

Part 3: Effects of Fuel Treatments on Fire Severity

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Summary

The role played by the fuel conditions within the Hayman Fire severity was complex and does not lend itself to a single conclusion or simple summary. Uncertainties in the original treatment prescription, its implementation, discerning the coverage, extent, and condition at the time of the fire made it difficult for us to clearly determine treatment effects and relate them to treatment type or amount. Available fire documentation such as the fire growth and severity maps compiled by the fire management and BAER (Burned Area Emergency Rehabilitation) teams were immensely helpful, but they oversimplify inherent complexities in fire behavior and ephemeral weather conditions and may contain random or systematic errors (for example, classification of burn severity).

Nevertheless, each of the different types of fuel modification encountered by the Hayman Fire had instances of success as well as failure in terms of altering fire spread or severity. The most obvious effects were produced by the Polhemus prescribed burn, the Sheepnose timber harvest, and the prescribed fires associated with the Big Turkey wildfire in the Turkey Rock area (fig. 63). The Hayman Fire was clearly unable to burn into the Polhemus burn area even as a heading fire under the most extreme weather conditions. Without surface fuel removal, most of the trees in Sheepnose sale were killed, but the thinning obviously restricted fire behavior to a surface fire with reduced fire severity compared to crown fire in surrounding untreated stands. Acting together, two prescribed burns (Turkey Rx1990, Rx1995) and the Big Turkey wildfire (1998) appeared to have temporarily prevented a crown fire on June 17 along a 2-mile section of the eastern perimeter, although this area burned the following day.

There is much variation and uncertainty in effects of individual treatment units or types. However, the detailed analysis of treatments encountered by the Hayman Fire supports the following general conclusions:

- Extreme environmental conditions (winds, weather, and fuel moisture) and the large size of the Hayman Fire that developed on June 9 overwhelmed most fuel modifications in areas burned by the heading fire that day. Exceptions include the Polhemus prescribed burn (2001) and the Schoonover wildfire.
- Except for the Polhemus prescribed burn (2001), the Schoonover wildfire (2002), and the Platte Springs wildfire (2002), which occurred less than 1 year earlier, fuel treatments did not stop the fire but did in many cases change fire behavior and effects. These are special cases because of their recent occurrence that should not be generalized for expectations for fuel treatment performance. Fuel treatments can be expected to change fire behavior but not stop fires from burning.
- Under more moderate wind and humidity conditions (June 10 through 16), recent prescribed burns appeared to have lower fire severity than older burns. This is consistent with typical trends in fuel accretion and changes in forest fuels over time. Examples include the sequence of Turkey (Rx1987, Rx1990, Rx1995) prescribed burns (fig. 53). In Rx1987, stands dominated by Douglas-fir within treatment boundaries also seem to have higher severity than those dominated by ponderosa pine.
- Landscape effects of treatment units and previous wildfires were important in changing the progress of the fire. These include the Polhemus prescribed burn (2001), which stopped the forward progress of the eastern head burning as a crown fire under extreme weather conditions, the Big Turkey wildfire (1998) and adjacent prescribed fires (1990, 1995), which prevented initiation of crown fire along a 2 mile segment of the perimeter when extreme weather returned on June 17, and the Schoonover Wildfire (May 2002) which, together with Cheesman Reservoir, split the head of the Hayman Fire on June 9 and prevented it from flanking toward the town of Deckers.
- Fuel treatment size relative to the size of the wildfire was probably important to the impact on both progress and severity within the treatment unit. Large areas, such as the Polhemus prescribed burn, were more effective than small fuel breaks (Cheesman Ridge). Under extreme conditions, spotting easily breached narrow treatments and the rapid movement of the fire circumvented small units.
- No fuel treatments were encountered when the fire was small. The fire had time and space to become large and generate a convection column before encountering treatment units. Fuel treatments may have been more effective in changing fire behavior if they were encountered earlier in the progression of the Hayman Fire.
- Few fuel modifications had been performed recently (see table 24), leaving most of the landscape within the final fire perimeter with no treatment

