United States Department of Agriculture

# 2013 Mountain Fire Fuel Treatment Effectiveness Summary

Forest Service

Pacific Southwest Region, October 2014

# 2013 Mountain Fire Fuel Treatment Effectiveness Summary

## Summary

The Mountain fire started at approximately 1:43 PM on July 15th on private property south of Idyllwild, CA, near the junction of Highways 74 and 243. The fire spread quickly to the east through grass, chaparral and into timber with litter and understory grasses and shrubs. The fire crossed Highway 243 and through the US Forest Service's Keenwild Station at a high rate of spread, threatening communities and properties dispersed through the San Bernardino National Forest. By the time that rainfall slowed active spread on July 21-22, seven homes and 23 structures were burned (including outbuildings). The fire burned north and east into San Jacinto Wilderness and stopped just east of Fern Valley. The fire was relatively inaccessible on the northeast flank in the Wilderness, but an existing tramline enabled crews to get within hiking distance and work to contain the fire. Considerable resources were deployed on the fire, including fixed and rotor-wing aircraft, ground crews and support infrastructure, at a cost of approximately $26 million. The fire was declared contained on July 30th at 27,531 acres.

The primary goal of this report is to assess the effectiveness of Forest Service fuel treatments in reducing fire behavior or improving the efficacy of fire suppression efforts near communities and maintaining vegetation where fire effects on natural resources are restored and help maintain ecosystems. The USDA Forest Service's fuel treatment program aims to reduce fire behavior and damage and protect values. This case study provides examples of the synergy of multiple groups cooperating to achieve fuel treatments. This report discusses how effectively fuel treatments completed by the Forest Service reduced fire behavior or immediate effects on vegetation and soil. The Mountain fire burned through about five categories of fuel treatments including mastication, hand-thinning, pruning up and piling/burning of fuels and prescribed burns (table 1). Agency cooperators who treated fuels tested by the Mountain fire include the US Forest Service, Cal Fire, and the Natural Resources Conservation Service (NRCS). The Mountain Area Safety Taskforce (MAST), Mountain Communities Fire Safe Council and local residents also cleared around homes with Cal Fire, NRCS, and USFS grant support. Several residents were also aided by the Forest Care program which provides grants for treatments on private properties with no homes. Southern California Edison removed trees in the vicinity of a power line, grinding them at a biomass energy facility which they set up locally.

Most treatments discussed in this report were conducted after the removal of beetle-killed trees in the early 2000s. This work aided the completion of subsequent fuel treatments and Mountain fire suppression activities because it reduced snag densities and associated hazards. Fuel treatments within the last 10 years that reduced fuel loading and shrub heights to about 7 feet resulted in a reduction in the severity of Mountain fire effects on soils and vegetation. Wildfire areas from 2000 and 2008 were partially burned again during the Mountain fire and exhibited some reduced fire effects. Recent treatments allowed both moderated fire behavior and effects and faster fireline production rates, because young chaparral facilitates line construction relative to older chaparral.

| **Location Information** | | |
|---|---|---|
| **Region: 5** | **Forest: San Bernardino** | **District: San Jacinto** |
| **Wildfire Information** | | |
| **Fire Number:** CA-BDF-010080 | | **Fire Name:** Mountain |
| **Date of Fire Start:** 07/15/2013 | | **Final Fire Size (acres): 27,531** |
| 2,122 acres of fuel treatments burned | | **Date Fire Contained:** 7/30/2013 |

**Table 1. Fuel treatment types and acres overlapping parts of the Mountain fire.**

| Project Unit/name | Treatment Type | Year Completed | Project Size* (acres) | Agency |
|---|---|---|---|---|
| Keenwild Station | mechanical and burn piles | ongoing, including 2013 | Approx. 10 | USFS |
| Bonita Vista Fuel Break | hand pile & burn in 2005 and mastication in 2013 | 2005 & 2013 | 185 ac. in 2005, 38 ac. masticated in 2013 | USFS |
| Bonita Vista Unit 1 | prescribed burn | 2007 | 309 | USFS |
| Bonita Vista Unit 4 | prescribed burn | 2008 | 123 | USFS |
| Bonita Vista Unit 5 | prescribed burn | 2010 | 25 | USFS |
| Private Land of Bonita Vista | Mechanical | ongoing, and mid 2000s | ~ | Private and NRCS |
| Private Land of Zen Center | Mechanical | ongoing, and mid 2000s | ~ | Private and NRCS |
| Private Land of Living Free Pet Shelter (ranch) | Mechanical | ongoing, and mid 2000s | ~ | Private and NRCS |
| Apple Canyon | dead tree and slash removal | 2008-2010 | 123 | Cal Fire |
| Hwy 243 | mastication, limb, thin smaller trees and brush | 2007-8 | 272 (*33) | USFS |
| Hwy 74 | mechanical | 2007 | 154 | USFS, MAST |
| Private Land of Fobes Ranch | mechanical | Ongoing | | private |
| May Valley Hazard Tree Removal | hazard tree removal | 2007 | 30 (*11) | USFS |
| Fobes Ranch | prescribed burn | June 1994 | 27 | USFS |
| Fobes Ranch | prescribed burn | May 1996 | 747 (*525) | USFS |
| Fobes Ranch | prescribed burn | April-June 1995 | 365 (*364) | USFS |
| Fobes Ranch | prescribed burn | June 1997 | 438 (*233) | USFS |
| Power Line Clearance | mechanical and hand-thinning | 1990s-present | ~ | USFS, then Southern California Edison |

* For treatments partially burned in Mountain fire, burned acres are in parenthesis.

## Fire Interactions with Fuel Treatments

*Weather and Fuels*

The Mountain fire started in lower montane mixed chaparral and redshank vegetation types and burned through areas of annual grasses, desert scrub, canyon live oak and mixed conifers. Shrub fuels ranged from sparse shrubs less than a half meter tall to dense, 12-foot tall shrub thickets. The weather for the first several days of the Mountain fire was typical hot and dry July weather with fairly strong afternoon winds. The temperature and winds were within range of other large fires in the area, however 10-hour fuel moistures were lower (Table 2). Live chamise moisture was at 58 percent. The Energy Release Components (ERCs) of the Mountain fire were 78, 97 and 105 for July 15th-17th respectively. The topography during the first day of the fire was relatively flat valleys mixed with rolling hills. Then the fire burned up into the canyons and steep, dissected terrain of the San Jacinto and Santa Rosa Mountains (figure 1). Typical afternoon winds in the area can produce 15 mile per hour gusts.

