of shrub and surface fuels from a site, but although it reduces available surface area and vertical extent of these fuels, it does not reduce local fuel loadings. In a number of cases, the presence of dry surface fuels in the masticated units appears to have abetted rather than resisted fire. Under wildfire conditions, fire modeling studies reported in the scientific literature predict high flame lengths and fireline intensities and high tree mortality in masticated stands.

6. On the whole, the forest thinning treatments we visited appear to have moderated fire by reducing crown torching and (slightly) increasing canopy tree survival, but only one treatment succeeded in both forcing fire to the surface and preserving most of the stand. The successful treatment was the only one which appeared to have had explicit reduction and removal of ladder and surface fuels. Crown thinning removes combustible biomass from the target stand, but is unlikely to represent sufficient treatment to guarantee desired fuel treatment performance under typical wildfire conditions.
Report Background

This report was requested by the Regional Office Fire and Aviation Management staff, and carried out by the Pacific Southwest Region Ecology Program. Field visits to areas of fuel treatment within the fire perimeter were made on July 30, 2008, in the company of Karen Jones, American River District Silviculturist, and Gary Fildes, Tahoe National Forest (TNF) Fuels Management Officer. Further information was also obtained from Jones and Fildes over the ensuing days, as well as from Jane Laboa, American River Complex Fire Information Officer; Don Will, TNF Deputy Chief of Fire Operations; Walter Levings, TNF Resource Staff Officer; Bob Davis, Yuba River District Vegetation Management Officer; Gary Cline, Yuba Ranger District Culturalist; and Ann Westling, TNF Public Affairs Officer. Attempts were made to contact other individuals, but they did not respond in time to be included in this preliminary report.

Fire and Land Use Background

The American River Complex was ignited by lightning on June 21, 2008, and declared contained on August 1, 2008. The 42-day period between ignition and control was a function of (1) extremely complex topography, (2) a relative lack of resources and personnel due to the large number of wildfires burning across California at the same time, (3) several days of dense inversion-caused smoke that limited air operations, and (4) management decisions related to the relatively benign nature of fire behavior for most of the fire’s duration. Total area burned was approximately 20,000 acres. The distribution of fire severity classes was approximately 57% low (including unburned), 23% moderate, and 20% high (i.e., stand-replacing) (Figure 1). Most of the high severity fire occurred in a two-day period beginning July 8, when inversion conditions lifted, temperatures rose and humidity dropped (Figures 2, 3, and 4). ERC (Energy Release Component, a measure of fuel dryness) values exceeded the 90th percentile for the season on July 9 and 10, which are probably record or near record values for the dates (Fig. 4). Large dead fuel moistures and live woody fuel moistures are available from June 25 and July 15. They are given in Table 1.

The American River Complex burned primarily through a matrix of Sierra Nevada mixed conifer forest (ponderosa pine, white fir, Douglas-fir, sugar pine, incense cedar, black oak), with stands of live oak and some chaparral on canyon slopes, and red fir, western white pine and Jeffrey pine stands at higher elevations. Landuse history of the fire area is complex. The eastern half of the fire area was clear cut in the mid and late 1800s. Evidence of this logging can still be seen in the grown-over railroad roadbeds that are visible throughout the forest. The southwestern portion of the fire gets into extensive plantations established after the 1960 Volcano Fire. In the 1970s and 1980s the erstwhile Nevada City District of the Tahoe National Forest carried out many clear cuts and shelterwood cuts in the fire area. In the 1990s some ridgetop stands in the fire area were thinned, and in some cases surface and ladder fuels were removed (some of this work was carried out under the CASPO thinning guidelines). More recently, the American River District has implemented a number of fuels treatments in the fire area. Specific information on the nature of forest thinning and fuel treatments at each visited site is given in the next section.
Figure 1. Fire severity map of American River Complex, with field site locations. Red = high (stand replacing), yellow = moderate/mixed, light green = low (surface fire), dark green = “unburned”. Postfire image from August 1. Map provided by Remote Sensing Applications Center, Salt Lake City.
Figure 2. Fire progression map of American River Complex. About 27% of the fire burned on July 9, when the inversion lifted and most of the high severity fire occurred. Initial burning occurred in the blue polygons, expanding to green, yellow, orange and then red.