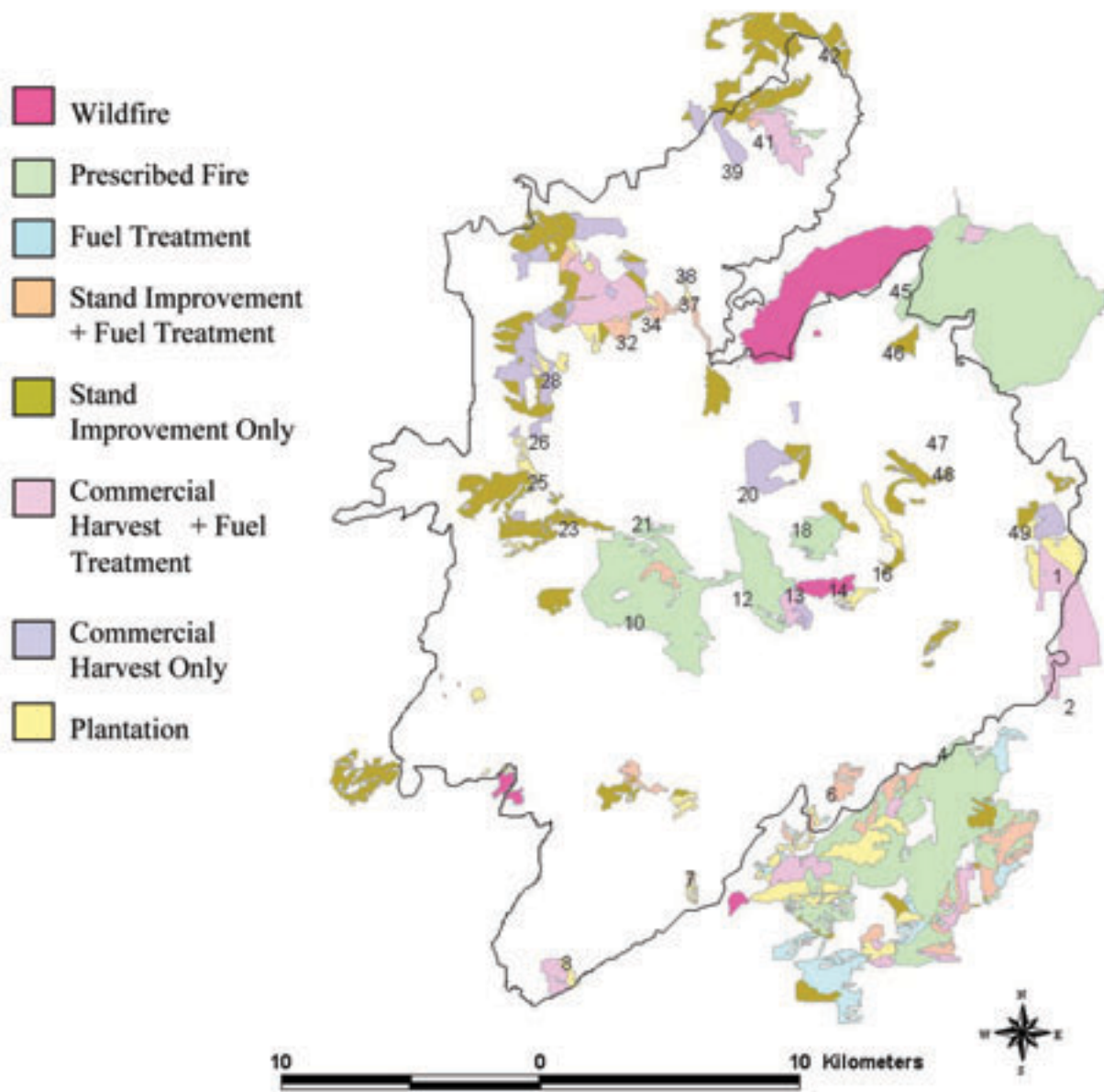


Figure 63—Approximate locations of helicopter photo points near fuel modified areas within the Hayman Fire.

Table 24—Distribution of fire severity classes and fuel modifications among windward (SW) and leeward (NE) aspects on slopes of less than 30 percent that burned in the Hayman fire on June 10.

Severity class	NE aspects	SW aspects
Unburned (%)	5	3
Low (%)	15	21
Moderate (%)	6	10
High (%)	74	66
Fuel Modification		
Yes	63	37
No	56	44

or only older modifications. This is significant because the high degree of continuity in age and patch structure of fuels and vegetation facilitates development of large fires that, in turn, limit the effectiveness of isolated treatments encountered by the large fire.

Introduction

Fuel treatments are distinguished from other land management activities by the intention to change fuels and potential fire behavior (Pyne 1984). Treatments can alter quantity, continuity, and compactness of surface fuels (for example, dead and downed woody material, grasses, shrubs, needle litter) and aerial fuels (trees and tree crowns, live and dead lower limbs). The prescriptions and techniques appropriate for accomplishing a treatment require understanding the fuel changes that result from different techniques and the fire behavior responses to fuel structure. Fuel treatments, like all vegetation changes, have temporary effects and require repeated measures, such as prescribed burning, to maintain desired fuel structure.

Clearly, many forest management activities have side effects that relate to fuels, but rarely can these activities be considered synonymous with fuel treatments. Commercial timber harvesting typically reduces the amount and continuity of aerial fuels but may increase surface fuels and surface fire intensities unless followed by slash removal (Agee 1997; van Wagtenonk 1996). Precommercial harvesting or thinning of only the smallest trees in a stand tends to decrease the vertical continuity of the forest by raising the crown base and separating the surface fuels from the aerial fuels. This can make ignition of the crown more difficult from a surface fire but may have little effect on surface fuels or on canopy cover. Prescribed fire reduces the quantity and continuity of surface fuels, increases fuel compactness, and may kill the lower limbs on the trees. These changes often decrease surface fire intensity and the vertical fuel continuity in the stand, making a crown fire less likely to start and crown damage less severe (Deeming 1990; Koehler 1993; Martin and others 1989; Helms 1979; Pollet and Omi 2002). Prescribed burning typically has little effect on the aerial fuels derived from the crowns of the largest trees.

This report summarizes postfire assessment of fire severity associated with many types of management activities. Some activities were designed as fuel treatments but most were implemented for other objectives. Fire effects must be interpreted in the context of the kind of activity, its likely effects on fuels, and the many unknowns with respect to the fire behavior and fuel conditions at the time the fire burned through a particular location.

Methods

The Hayman Fire encountered many types of fuel conditions. We classified these as natural disturbances (primarily wildfires), prescribed fires, surface fuel treatments, timber stand improvements, commercial timber harvests, and plantations. Each of these treatments or disturbances could be expected to alter different components of the overall wildland fuel complex. A total of 21,283 acres were found to have been affected by one or more management activities. This total contained the following categories:

- **Wildfires** (544 acres) temporarily reduce the quantity and continuity of surface and ladder fuels, and reduce the density canopy fuels by killing or consuming tree crowns. Consequently, potential surface and crown fire behavior is likely to be reduced after wildfires, until surface fuels accumulate and canopy fuels increase through regeneration and in-growth of trees. Fuel changes are spatially variable within the burned area.
- **Prescribed fires** (5,814 acres) have effects similar to those of a moderate wildfire. Ignition patterns and the weather and moisture conditions generally associated with prescribed burning tend to reduce canopy damage compared to wildfires. As a result, there may not be as much surface fuel consumption from prescribed fires as compared to wildfires. Crown density and continuity may not be affected but ladder fuels will often be reduced. Prescribed fire can be expected to moderate subsequent surface fire intensity and reduce the potential for crown fire initiation, but generally not to the extent expected in areas burned by wildfire.
- **Fuel treatments** (13 acres) refer to surface fuel modification for the purpose of mitigating wildfire potential by means other than prescribed fire. Some examples include lop and scatter, piling and burning, and mechanical or manual removal of surface fuels. The result is a rearrangement or reduction in surface fuels, which would be expected to reduce potential surface fire intensity. However, ladder fuels, crown bulk density, and crown base height are generally unaltered by these fuel modifications. Thus crown fire potential may not be as effectively reduced as by prescribed burning or wildfire.
- **Timber stand improvements** (7,670 acres) include precommercial thinning, removal of trees weakened by insects or disease, or weeding of undesirable species or individuals. These activities predominantly involve mechanical removal of understory trees, with minimal removal of overstory trees. Reduction in vertical fuel continuity, and to