**Table 2. 1:00pm weather readings for the Mountain and historic fires.**

| Fire | First day of fire | Temp (F) | RH % | Wind (mph) | 10-hr fuel moisture |
|---|---|---|---|---|---|
| Mountain | July 15, 2013 | 94 | 19 | 8 | 3.8 |
| Dry Falls | August 26, 1980 | 86 | 29 | 15 | 8 |
| Center | August 28, 1981 | 100 | 16 | 3 | 8 |

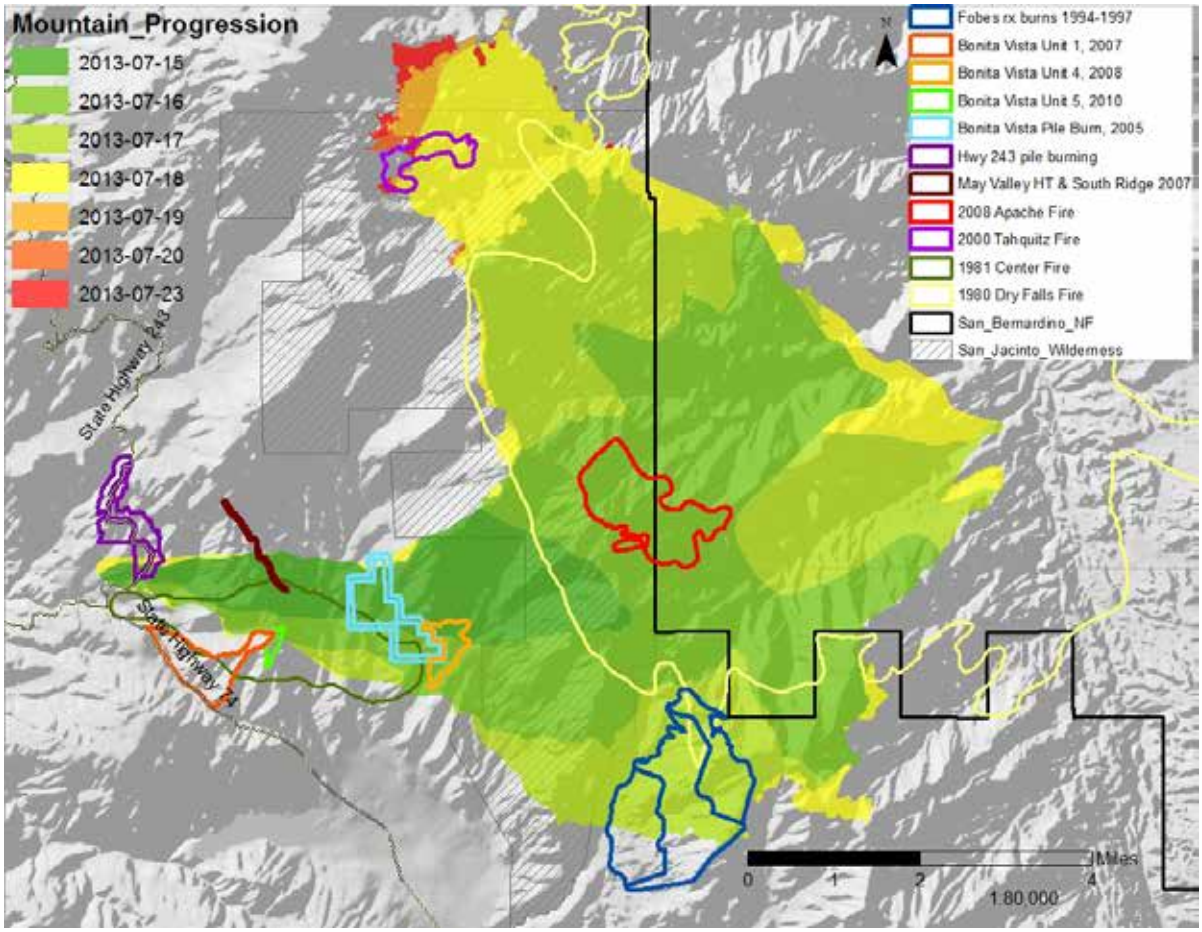


**Figure 1. Overview map of Mountain fire progression, fuel treatments, and recent fire history.**

*The Start of the Mountain Fire*

A local Fire Safe council member saw a small plume of smoke on July 15th, and by the time she opened her cell phone to call in the fire, the plume had grown. The fire spread quickly in the dry fuels, pushed by a west wind around 8 miles per hour, but typical afternoon winds can have 15 mile per hour gusts. Locals from the area reported that the fire spread to the May Valley area (1.5 to 2 miles) from the ignition point in 45 minutes.

The fire pushed east off of private land and jumped Highway 243 to threaten the Keenwild Station. Although fire crews knew their Station was in danger, they also saw that the fire was threatening the privately owned propane storage tank area next door, referred to as the 'propane farm,' that if ever ignited could be catastrophic. The firefighters first attended to the fire bearing down on the propane farm.

The Mountain fire pushed through the Keenwild Station from the west in roughly an hour after starting. Fuel clearing in the home ignition zone and surrounding areas of the Keenwild Station enabled buildings to survive *unattended* when the fire passed through (figure 2). Fuel clearing had been done on an ongoing basis around the Keenwild Station. Shrubs and trees were thinned and fuels removed or masticated. Litter was raked away from the building and combustible material was not kept adjacent to buildings. The fuel clearing around the Keenwild Station was instrumental in allowing the building to survive unattended through the initial period of the Mountain fire while crews managed the fire at the propane farm and evacuated people in the expected path of the fire.

**Figure 2: Treated fuels surrounding Keenwild Station near fire edge (masticated fuels in foreground).**

Several residents in the area were evacuated, and many had done fuel reduction on their properties prior to the fire. The owners of the Living Free animal shelter ranch had completed fuel reduction in conjunction with earlier NRCS treatments that were completed in strategic sections and travel paths. The Living Free animal shelter property was only partially burned by the fire; the south west edge of the fire was contained in the vicinity of Living Free. The fire did burn through the community of Bonita Vista (front cover figure) and the Zen Mountain Center (figure 3). The Zen Mountain Center and some residents in the Bonita Vista community had completed fuel treatments on an ongoing basis. Some treatments were initially completed by the NRCS and

others were coordinated through the local Fire Safe Council and the Mountain Area Safety Taskforce (MAST), a unique collaboration of private and government entities which greatly aided in the coordination and funding of fuel treatment projects on private land in the area.

A power line runs between the Keenwild station and the community of Bonita Vista. Maintenance by Southern California Edison was effective in reducing fire intensity under the power lines. In 1995 Forest Service fire crews had helped with clearing fuels under the lines. No power to the communities was lost during the prescribed fires or the Mountain fire. Unfortunately, some heat damage occurred to the lower level line owned by a communication company during the Mountain fire.