Figure 3. Maximum temperatures and minimum humidity measurements from Foresthill, California, approximately 10 miles SW of the fire area. July 9, the day that 27% of the fire burned, much of it at high severity, is marked. Y axis is degrees Fahrenheit for temperature, and % for humidity. Source: http://www.wunderground.com
Figure 4. ERC values from the Foresthill Seed Orchard RAWS weather station, June 10, 2008 to July 20, 2008. Values exceeded the 90th percentile for the season on July 9-11 and July 18-20.

Table 1. Fuel moisture values for June 25 and July 15, 2008.

<table>
<thead>
<tr>
<th></th>
<th>June 25, 2008</th>
<th>July 15, 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large dead fuel moisture (%)</td>
<td>8.25%</td>
<td>8.80%</td>
</tr>
<tr>
<td>Live woody fuel moisture (%)</td>
<td>USBR chamise: 92.1%</td>
<td>Tyler Foote Manzanita: 144.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>USBR chamise: 74.3%</td>
</tr>
</tbody>
</table>

Source: Sean Griffis, California Department of Forestry and Fire Protection
Specific findings from sites visited within the American River Complex Fire, July 30, 2008

Site 1: Texas Hill Spring fuel treatment (T16N R12E, Sec 20)
This site is on the upper portion of a SE-facing ridge, above Burnett Canyon. The stand is dominated by ponderosa pine, incense cedar, sugar pine and Douglas-fir. According to the fire progression map, burning occurred here on July 1. Karen Jones thought that there may have been a slight lifting of the inversion at the time. Needle freeze shows that there was little if any wind. This stand was thinned in 1996 as part of the Dawson timber sale. According to the Environmental Assessment, the goal of the harvest was to “improve forest health by thinning slow-growing, overcrowded trees less than 30 inches in diameter; creating fuel reduction zones as part of a wildfire defense strategy for the entire analysis area”. Thinning was accomplished mechanically with a feller-buncher to a +/- 20-25 foot spacing. There is no written record of further treatment, but the stand is very open, with little or no ladder fuels and low surface loadings as well. According to Karen Jones, it was not unheard of for the district to use engine crews to clear ladder and surface fuels from some units and for these events to go unrecorded. Both Karen and I believe this may have occurred here. The untreated stand below the road was clearcut in the late 1800’s and regenerated naturally. This area is a poster-child for fuel treatment effectiveness (Figures 5 and 6). Table 2 below compares fire severity in the treated versus untreated stands. Bole char was measured with a handheld laser rangefinder. Sample size was 10-20 trees at each location.

<table>
<thead>
<tr>
<th>TABLE 2. Texas Hill Spring FRZ</th>
<th>Mortality (%)</th>
<th>Bole char ht (ft)</th>
<th>Scorch (%)</th>
<th>Torch (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated forest</td>
<td>90-100</td>
<td>Top of trees</td>
<td>+/-100</td>
<td>50-100</td>
</tr>
<tr>
<td>Treatment, adjacent to untreated forest</td>
<td>15-30</td>
<td>10-20</td>
<td>50-80</td>
<td>0-20</td>
</tr>
<tr>
<td>Treatment, 150’ from untreated</td>
<td>0-5</td>
<td>2-10</td>
<td>10-50</td>
<td>0-5</td>
</tr>
</tbody>
</table>

The slope angle is constant from the untreated stand into the treated stand, then lessens gradually as one moves into the treatment. Fire severity differences at this site were clearly due to differing fuel loadings between the treated and untreated stands, and the existence of dense ladder fuels in the untreated stand.

Site 1: Texas Hill Spring masticated unit (T16N R12E, Sec 20 and 21)
This is a 20-year old plantation, clear cut in 1987 in the Burnett timber sale. The unit was tractor-piled and burned in 1989, planted in 1990, released in 1996 (manual release to 4 foot radius), and finally in 2007 a precommercial thin to 20 foot spacing was followed by mastication of the shrub layer (3-5’ tall chaparral by that time). The untreated neighboring forest stand was clear cut in the late 1800s and regenerated naturally. The fire burned very hot in the untreated forest, with nearly 100% stand mortality.
Figure 5. Site 1, Texas Hill Spring fuel treatment. Treated area on the right, untreated forest on the left. The fire came from left to right, under moderate weather conditions. Crown fire became a surface fire within a space equivalent to the width of the road.