a lesser extent horizontal canopy continuity, would be expected. However, the tree cutting produces additional surface fuels with increased exposure to solar radiation and winds, potentially resulting in increased surface fuel availability and surface fire intensity under wildfire conditions. These effects may be mitigated by subsequent treatment of the slash and preexisting surface fuels. Where this is the case, the combined reduction in surface and crown fuels would be expected to moderate potential wildfire behavior.

- **Commercial timber harvests** (5,629 acres) involve removal of trees that have merchantable value. Included are patch and stand clearcuts, shelterwood preparation and seed cuts, individual tree selection, and commercial thinning. These activities remove overstory trees, resulting in reduced crown bulk density. Depending on stand structure and the silvicultural prescription, commercial harvests may or may not affect small trees or crown base height. Harvesting residues (also called activity fuels) increase the amount of surface fuels that can be mitigated by subsequent surface fuel treatments like prescribed burning. Large changes in canopy structure increase the sun and wind exposure of surface fuels and potential surface fire behavior.
- **Plantations** (1,613 acres) are even-aged stands regenerated by direct seeding or planting. The surface and ground fuels depend on the method of site preparation used to regenerate the stand. The height to crown base and crown bulk density both depend on the species, age, and spacing of the plantation. In general, surface fire behavior would not be expected to be extreme in plantations. However, crown fire potential could be relatively high due to the low crowns and increased continuity of aerial fuels.

Explanation of every shift in the spread and behavior of the Hayman Fire as it entered each of these different types of fuel modification is beyond the scope of this report and would probably be impossible. However, systematic comparison of available documentation allowed us to make limited inferences regarding changes due to historic management activities and disturbances.

Determining the role of fuel modifications within the Hayman Fire relied on spatial analyses using Geographic Information System (GIS) software and databases provided by the Pike-San Isabel National Forest, supplemented by a helicopter survey of the fuel-modified areas. Approximate locations of where the photos were taken in relation to areas of fuels modification are shown in figure 63.

Spatial information provided by the Pike-San Isabel National Forest was used to assess the influence of prefire fuel modifications on the spread and severity of the Hayman Fire. Our assessment included qualitative evaluation of patterns in fire spread and severity in relation to fuel modifications, as well as quantitative analysis of the distribution of fire severity classes in fuel modified areas compared to that in unmodified areas. The information used in our assessments included a fire severity map (fig. 64) derived from satellite imagery, a map of fire progression (fig. 65), maps of previous fuel modifications, and a Digital Elevation Model that was used to derive aspects and steepness of slopes. While all these sources of information are prone to errors, they represent the best information currently available.

The fire severity map was produced by an inter-agency Burned Area Emergency Rehabilitation (BAER) team. BAER fire severity maps generally distinguish four classes of fire severity interpreted from satellite imagery: foliage consumed (high), foliage completely scorched (moderate), patchy foliage scorch, (low), foliage unscorched (unburned). While the “unburned” class indicates little or no canopy scorch, fire may have burned through the area as a low-intensity surface fire. Since our assessment relied heavily on the BAER fire severity map, we visited several locations representing the range of fire severities depicted on the map to verify its classification.

The fire severity map reflects fire effects primarily in terms of overstory tree mortality, and does not necessarily reflect changes in causative fire behavior that are potentially important to fire suppression or progress (for example ember production, fireline intensity, fire spread rate). Fire severity is the product of several interacting variables. These include fire intensity, vegetation sensitivity to scorch and consumption, and weather conditions that affect upward heat transfer, particularly temperature and windspeed. Further, fire intensity itself is the product of interactions among weather, topography, and fuels. Therefore, in our quantitative analysis we attempted to minimize the effects of factors other than vegetation conditions that may have influenced fire severity.

The influence of weather variations was addressed by restricting the quantitative analysis to a single burning period, the afternoon of June 9. This particular period was chosen because it appeared to be the most active in terms of fire growth, fire severity, and the number and variety of fuel-modified areas encountered. The area burned on the afternoon of June 9 is shown in relation to Hayman Fire severity and areas of fuel modification in figure 64.

Variations in topography were minimized in the analysis by focusing on only those areas of moderate slope (less than 30 percent), since this is where the