**Figure 3. Fuel clearing and a home ignition zone consisting of incombustible material helped the Zen Mountain Center survive the Mountain fire. Note on left side, the fire edge came near the rock wall.**

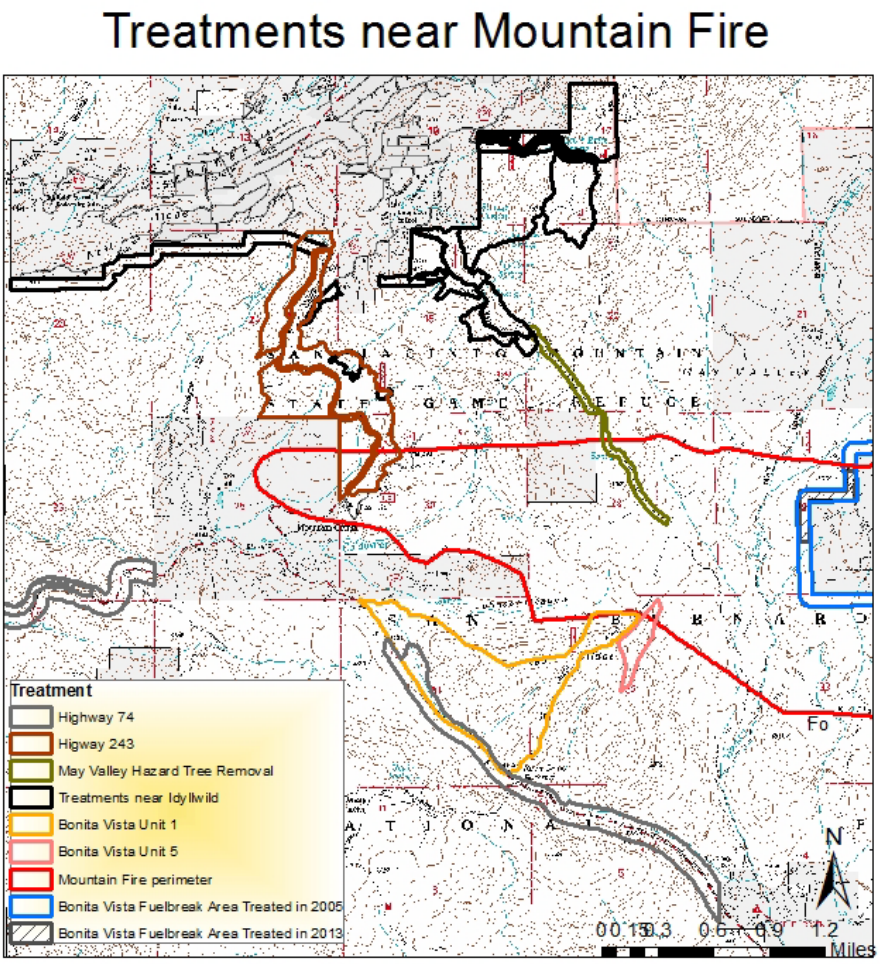


**Figure 4. Treatments in the vicinity of the west side of Mountain fire.**

## Treatments near Keen Summit

Two prescribed burn units, Bonita Vista Unit 1 and 5, were located on the south western edge of the Mountain fire, within the area that burned the first and second days (figure 4 and 5). These treatments fell mostly outside the Mountain fire, but were still useful to fire suppression efforts as potential containment or secondary lines and created safer travel routes.

Twenty-five acres were burned with prescribed fire in Bonita Vista Unit 5 in February 2010. Although the 25 acres mapped in Unit 5 extend slightly into the Mountain fire perimeter, it is believed this is a mapping error, and the Mountain fire was controlled at the edge of the Unit 5 burned in 2010 with only signs of low-intensity flanking fire burning up to this edge (figure 4 and 5). The burn severity imagery used in this report is from the Rapid Assessment of Vegetation Condition after Wildfire (RAVG) process (USFS 2013), and was displayed as a four-color rating for composite burn severity. Note the burn severity satellite-derived image is initially taken right after the fire, then often again one year later. Burn severity for sprouting and annual plants is sometimes calculated at a lower severity value one growing season later, which might be the case for large sections of the Mountain fire in chaparral or sprouting shrub and grass vegetation types.

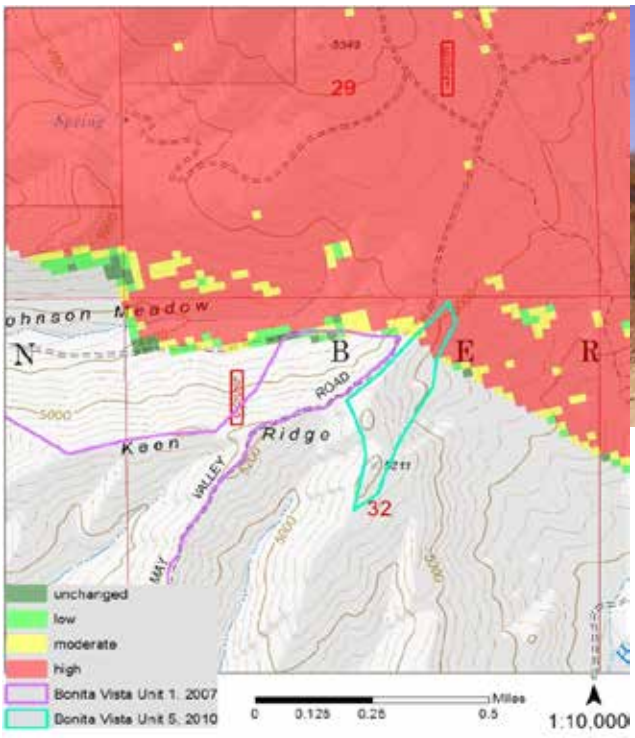


**Figure 5, Left. Map of Bonita Vista Units 1 and 5 and Mountain fire composite burn index (RAVG 2013).**

**Figure 6, Right. Boundary between the Bonita Vista Unit 5, 2010 prescribed fire on the left (unburned in the Mountain fire) and older chaparral on the right outside of Unit 5 (burned in Mountain fire) near Keen Summit.**

The Bonita Vista Unit 1 was a 309-acre prescribed burn completed in 2007 located on a hill south of the fire. Although the fire never reached this location, this previous work made contingency line building faster. Unit 1 was instrumental in allowing bulldozers to quickly and safely build contingency line along Keen Summit Ridge. The reduced height and cover of the vegetation, even after 6 years, (figure 7) assisted firefighters in their work to cut hand-line along the fire edge. Bonita Vista Unit 1, formed part of the south western boundary of the Mountain fire, suggesting that it played a role in fire containment in this area.

**Figure 7. *Left.* The reduced height and cover of the vegetation (note dead branches killed by the 2007 prescribed fire), even after 7 years (maximum shrub height is 7 ft). *Right.* A patch of chaparral within an untreated area near Keen Summit is exceedingly difficult to move through and illustrates what the vegetation would have been like without the prescribed fire (maximum height 12-15 ft).**

## Treatments focused on the community of Bonita Vista

Several treatments were accomplished by multiple groups in the vicinity of the Bonita Vista community (figure 8). These fuel treatments generally reduced surface fuel loads and lowered fire behavior and subsequent fire severity. The treatments included: a fuel break and several prescribed burns completed by the Forest Service, clearing in and around the homes and buildings of Bonita Vista conducted by private entities and NRCS, and dead tree and slash removal completed in Apple Canyon by Cal Fire.