Stand mortality in the untreated forest was nearly 100% and the intensity was great enough to completely consume old railroad ties on a series of roadbeds left over from 19th century logging. There was relatively little sign of fire in the treated plantation unit, with only a few small spot fires apparent, and all trees survived. Current plantation shrub cover is 30-50%, greenleaf manzanita, huckleberry oak and mountain whitethorn, 1 to 2 feet tall. Masticated (i.e., dead) fuels were very sparse and did not form a continuous fuel bed. There was obviously little or no wind here during the fire event, as the fire stopped directly at the plantation edge and did not advance into the plantation unit along the ground. It appears that the fire was moving in a vector that was acute to the treatment boundary (i.e. it did not head directly into the treatment).

Site 2: Dawson Springs fuel treatment on Sawtooth Ridge (T16N R12E, Sec 28)
This site is also part of the 1996 Dawson timber sale, and is located on a north-facing slope dominated by white fir (Fig. 7). The fire backed down this slope under climatic inversion conditions. Similar to the Site 1 fuel treatment (same prescription), forest health thinning was accomplished here by a mechanical feller-buncher with whole-tree yarding, but there was no explicit ladder or surface fuel treatment. An underburn was planned but had not yet been carried out. An untreated owl Protected Activity Center (PAC) below
the road here was burned with about 80% mortality of overstory trees, and the ground was covered with white ash (Fig. 8). Fire effects in the neighboring fuel treatment were not very different at first glance, although measurements of a few dozen trees in the two areas showed a slight difference in fire severity (Table 3; heights measured with laser rangefinder). Given the amount of scorch and bole char, it appears that most trees in both the PAC and the fuel treatment will ultimately die. According to Karen Jones, there are many PACs along Sawtooth Ridge which were lost to the fire.

<table>
<thead>
<tr>
<th>TABLE 3. Sawtooth Ridge</th>
<th>Mortality (%)</th>
<th>Bole char ht (ft)</th>
<th>Scorch (%)</th>
<th>Scorch ht (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated forest (owl PAC)</td>
<td>80%+</td>
<td>25-40</td>
<td>80-95</td>
<td>80-120</td>
</tr>
<tr>
<td>Treatment, adjacent to untreated forest</td>
<td>60%+</td>
<td>20-40</td>
<td>60-90</td>
<td>60-90</td>
</tr>
</tbody>
</table>
Site 3: Thinning along Texas Hill
This treated area was used as a safe zone and an anchor point for a small burnout on July 1 (according to Karen Jones and Gary Fildes). As the severity map shows, this area burned mostly at low and mixed severity.

Site 4: New York Canyon
The photo (Fig. 9) looks east at west-facing slopes. The foreground of this picture was burned on July 9 (the blow-up day on which 5,400 acres were burned), the background on July 10. Severity is relatively high on the slopes, low in the draws. There were no treatments in this area.

Site 5: Whiskey project ridgetop fuel treatment (T16N R13E, Sec 32, S ½)
This site is a NW-trending ridgetop, trees are western white pine, white fir, red fir, ponderosa pine and/or Jeffrey pine. Dominant shrubs were huckleberry oak, pinemat manzanita, and green-leaf manzanita. Soils are very rocky (bedrock is metamorphic siltstone and slate), and productivity is low. The stand record card from 1989 noted that
Figure 8. Site 2, photo taken within the spotted owl PAC. Surface fire was intense enough to generate widespread white ash, although little torching occurred.

Figure 9. Looking at New York Canyon from Site 4.
this stand is growing at only 50ft³/ac/yr, which is barely at the minimum level for forestland. This unit was cut in 1989 as a shelterwood/sanitation harvest on 26 acres at the SE end of the ridge, and as an overstory removal/sanitation harvest on 18 acres at the NW end of the ridge (the area between the two treatments was apparently not treated in any way). In 2007 the area was precommercially thinned to 18x18 foot spacing (there was white pine blister rust infection on the ridge) and the shrub layer was masticated. Treatment width was 150 to 200 yards. There was no removal of surface fuels from the site, and no limbing was done to increase live-crown height. Fire hit this site on July 9, the day of the blowup. Needle freeze documents relatively strong winds from the west at the time of burning. Burning was very severe through most of the treated area and the untreated area adjacent to it (Fig. 10). Almost all trees are dead, and surface fuel consumption is nearly complete, except in a few areas which were not masticated (e.g. the area between the treatments along the ridge) and were protected from direct wind

Figure 10. Site 5, photo taken within the ridgetop fuels treatment. Fire appears to have been carried by masticated shrubs. Note the caterpillar treads from the masticator. Wind direction and strength indicated by needle freeze.
Figure 11. Site 5, unmasticated “island” that did not burn. Burned areas on either side of the island had been masticated the previous year. Note that this “island” is also in the lee of the slope and was partly protected from wind.

on the NE side of the Ridge (Fig. 11). The unmasticated area is in a rocky patch between the two treatments, and it appears that the fuel discontinuity as well as fuel moistures in the unmasticated shrubs allowed some of these patches to resist fire.