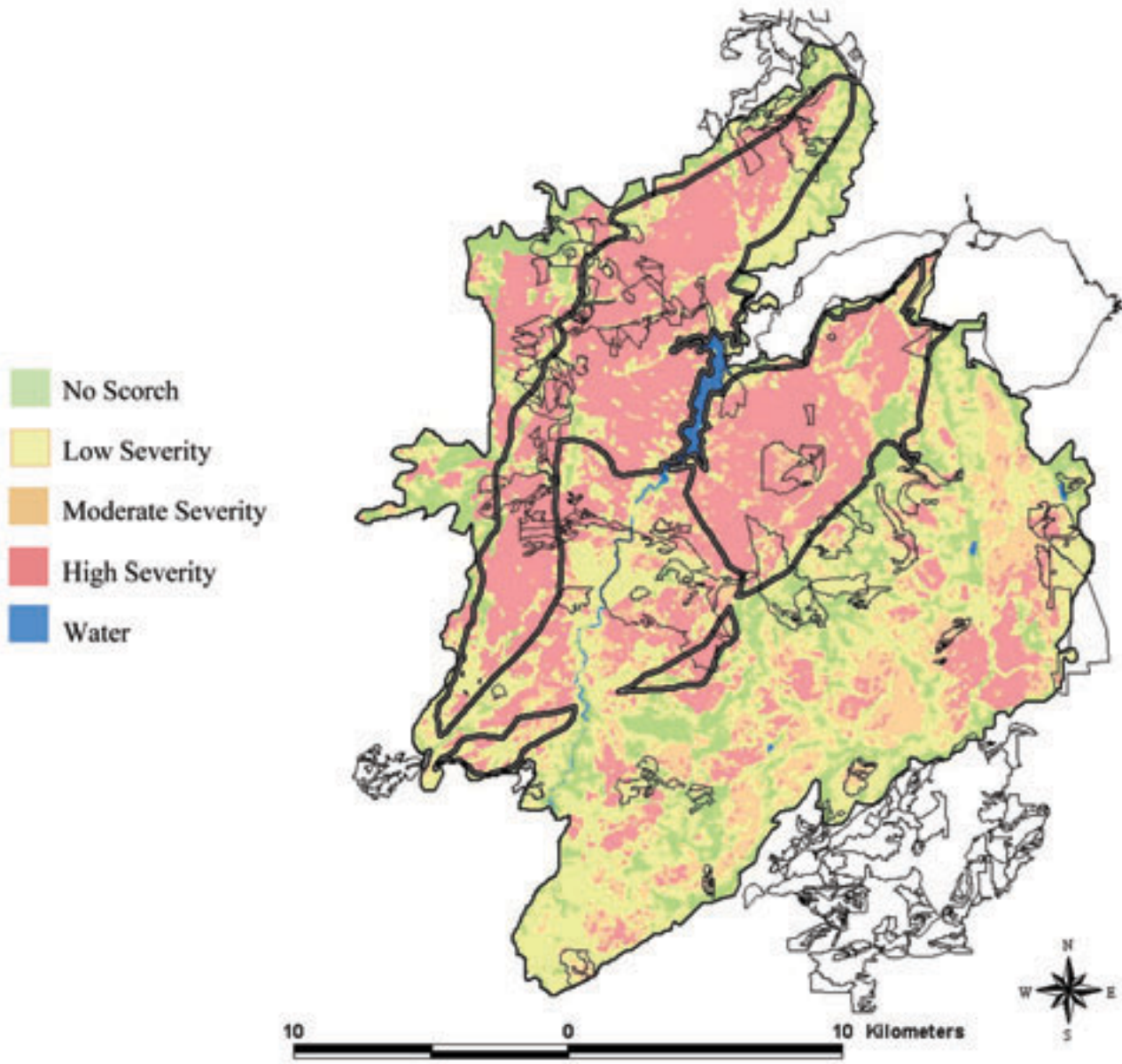


Figure 64—Fuel modifications in relation to Hayman Fire severity and area burned through June 9, 2002.

majority of fuel modifications were located (88 percent of the fuel modified areas affected on June 9 were on slopes of less than 30 percent). Since our analysis was restricted to moderate slopes, we assumed aspect had no effect on fire behavior and severity within the analyzed area. This assumption greatly simplified our analysis and was confirmed by comparison of fire severity in untreated areas of moderate slope on northeast versus southwest aspects (table 24).

Somewhat surprisingly, fire severity was slightly greater on the lee face (northeast aspects on June 9) of these moderate slopes. However, on steeper slopes we would expect greater fire intensity on the windward side. Further, aspects were similar among unmodified

areas and areas that had fuel modifications, though northeast aspects were slightly more prevalent among the modified areas. Because northeast aspects experienced slightly greater fire severity in the areas we considered, our analysis could be considered a somewhat conservative assessment of the effects of fuel modifications under the hypothesis that they mitigate wildfire severity.

Results

Comparing the fire progression map with areas of fuel modifications reveals several striking patterns in the growth of the Hayman Fire (fig. 65). Most notable is the adjacency of much of the final fire perimeter with