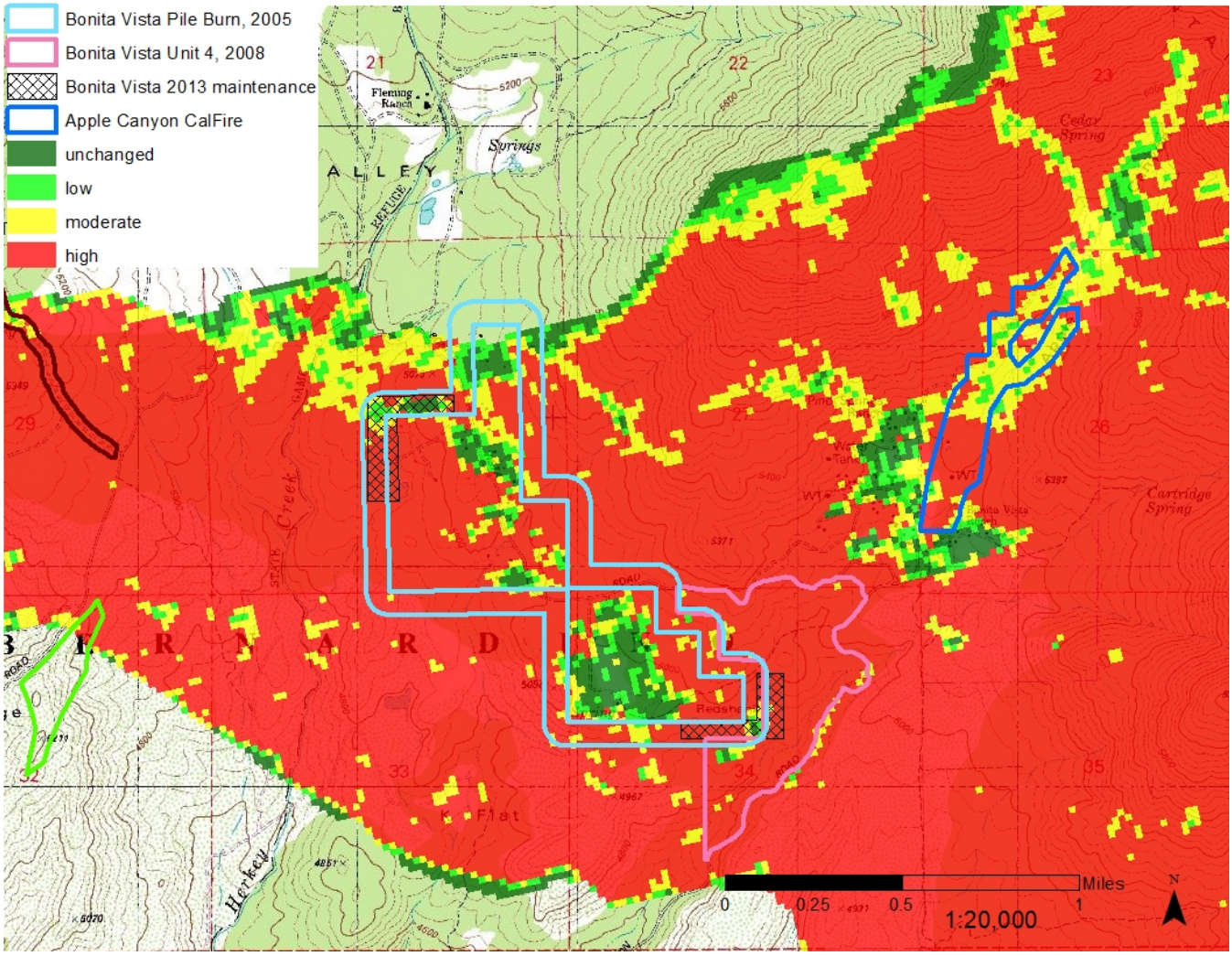


**Figure 8. Map of Bonita Vista area fuel treatments and burn severity (RAVG CBI 2013).**

In 2008, 123 acres were burned with a combination of hand- and helitorch-lighting in Bonita Vista Unit 4 on the east side of the Bonita Vista community. In this relatively sparse brush-fuel type, higher winds were needed to carry the prescribed burn than the burn prescription would allow, so treatment acres were limited. During the Mountain fire, the Unit 4 prescribed burn treatment was likely burned by flanking fire spread, somewhat after the head fire spread (west to east) past the majority of the community. This prescribed burn was effective in lowering fire severity, and potentially fire behavior, according to satellite imagery and plot data (figure 8).

The US Forest Service hand-piled and burned fuels in a 300-foot wide fuel break around the community in 2005 (figure 9). The vegetation in this fuel break had largely re-grown to an average height of about 6 feet (see photos in appendix) since 2005, making the fuel treatment ineffective in independently changing fire behavior during the wind-driven Mountain fire. Two portions of the fuel break were re-treated by masticating vegetation between January and March of 2013 and were effective in reducing fire behavior.

**Figure 9. Western corner of Bonita Vista fuel break.**

On the southeast side of the Bonita Vista inholdings, the fuel break is separated from private treatments by untreated chaparral on private land (Figure 8). The private treatments extended only up to the diagonal road. The fuel break certainly was useful in facilitating the 2008 prescribed burn, and likely resulted in reduced fire intensity and effects during the Mountain fire.

## Highway 243 Treatment

An area totaling 230 acres was treated along Highway 243 in and north of the Mountain fire. Approximately 33 acres of this treatment area were burned by the fire. This treatment along Highway 243 was intended to provide an area of lower fuel heights adjacent to the highway, so that the highway could remain open and serve as an evacuation route during a fire. The treatment was implemented starting in 2004 and completed by 2006. A combination of mastication, branch pruning, and thinning of small trees and brush was completed in a 'matrix' pattern with islands of vegetation left to keep some screening along the road. At the vistas and viewpoints, all vegetation was removed to aid in scenic views along Highway 243. Although strong wind pushed embers across the road, which eventually lead to the fire crossing the road (or spot fires), in general, the fuel treatment along Highway 243 aided suppression and evacuation efforts occurring during the Mountain fire.

## Highway 74 Treatment

Similar to the Highway 243 treatment, the Highway 74 treatment was completed in a patchy pattern in 2007. Its purpose was to lower potential fire behavior along the highway corridor in order to allow the highway to serve as an evacuation route during fires. Although the Mountain fire did not reach Highway 74, this treatment would have afforded fire resources greater opportunity to use Highway 74 had the need occurred.

## Treatments around Idyllwild Community

The US Forest Service, Cal Fire, NRCS, and other agencies as well as private landowners conducted a large number of treatments in and around the community of Idyllwild, CA. Although the Mountain fire did not reach the community of Idyllwild, burning embers did, and these fuel treatments could have proven instrumental had the Mountain fire spread north into the community. One of the treatments near Idyllwild which extended into the Mountain fire approximately 14 acres was the May Valley hazard tree removal project along May Valley Road completed in 2007 that created safer travel routes and areas to control the Mountain fire.