Site 6: Tadpole owl PAC (T15N R13E, Sec 5 NE ¼)
This is another PAC lost to the fire (Fig. 12). Stand was dominated by red fir and white fir with some western white pine. Severity was very high in this stand, and tree mortality was 100%.

Site 6: Tadpole masticated plantation (T15N R13E, Sec 5 NE ¼)
This is an approximately 6 acre plantation nested within mature forest and adjacent to the owl PAC. The area is west facing. This area was clearcut in 1989, tractor piled and burned in 1990, and planted to Jeffrey pine, white fir and red fir in 1991. Manual release occurred in 1993 and finally a precommercial thin (18 foot spacing) and shrub mastication were carried out in 2007. According to Gary Fildes, the dead fuels layer on the ground was up to 3 or 4 inches thick. This unit was burned through on July 9 (blowup
Figure 12. Site 6, Tadpole spotted owl PAC. No vegetation treatments had been carried out in this stand.

Figure 13. Site 6, Tadpole plantation. Shrubs had been masticated one year before fire. Fire burned through this treatment with nearly complete combustion of surface fuels.
day) with complete loss of the plantation. Needle freeze shows a strong wind from the west at the time of burning (Fig. 13).

Site 7: Whiskey 2 plantation (T15N R13E, Sec 5 NW ¼)
A shelterwood harvest was carried out here in 1991, the site was tractor piled and burned the same year, and Jeffrey pine, white fir, sugar pine and red fir were planted in 1993, with a release treatment in 1995. This plantation had no mastication treatment. At the time of the fire, shrub cover in this unit was 50-80% and shrub height was 1-3 feet, with scattered conifer saplings up to 6 feet tall. According to the fire progression map, this area probably burned in the late afternoon or early evening of July 9 (the blowup day), i.e. when humidity began to recover. This site survived fire, although there are many spot-fire traces within the plantation (Fig. 14). It appears that live fuel moistures were sufficiently high to resist burning.

Figure 14. Site 7, Whiskey 2 plantation. High live fuel moistures in the dense shrub cover probably prevented the plantation from burning. Fire moved from right to left.

Site 8: Whiskey 1 fuel treatment
This area is found on Whiskey Hill, an ENE-trending ridge to the north of Secret Canyon. The stand is mixed conifer, with white fir, ponderosa pine, incense cedar and sugar pine. This 164 acre unit is part of an owl Home Range Core Area (HRCA). It was commercially thinned in 2005 to 50% canopy cover (25 foot spacing) in 2006, and only trees <24” dbh were removed. Trees were yarded to landings before they were limbed to
reduce activity fuels. In 2007, surface fuels were grapple-piled into 8x8’ piles spaced about 50 feet apart. There were also four very big landing piles. The piles were scheduled to be burned, but at the time of the fire pile burning had not yet been accomplished. There was also an underburn planned, 3 or 4 years from now (to allow time for the trees to recover from the initial treatments). According to Karen Jones, fire entered into this stand from the NW on July 8 after spotting across a (wide) bladed fire line at the top of the ridge. According to Jane Laboa (Fire Information Officer), who was on site as this area burned, the ground was a mixture of dirt and scattered needlecast and the fire only progressed very slowly through surface fuels. However, spotting embers got into the grapple piles and this generated local torching and more spotting, which quickly spiraled out of control (Fig. 15). According to Jane, the heat generated was extremely intense; large amounts of white ash on the soil surface attest to this (Fig. 16). One or two of the huge landing piles were protected from burning by bulldozer blading and watering. The result of fire in this fuel treatment was high levels of crown scorch and localized torching. Mortality is over 80% across most of the stand. The high stand mortality notwithstanding, fire behavior was sufficiently moderated by the fuel treatment to allow control along a road immediately south of the unit.