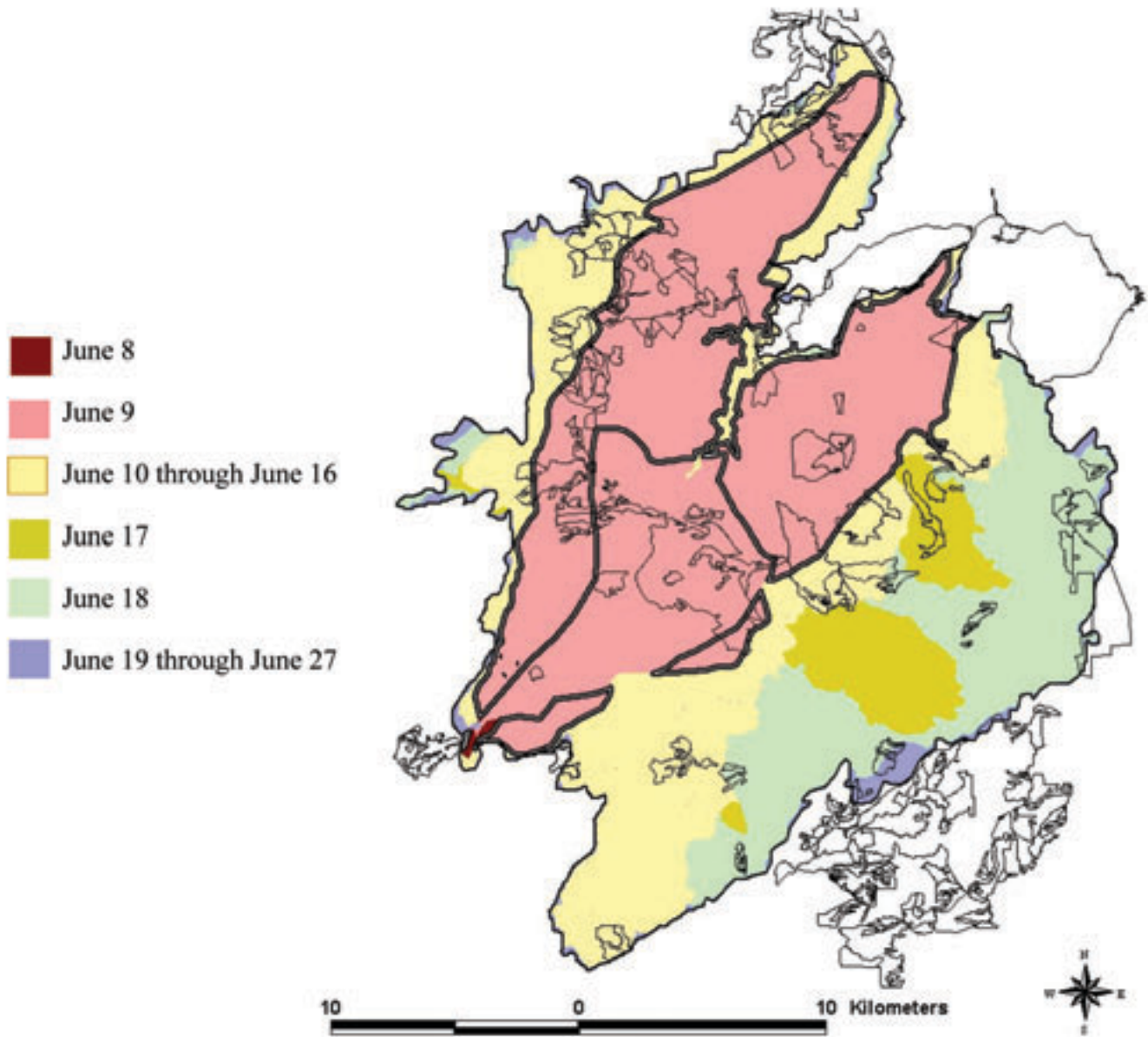


Figure 65—Hayman Fire progression in relation to areas of fuel modification.

the boundaries of fuel-modified areas, suggesting that they may have helped prevent further fire spread. On the other hand, equally striking is the June 9 run over 60,000 acres that included several areas of fuel modifications with little apparent effect on fire severity (fig. 64). This impression was confirmed by our analysis of the distribution of fire severity classes in the various types of fuel-modified areas that burned on the afternoon of June 9 (table 25). Field verification of the fire severity map used to conduct this analysis confirmed that it is generally accurate, though the moderate and high classes seem poorly distinguished (table 26), suggesting that they should probably be

combined when evaluating the severity map or interpreting table 25.

The results of the quantitative assessment indicate that fuel modifications generally had little influence on the severity of the Hayman Fire during its most significant run on June 9. However, there was some variability among the different types of fuel modification, with prescribed fires and other surface fuel treatments that seemed to be most effective at changing fire severity and behavior. Also, there were several instances on moderate days (following June 9) where fuel modifications appear to have had a greater influence on fire spread and severity. The apparent effects

Table 25—Distribution of fire severity classes among fuel-modified areas on moderate slopes (less than 30 percent) that burned in the Hayman fire on June 9, 2002.

	Area (ac)	Unburned (%)	Low (%)	Moderate (%)	High (%)
Unmodified	22,546	4	18	8	70
Recent Modifications (after 1990)					
Wildfires	12	0	0	25	75
Rx fires	719	6	20	11	63
Fuel treatments	0	NA	NA	NA	NA
Improvements + treatment	395	0	19	7	74
Improvements, no treatment	625	3	12	9	76
Harvest + treatment	1622	5	14	10	71
Harvest, no treatment	583	0	1	33	66
Plantation	136	0	8	5	87
Older modifications (prior to 1990)					
Wildfires	Unknown	NA	NA	NA	NA
Rx fires	84	17	50	8	25
Fuel treatments	5	0	86	14	0
Improvements + treatment	0	NA	NA	NA	NA
Improvements, no treatment	1462	1	14	8	77
Harvest + treatment	3	0	16	9	75
Harvest, no treatment	948	3	27	2	68
Plantations	314	0	27	10	63

Table 26—Correspondence of fire severity classifications on the BAER map to our field assessments.

Field classification	Map classification			
	High	Moderate	Low	Unburned
High	4	7	1	0
Moderate	0	3	3	0
Low	0	1	10	1
Unburned	0	0	0	1

of each of the different types of fuel modification are discussed separately below.

Wildfires: The Hayman Fire burned over several recent wildfires (544 acres total), including 12 acres of the Schoonover fire on the afternoon of June 9. The Schoonover occurred two weeks prior to the Hayman Fire and is located west of point 45 on figure 63. The area burned over on June 9 was a spot fire separate from the main body of the Schoonover fire that had no effect on the severity of the Hayman (table 25). However, it is evident that the main body of the Schoonover fire altered the spread pattern of the Hayman Fire during its June 9 run (fig. 64). This took place along the eastern flank of the Schoonover Fire which burned as a surface fire resulting in little impact on the canopy.

This area shows up as a green strip separating the Schoonover from the Hayman Fire (fig. 51). The Hayman encountered this strip on June 9 and only burned a short distance into it.

The Hayman Fire burned over two other recent wildfires, the 2002 Platte Springs and the 1998 Big Turkey fires (fig. 66). The Platte Springs fire is on the Southwest perimeter of the Hayman Fire in area where the fire did not burn very intensely. This wildfire was partially burned over with low severity by the Hayman Fire, but adjacent unmodified fuels also burned with low severity, so no effect was apparent. However, it is interesting the way the Hayman Fire seemed to burn around much of the Platte Springs fire having low severity effects.