## Treatments around Fobes Ranch area

Fuel reduction was completed by four prescribed fires near the Fobes Ranch area in different sections, which over time amounted to a larger continuous fuel treatment. The Forest Service completed the prescribed burns on the four units between 1994 and 1997 which were partially overlapped by the Mountain fire (figure 10). When viewing the Fobes Ranch hillside immediately after the Mountain fire, no signs were evident that these older prescribed burns had reduced fire behavior or effects significantly. *These burn areas may have had enough vegetation regrowth to be ineffective* (approx. 16 to 18 years old) *in changing Mountain fire behavior or effects.*

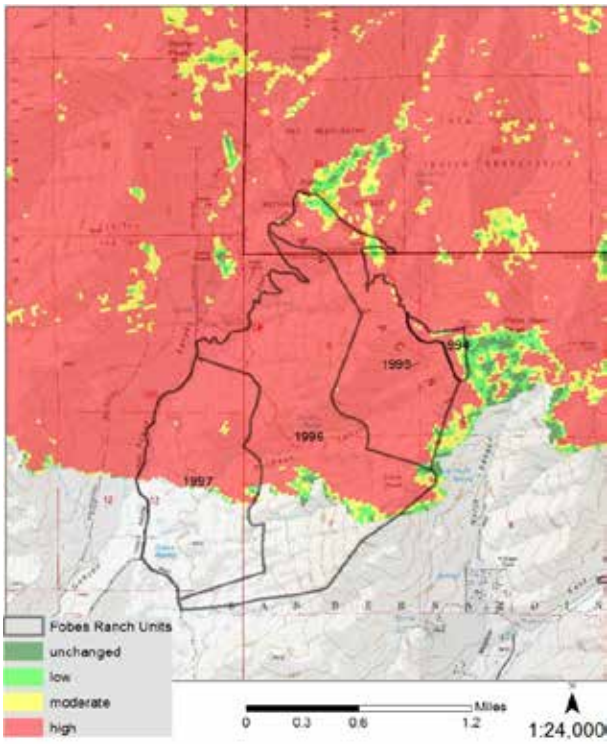


**Figure 10. Prescribed burns completed by the Forest Service in the vicinity of Fobes Ranch, showing the Mountain Fire immediate post-fire severity (RAVG 2013).**

The private ranch had done ongoing fuel reduction maintenance around their buildings, including building material upgrades. These ranch fuel reduction activities, in conjunction with wetting the vegetation immediately adjacent to the homes before evacuating, created a situation where no buildings in the home ignition zone were burned during the Mountain fire. This success occurred even though residents evacuated, and no suppression resources could stay and defend in this canyon area when the fire came through there. Most of the adjoining and surrounding vegetation did burn where no recent treatments had occurred, including one distant building. Areas like this with narrow, box-canyon-like topography, heavy fuels, and only one route for egress are high risk areas for firefighters.

## Interactions between Recent Wildfires

### 2008 Apache and 2000 Tahquitz fires

Trees within the areas of the 2008 Apache (770 acres) and 2000 Tahquitz fires (152 acres burned of the 199 acre perimeter) inside the San Jacinto Wilderness, in the central and north side of Mountain fire respectively, appeared still green after Mountain fire from aerial observations (figure 11), indicating that fire severity was lower within these areas where other fires recently burned. Although the Mountain fire burn severity (composite burn index by RAVG 2013) within the 2000 Tahquitz fire area was not distinct from the severity outside the Tahquitz fire perimeter, potentially due to the 13 years since this fire, a portion of the Mountain fire was contained in the Tahquitz fire perimeter, indicating some benefits may have been from the Tahquitz fire management efforts (figure 12, left side). The Mountain fire burn severity within the Apache fire perimeter did reburn completely, but mostly at low and moderate severities as indicated by immediate post-fire satellite imagery (figure 12, right side). Large areas of low and unburned severity match the borders of the 2008 Apache fire almost exactly in over half of the Apache fire area. This demonstrates reduced fire severity or fire effects did occur when fire returns to a recently burn area.

**Figure 11. Photo of the Apache fire area within the Mountain fire area taken from the air.**

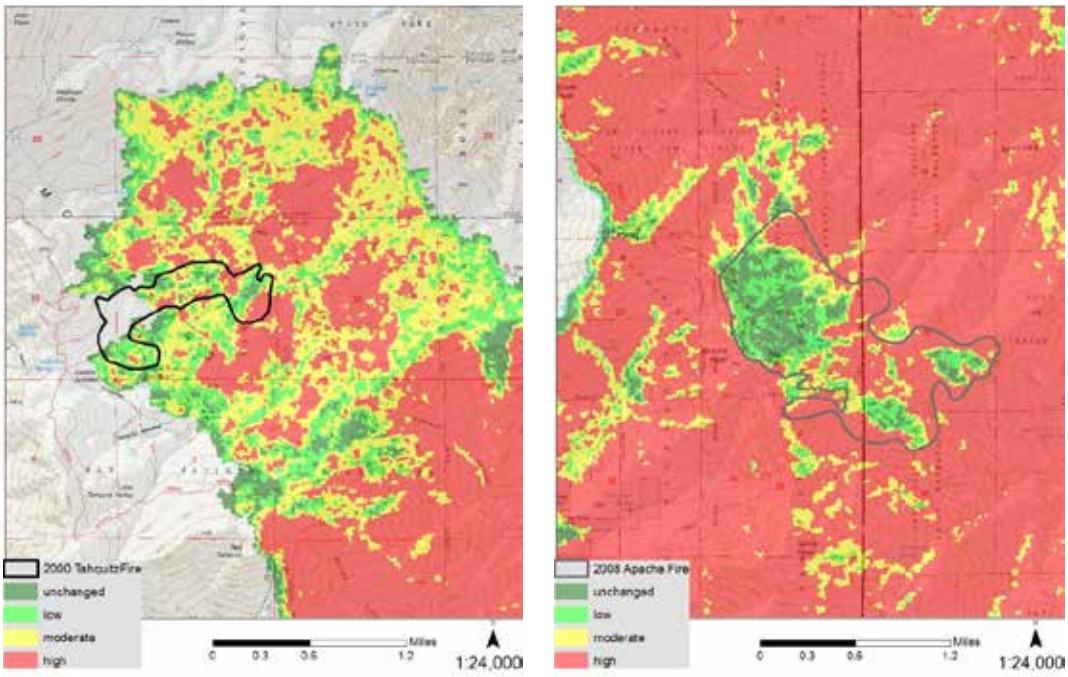


**Figure 12. Mountain fire composite burn index (RAVG 2013) focused on the 2000 Tahquitz fire (left map on north side of the Mountain Fire) and the 2008 Apache fire (right map in the central portion of the Mountain Fire).**

## Post-fire Field Monitoring Data

In order to support this fuel treatment effectiveness assessment, field-based fire severity monitoring was conducted between July 22 and 25, just following the major rainfall event of July 21-22. Fire severity was sampled in plots at several key locations on the Mountain fire including the Bonita Vista fuel break, surrounding prescribed fire areas, the Keenwild Station, and Forest land near and at Living Free pet shelter. Reference areas outside of treatments were also sampled in some locations. The focus of data collection was in and near the vicinity of the first day of the fire, which was largely a west to east wind driven event, and near the majority of the San Bernardino National Forest's fuel treatments. Substrate and vegetation severity were rated according to the National Park Service Fire Monitoring protocol (NPS 2003, Appendix 2). Photos, GPS points, and estimates of pre-fire shrub height were recorded.

*Across all plots, the severity data trends show that areas with taller pre-fire shrub cover tended to have the potential for higher substrate (soil) and vegetation (shrubs) burn severity*. Pre-fire shrub heights were based on reference conditions in unburned areas nearby treatments or on remaining thick woody shrub stems that were still upright post-fire (a.k.a. shrub skeletons). In support of this conclusion, substrate and vegetation effects were least severe (on a scale of 1-5, where 5 indicates unburned) where shrub heights were less than about 6 feet as indicated by the *red veil line* in figure 13.