Figure 15. Grapple piles beginning to burn within the Whiskey 1 fuel treatment, toward the upper edge of the treatment area. Ignition source was spotting embers from fire on slope to the north. Jane Laboa photo.
Site 9: Humbug Ridge
This is a 990 acre treatment area, about \( \frac{1}{2} \) of which is in designated Wildland Urban Interface (WUI). This area is within the 1960 Volcano Fire perimeter and was planted in 1961 or 1962. The stand was commercially thinned to 25 foot spacing in June, 2008 in the North Divide timber sale, with whole-tree yarding. Grapple- or tractor-piling was planned for the \( \frac{1}{2} \) of the stand in the WUI but it had not yet been performed at the time of the fire; there were no plans to further treat fuels in the rest of the stand. No surface or ladder fuel treatments had been accomplished when the fire hit this area. There were relatively high loadings of surface and ladder fuels in the area after treatment (Fig. 17). This area burned on the blow up day, July 9, when temperatures were very hot and humidity low. The logging firm was actually on site when fire hit this area. Fire mortality within the treated area (and in the untreated area adjacent) was high but we did not have opportunity to quantitatively assess it (Fig. 18).
Figure 17. Site 9, thinned area at Humbug Ridge, just beyond the fire perimeter. Needle litter depths were up to 4 inches.

Figure 18. Site 9, Humbug Ridge.
Conclusions

Taken together, the evidence from the American River Complex fire suggests two basic conclusions with regard to fuel treatment performance:

1. Mastication
Mastication does not remove fuels from the site, but redistributes them (Figure 19). By design, mastication reduces the ladder fuel effect but increases surface fuels. Until the masticated fuels decompose, they are also much drier and more easily ignited than live fuels. The American River Complex burned early in the fire season, and primarily under moderate weather conditions, when fuel moistures were still relatively high. As a result, live shrubs and hardwoods were resistant to burning, and even masticated units may have provided some resistance to fire (although this was probably at least partly due to the shruby live fuels on site). However, under the more severe fire weather conditions encountered on July 9, masticated fuels proved no barrier to fire spread and tree mortality in the masticated stands was 100%. The fact that these masticated units performed so poorly under early season conditions suggests that caution should be used in their implementation, especially in areas of long summer drought like the Sierra Nevada. It is recommended that readers consult Stephens and Moghaddas (2005, *For. Ecol & Mgt.*, vol. 215:21-36) and Knapp et al. (2008, Final Report, Joint Fire Science Program Project 05-2-1-20) for results of scientific trials and fire modeling which call into question the advisability of using masticated treatments alone (i.e., without further treatment) in Sierra Nevada mixed conifer forest. In the Stephens and Moghaddas (2005) study, a comparison of different treatment techniques showed that masticated treatments supported the highest rates of spread, fireline intensities, flame lengths, and levels of tree mortality (even higher than or equal to the untreated control) under 80th and 90th percentile weather conditions. In the Knapp et al. (2008) study, modeled wildfire in 10 different masticated units in northern California resulted in >95% tree mortality under only 80th percentile weather conditions.

2. Forest thinning
All but one of the fuel treatments we visited in mature forest experienced moderate to severe fire effects. It is probably no coincidence that the exception (Texas Hill Spring) was the only treatment where both reduction and removal of surface and ladder fuels had been (apparently) accomplished. Although the Whiskey 1 fuel treatment had had natural fuels piled by a grappler, the piles were still onsite when the treatment encountered fire. The cost of cutting small trees and removing natural surface fuels is prohibitive and this situation – where commercial thinning has been accomplished but it has been followed by little or no explicit treatment of ladder fuels or natural surface fuels – is common on National Forest land across California. Forest thinning alone, especially when accomplished via whole-tree yarding, reduces forest biomass and may be expected to ameliorate fire behavior and fire severity, at least to some extent. Our visits qualitatively suggested that forest stands treated in this manner within the American River Complex perimeter were somewhat less likely to experience crown torching than neighboring untreated stands, but fire behavior was still severe enough to cause high levels of crown scorch and tree mortality. Various scientific papers (e.g., Stephens and Moghaddas [2005,
cited above]; Graham et al. 2004 [RMRS General Technical Report-120]; Agee and Skinner [2005, For. Ecol & Mgt., vol. 211:83-96]) note that crown thinning alone is not likely to meaningfully change potential fire behavior or effects. Events on the American River Complex fire support these general findings.

Figure 19. Unburned masticated area just outside the American River Complex fire perimeter, Tahoe National Forest.