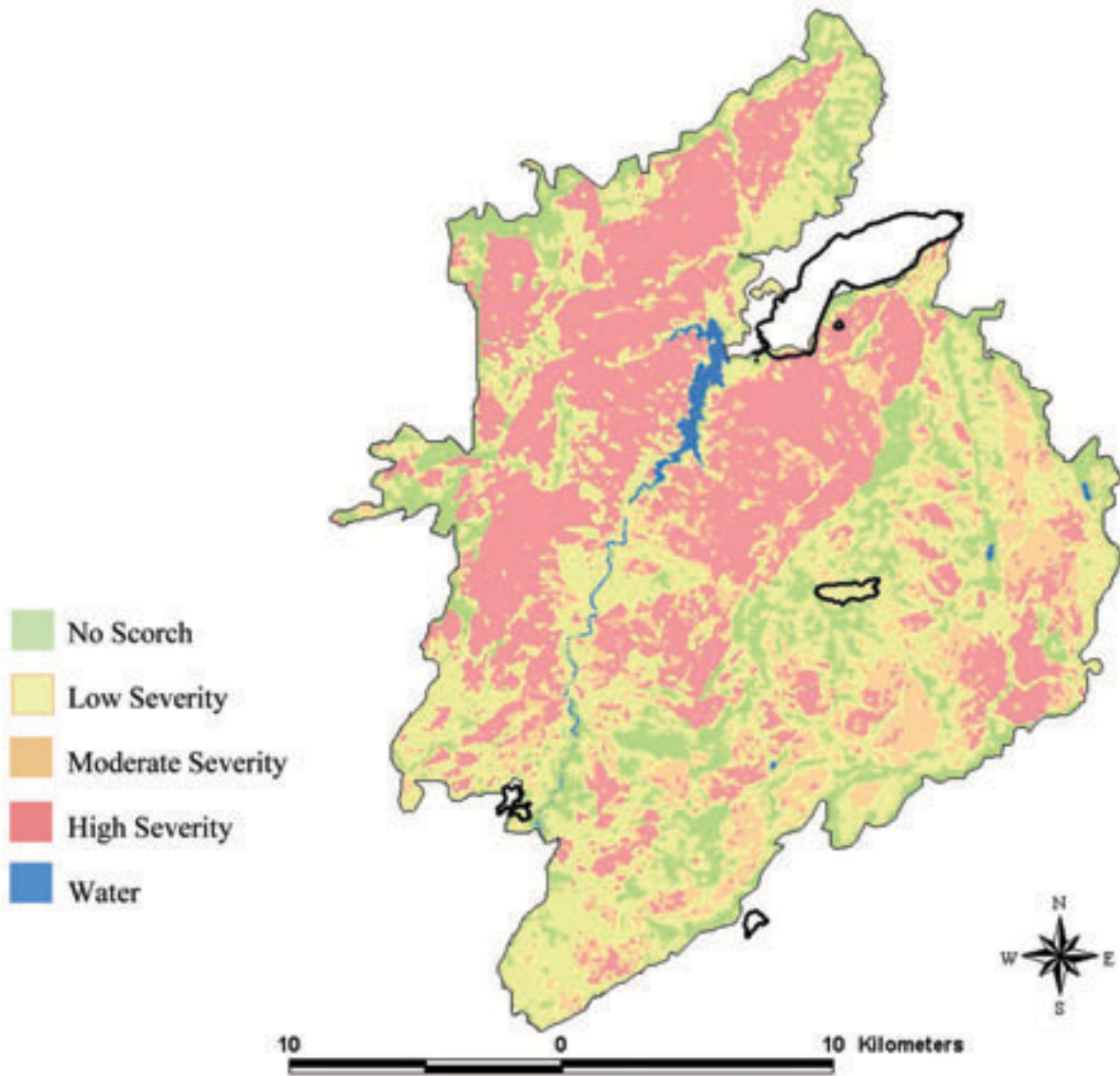


Figure 66—Recent wildfires in relation to the Hayman Fire perimeter and severity.

The area around the Big Turkey Fire (point 14 on fig. 63) burned over the several days between the large runs of June 9 and 17. Though there are patchy areas adjacent to this fire where the Hayman Fire crowned, from the air the Hayman appears not to have entered the Big Turkey Fire area (fig. 53, 54, 56b). Even more interesting is the apparent effect of the Big Turkey Fire on the pattern of fire spread the afternoon of June 17 (see Fire Chronology section, fig. 56). Winds from the northwest initiated runs on either side of the Big Turkey Fire, but not from within it. The older wildfire, in combination with the adjacent Turkey prescribed burns (1990, 1995) appears to have prevented the spread of fire out of that area along a 2-mile segment of the perimeter when extreme weather conditions returned.

We were aware of at least two older wildfires within the Hayman’s perimeter, the Turkey Creek and Wildcat fires which both burned in 1963. Though we do not know their exact perimeters, approximate locations have been revealed by previous fire history studies. The Turkey Creek fire burned a small area in the lower Turkey Creek drainage (midway between points 20 and 21 on fig. 63) and appears to have considerably reduced overstory density. This area burned in the high intensity fire on June 9, but green trees in the area could be seen from the air (fig. 67). It should be noted that since we did not know the perimeter of this fire, it was considered unmodified fuel in the GIS analysis. Thus, the severity for unmodified fuels may be somewhat underestimated in table 25.



Figure 67—Photo of 1963 Turkey fire (between points 20 and 21 on fig. 63) showing green tree crowns following the Hayman Fire.

The Wildcat fire burned in the same area as the Northrup prescribed burn (between points 10 and 21 on fig. 63). This prescribed burn covered several thousand acres straddling the South Platte River (fig. 68). This Wildcat area was burned on the morning of June 9. Stocking of large conifer trees was low within most of the Wildcat burn area. Patches of conifers did survive here, but many were completely scorched and presumed killed. Pockets of aspen that sprouted after the 1963 fire also survived the Hayman Fire. Some forested areas immediately downwind of The Wildcat burn did not crown in the Hayman Fire, but complete crowning resumed just beyond during the June 9 run (fig. 69).