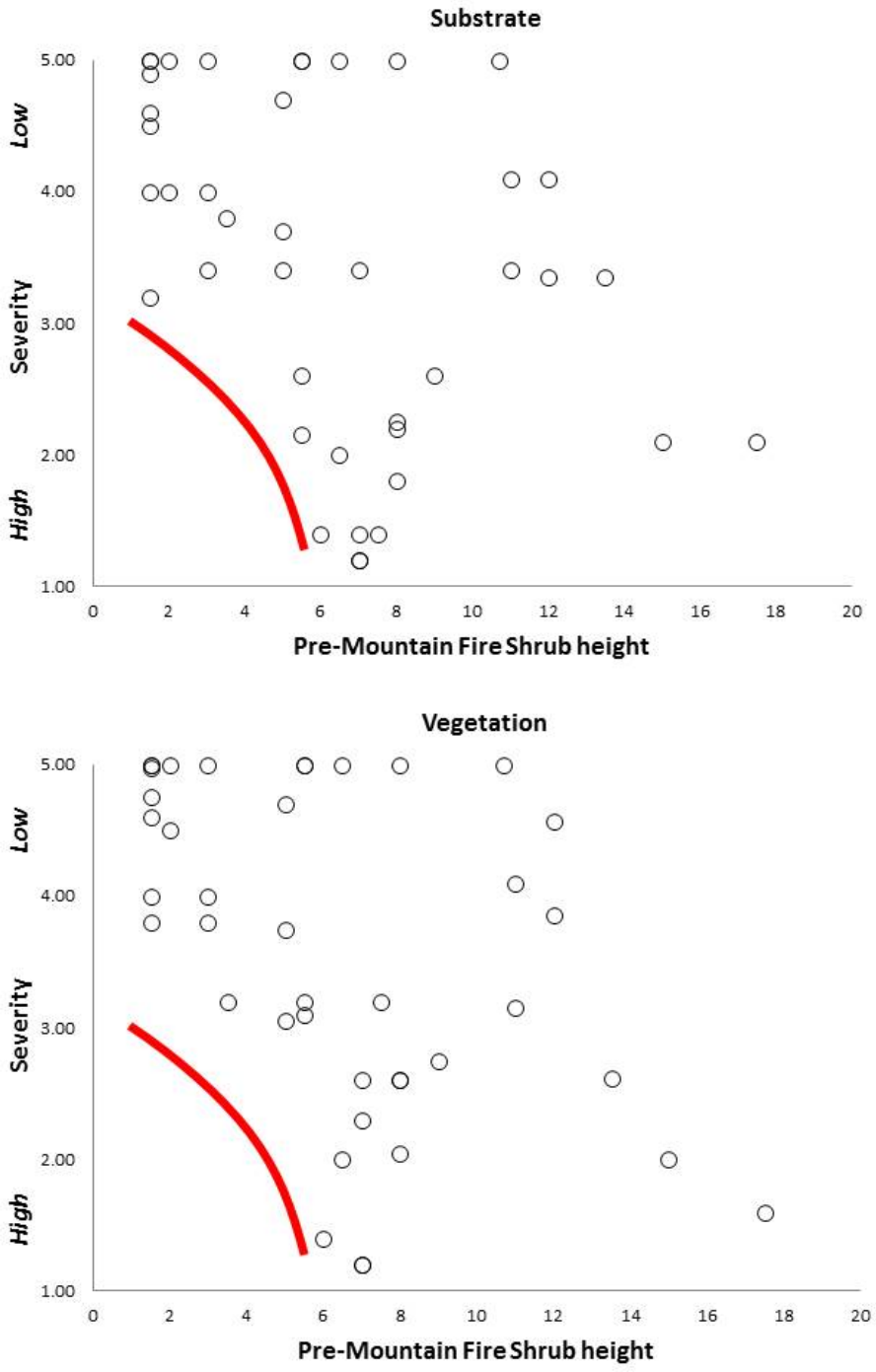


**Figure 13. Relationship between substrate (soil) and vegetation severity and estimated pre-fire shrub height. High severity effects (code 1) were not found below the red veil line, suggesting that shrub height is related to fire severity. Severity is rated based on NPS descriptions (USDI 2003, Appendix 2) where code 1 is the highest severity and code 5 is unburned.**

## Bonita Vista Observations

Private landowner and/or NRCS mastication was conducted interior to the USFS Bonita Vista fuel break on private land in 2005, and then partially re-treated in early 2013. The Unit 4 Bonita Vista prescribed fire occurred in 2008 and was adjacent to and east of the USFS fuel break. Representative fire severities in this southeastern portion of the Bonita Vista area are shown in figure 14. See figure 1 and 8 for an overview and focused reference maps, respectively.