In addition to wildfires, the Hayman Fire burned over another type of natural fuel modification: an area affected by a spruce budworm outbreak. Most Douglas-fir in the area between points 47 and 48 on figure 63 were killed by spruce budworm in the early 1990s with subsequent mortality in remaining trees from Douglas-fir beetle. Surface fuel loads were not excessive, since most of the Douglas-fir snags remained

standing. The only live trees remaining prior to the Hayman Fire were scattered ponderosa pine and the reduction in crown cover due to insect mortality seemed to affect fire behavior. The fire spread towards the southeast through this area during the relatively inactive period between the runs of June 9 and 17. The fire burned mostly as a surface fire on both sides of Westcreek, with small patches of crown fire activity. From the air the burn appeared less severe than in areas outside the budworm affected area (fig. 70).

Prescribed Fires: The Hayman Fire burned over 5251 acres of area that had been recently prescribed burned (fig. 71). Of this area, 719 acres were burned the afternoon of June 9 and included in our GIS analysis. Most of this area falls within the northern half of the 1990 Turkey prescribed burn (Turkey Rx1990) (point 12 on fig. 63). The results of the GIS analysis suggest that burn severity in this area was only slightly lower than adjacent areas with unmodified fuel on similar topography that burned in the same period (table 25). However, fire severity was patchier within Turkey Rx1990 than adjacent un-

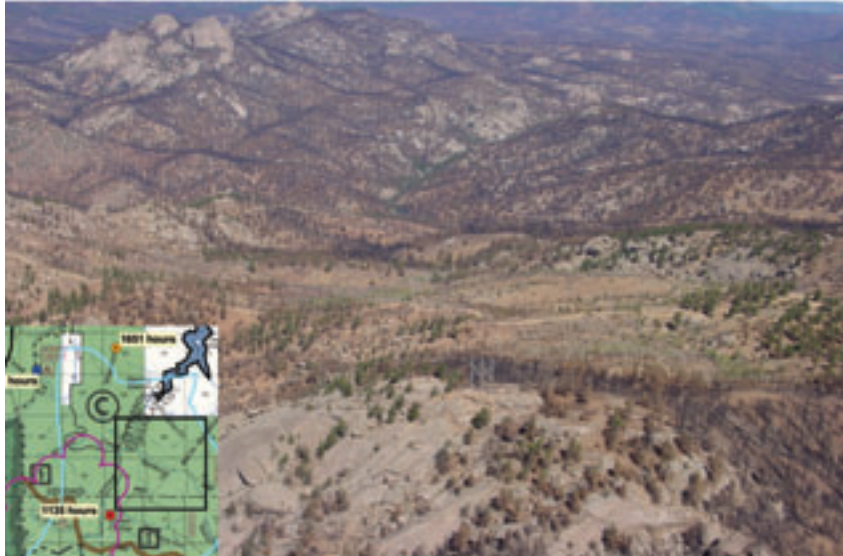


Figure 68—Photo point 10 showing surviving forest within Northrup 1992 prescribed burn from different angles.



Figure 69—Photo point 10 showing surviving forest within 1963 Wildcat wildfire from different angles.



Figure 70—Variable fire effects on the overstory in area of spruce budworm mortality. Hayman Fire burned through this area between June 10 and June 16.