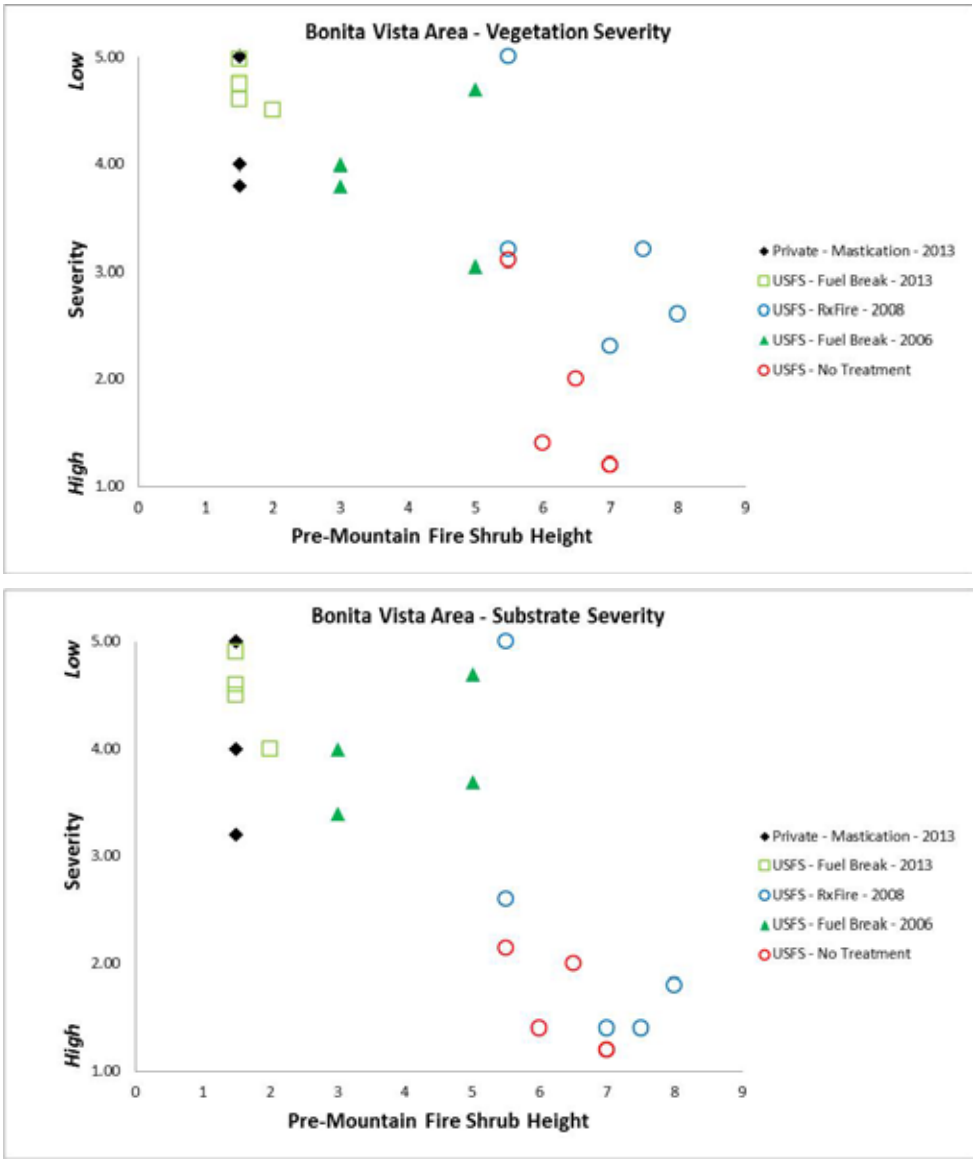


**Figure 14. Effects of Mountain fire on vegetation (top) and substrate (soil; bottom figure) severity on the south and eastern side of Bonita Vista. Plots were sampled on private and USFS land. Severity is rated based on NPS descriptions (USDI 2003, Appendix 2) where "1" is the highest severity and "5" is unburned.**

*For the Bonita Vista area, higher severity trends* (unburned is rated as 5 while the highest severities are rated as 1, Appendix 2) *were found in reference/untreated sites well downwind of the Bonita Vista focus area* ('USFS – No Treatment" in figure 15). Some parts of the 2008 prescribed burn area east of Bonita Vista burned with relatively low severity, on par with 2013 treatments. These low severity areas recorded inside the 2008 burn

perimeter may have occurred during the Mountain fire because of "treatment shadow" effects from the Bonita Vista private treatments and USFS fuelbreaks. Plots that fell in the fuel break portion retreated during 2013 or on the private 2013 mastication treatment had the lowest severity trends.

Chaparral height generally increases with time-since-treatment for the first decade or so, although much variability exists in this relationship (figure 15). Shrub height is proportional to fuel load and difficulty of fire suppression line construction. *Based on our limited field data, treatments repeated every 10 years or less would, on average, would maintain vegetation below a height of 7 feet. Our field data indicate that a reduction in severity can only be expected up to this height or less*. Variability in the relationship between shrub height and time-since-treatment is potentially associated with topographic variability, site productivity, differences in how treatments are performed, and different shrub species.

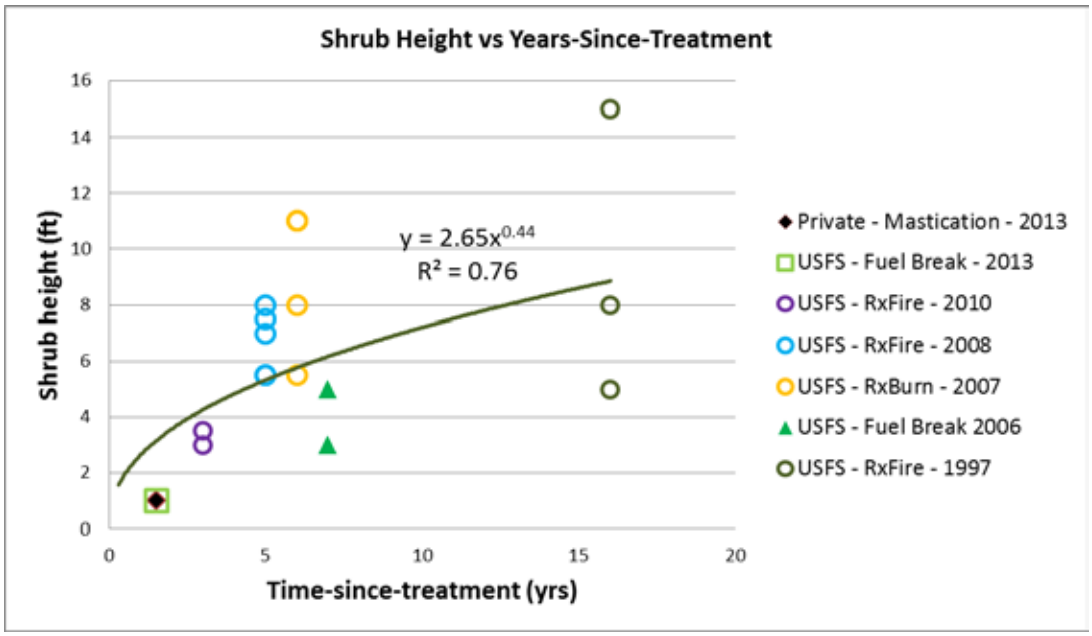


**Figure 15. Mean shrub height (pre-Mountain fire) in mechanical fuel treatments and prescribed fires as a function of years-since-treatment.**

## Conclusions and Recommendations

- Some fuel treatments were effective during the Mountain fire for reducing fire effects (as a surrogate for the preceding fire behavior) and assisting fire suppression actions.
- Homeowner and private landowner actions, in conjunction with agency projects seemed successful in assisting fire management efforts or reduce severity. The USFS should continue to encourage and to coordinate fuel treatment efforts on adjacent private land. Fuel treatments on private property in Bonita Vista and May Valley were highly effective in protecting structures.
- Fuel breaks (or linear-shaped treatments) adjacent to private land best reduced fire effects when they were connected to treatments on agency land. Where this was not the case (e.g., around much of the Bonita Vista fuel break), the fire burned through untreated fuels on private land. To maximize fuel break effectiveness in the wildland urban interface or adjacent to private land, fuel treatments should be coordinated between USFS and private landowners using an All Lands Approach.
- Across all plots, the severity field data showed that, in areas with taller pre-fire shrub cover, effects on substrate and vegetation tended to be more severe during the Mountain fire. In support of this conclusion, substrate and vegetation severity was lower where shrub heights were less than about 6 feet. Lower severity effects can be expected in treatments up to about 7 years–since-treatment.
- Prescribed fire treatments which were outside of, yet near, the Mountain fire facilitated containment line construction, as seen in the 2007 and 2010 prescribed fires in the Keen Summit area (Bonita Vista Units 1 and 5).
- Linear treatments that are not aligned with prevailing winds are less effective in facilitating fire containment tactics. As seen in Bonita Vista, fuel breaks oriented perpendicular to the direction of likely fire spread are unlikely to be wide enough to prevent spotting across the treatment.
- Consider future fire behavior or fire spread inside untreated areas, like stream corridors, located inside treatment projects, which can perform during wildfires like a “fuel bridge” instead of a “fuel gap,” opposite to the goal of the rest of the fuel treatment.
- Area (or polygon-shaped) fuel treatment priority areas adjacent to communities (e.g., Bonita Vista Unit 4 prescribed burn) should be on the windward side of the community, given prevailing winds.
- The usefulness of past wildfire areas (and related reduced fuel loads) to regulate subsequent wildfire effects was shown by the 2008 Apache fire. The continued use of fire as a natural fuel treatment process on the landscape can potentially avoid large patches of homogenous high severity effects from subsequent wildfires. Future case studies should attempt to gather eyewitness accounts of reduced fire behavior as wildfire perimeters overlap each other.
- As mentioned in the report, the one year post-fire burn severity imagery (compared to an immediate post-fire image) should better highlight the Mountain fire burn severity related to the quick recovery of sprouting shrubs and oaks and annual vegetation types, as are commonly found in many parts of the Mountain fire area.

### Broader themes for potential exploration or improvement

- Our trends suggest that fuel treatments can facilitate suppression activities and potentially **reduce** fire behavior and fire effects, depending on the fire weather or conditions. Fuel treatments are not designed to independently **stop** fire spread without wildfire management actions.
- Prescribed fires and mechanical treatments should be located where they are:
    - simple to install and maintain through time (environmental planning process and management operations), and
    - located where they will have the most success in meeting objectives.

- The value of fuel treatments may extend beyond their boundaries. Evidence was found of positive "treatment shadow" effects to the east of Bonita Vista. Fuel treatment benefits beyond their treatment boundary areas may include lower fire behavior upon entry into untreated fuels (transition zone); reduction in ember production (less fuel built up in treatment area to travel to adjacent area), and facilitation of fire containment activities.
- Based on limited observations in tree dominated areas, fuel treatments might have reduced burn severity on overstory trees. Further study is needed on this topic.
- Further study is needed to quantify the cost/benefits of fuel treatments. A wealth of knowledge is being amassed based on case studies like this, where fuel treatments were tested by wildfires, or based on field data and modeling (websites: https://www.firescience.gov/JFSP_fuels_treatment.cfm, http://cafiresci.org/fuel-treatments; publication: http://www.fs.fed.us/fire/fmt/fmt_pdfs/FMT73-2.pdf).
- Facilitators and barriers to completing and maintaining fuel treatments could be explored. For example, limited and declining funding levels for fuel treatments make consistent planning, implementation, and maintenance of fuel treatments difficult. Another example is the need for increased communication and planning with community cooperators and agency partners about the risks and gains of completing fuel treatments.

## Improvements for Efficient Fuel Treatment Effectiveness Monitoring

- Fuel treatment effectiveness assessments would be better facilitated if it was part of incident management practices. For example, if Division Supervisors would write a few observations about how fuel treatments worked on their divisions (possibly based on personal or crew observations) each shift, and include a map sketch or highlighted map from the Incident Action Plan to the Incident Command Team, this information could be collected and provided to the land managers for mandated reporting.
- Improved understanding of fuel treatment effectiveness would be better facilitated if estimated perimeters of prescribed fire and mechanical/hand treatment areas were walked with a GPS and double checked as correctly mapped in the database. Documenting the precise perimeters of actual treated areas, rather than using planning area polygons, helps rectify differences or treatments phased over years. Geographic data on fuel treatments are frequently lacking across the Forest Service and hamper assessment of fuel treatment effectiveness.
- Future case studies should attempt to gather eyewitness accounts of changed fire behavior as a wildfire overlaps a previous wildfire area or into a fuel treatment.
- Fuel treatment effectiveness studies should include the individual treatment objectives, and if they pertain to fire behavior and firefighter/forest staff and public safety.

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## References

National Park Service (NPS). 2003. Fire Monitoring Handbook. USDI National Park Service, Fire Management Program Center, National Interagency Fire Center, Boise, ID.

Rapid Assessment of Vegetation Condition after Wildfire (RAVG). 2013. Online data for immediate and 1-year post-fire data, available at http://www.fs.fed.us/postfirevegcondition/index.shtml. US Forest Service, Remote Sensing Applications Center.

## Personal Communications (during and after the fire)

Carey, Hal. 2013. Former USFS San Jacinto District Forester, currently with USAID, interview.

Landowners and managers of private property including Living Free, Zen Mountain Center, and Fobes Ranch.

Poopatanapong, Anne. USFS San Jacinto District Wildlife Biologist, email correspondence.

Walker, Norm. 2013. Former USFS San Jacinto District Fire Specialist, currently with Big Bear Fire.

San Jacinto District staff and other employees of the San Bernardino National Forest, including Kayanna Warren, Daniel Felix, Arturo Delgado, Freddie Espinoza, and Chris Fogle.

# Appendix 1. Additional Photos

**The variability in fire severity is illustrated by the differences between the top (high severity) and bottom (low severity) photos taken to the east of Bonita Vista community in untreated chaparral. Variability shown here is reflected in the scatter in Figures 13 and 14, and the fact that severity is determined not only by fuel conditions, but also by weather and the vicissitudes of fire spread.**

**Mastication treatment on private land in Bonita Vista. Top photo area was unburned by the Mountain fire, and the bottom photo was burned. These sites are included in Figures 13-15.**

# Appendix 2. Burn severity coding matrix from the National Park Service

**Table A2. Burn severity coding matrix from the National Park Service (USDI 2003).**

| Code | Forests | | Shrublands | |
|---|---|---|---|---|
| | Substrate | Vegetation | Substrate | Vegetation |
| Unburned (5) | not burned | not burned | not burned | not burned |
| Scorched (4) | litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged | foliage scorched and attached to supporting twigs | litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged | foliage scorched and attached to supporting twigs |
| Lightly Burned (3) | litter charred to partially consumed; upper duff layer may be charred but the duff layer is not altered over the entire depth; surface appears black; woody debris is partially burned | foliage and smaller twigs partially to completely consumed; branches mostly intact | litter charred to partially consumed, some leaf structure undamaged; surface is predominately black; some gray ash may be present immediately after burn; charring may extend slightly into soil surface where litter is sparse otherwise soil is not altered | foliage and smaller twigs partially to completely consumed; branches mostly intact; less than 60% of the shrub canopy is commonly consumed |
| Moderately Burned (2) | litter mostly to entirely consumed, leaving course, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common | foliage, twigs, and small stems consumed; some branches still present | leaf litter consumed, leaving course, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common | foliage, twigs, and small stems consumed; some branches (0.25-0.50 inch in diameter) still present; 40-80% of the shrub canopy is commonly consumed. |
| Heavily Burned (1) | litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred and rotten logs are completely consumed. This code generally applies to less than 10% of natural or slash burned areas | all plant parts consumed, leaving some or no major stems or trunks; any left are deeply charred | leaf litter completely consumed, leaving a fluffy fine white ash; all organic material is consumed in mineral soil to a depth of 0.5-1 in, this is underlain by a zone of black organic material; colloidal structure of the surface mineral soil may be altered | all plant parts consumed leaving only stubs greater than 0.5 in diameter |
| Not Applicable (0) | inorganic pre-burn | none present pre-burn | inorganic pre-burn | none present pre-burn |