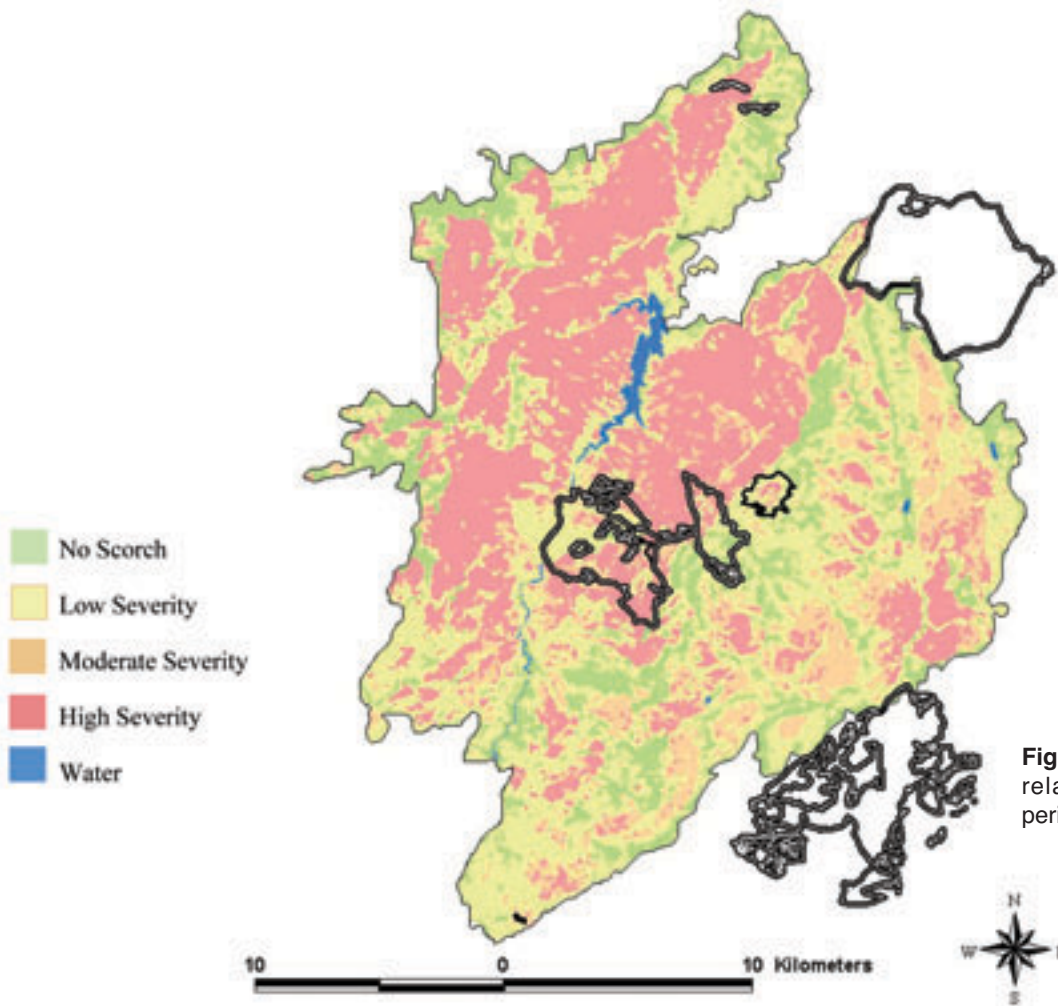


Figure 71—Prescribed burns in relation to the Hayman Fire perimeter and severity.

treated stands, having a greater proportion of low to moderately scorched trees (fig. 53, 72). Tree density was quite low in some parts of this area, perhaps due to past thinning activities; stumps are present in this area along the road into the south side of Cheesman Reservoir.

The southern half of Turkey Rx1990 is immediately adjacent to Turkey Rx1995, both of which burned over several days between the runs of June 9 and 17. The Hayman Fire burned quite moderately through these prescribed burn areas, but the evidence of treatment effectiveness is somewhat conflicting. While there are patches of apparent crown fire activity in adjacent unmodified fuels to the northeast, unmodified vegetation to the southwest appears to have been even less severely impacted than that within the prescribed burns. However, this area of low severity to the southwest may have benefited from a buffering effect provided by a strip of fuels treated by the Northrup Rx1992 burn. The unmodified fuels to the northeast of the Turkey Rx1990 burn had no such buffer and thus may have been more prone to crown fire initiation.

The run on the evening of June 9 also encountered the Brush Creek Rx1992 burn (northeast of point 41 on fig. 63). This prescribed burn followed commercial harvest in 1989. The severity of the Hayman Fire

generally appears similar inside and immediately adjacent to these prescribe-burn units. But there are a few small patches of more moderately burned vegetation on the ridge immediately behind the northern section, suggesting a buffer effect that reduced fire intensity for a short distance behind the treatment. The effectiveness of this prescribed burn might have been greater and more apparent had it been wider. The run on the afternoon of June 9 also encountered the 1992 Brush Creek prescribed fire (northeast of point 41 on fig. 63). However, the severity of the Hayman Fire appears similar inside and immediately outside of this treatment area.

Three other recent prescribed burns were encountered by the Hayman Fire after June 9. These were Polhemus Rx2001, North Divide Rx1998, and Northrup Rx1992. The Hayman's June 9 run crossed Trout Creek and Highway 67 but stopped at the edge of the Polhemus burn (point 45 on fig. 63). On subsequent days the Hayman burned through an unburned notch between the Polhemus and the Schoonover Fires but made little progress into either (fig. 47, 48, 49, 50). From the air the Polhemus prescribed burn did not appear to change overstory forest density, but because of the 2002 drought there was little surface fuel of any kind within this area.



Figure 72—Photo point 12 and 13 facing northwest shows areas within the Turkey prescribed burn in 1990 and 1995.

The North Divide Rx1998 is at the southeast perimeter of the Hayman Fire and at first glance appears to have stopped its forward spread (point 4 on fig. 63). However, a field visit to this area made it apparent that the Hayman Fire stopped here because of the presence of the perennial Phantom Creek and associated beaver ponds. Though the Hayman Fire was crowning in several areas as it approached Phantom Creek (fig. 73), it is evident from the low-severity effects that the Hayman Fire was not able to cross the road and the creek directly (fig. 74). We could not evaluate, however, the possibility that the North Divide Rx1998 burn stopped the Hayman Fire by reducing the success of embers igniting spot fires.

Much of Northrup Rx1992 is in the same area as the 1963 Wildcat wildfire described above (between points 10 and 21 on fig. 63). While this area appears as a low severity patch within the matrix of general high severity from the June 9 run, this is most likely due to the extreme openness of the area rather than treatment effects of the prescribed fire. Nevertheless, in contrast to adjacent untreated areas, patches of sparse ponderosa pine did survive within the Northrup area prescribed burn unit (fig. 68). Also, as discussed above, this burn appears to have had a buffering effect on the adjoining a Turkey Rx1990 treatment area.

The Hayman Fire also burned over the Turkey Creek Rx1987 prescribed burn (563 acres). Of this total, 84 acres burned the afternoon of June 9 (point 18 on fig. 63) as the fire flanked to the east (fig. 65). This portion, along with adjacent untreated stands, appeared to have experienced lower severity overstory effects than surrounding areas burned that same day (table 25). Thus, it is difficult to attribute a possible reduction in severity within the prescribed burn solely to the treatment. By contrast, the interior of the Turkey Creek Rx1987 unit burned on June 10 showed apparently greater severity than surrounding unmodified fuels (fig. 53). Definitive reasons for this cannot be determined at this time, but burn coverage and fuel consumption levels in the original prescribed burn (Turkey Creek Rx1987) may have varied spatially, fuel changes over the 15 years since treatment may have recovered to essentially pretreatment levels, or more fuel may have been made available to the Hayman Fire because of tree mortality. Forest species composition may also be interacting with these factors in producing various fire effects. Forest type classifications for the Rx1987 burn unit (fig. 53) suggested that Douglas-fir was dominant compared in the interior and more severely burned areas compared to ponderosa pine around the outside edge.



Figure 73—Photo point 4 looking south over North Divide (1998) prescribed burn.



Figure 74—Photo point 4 looking at North Divide prescribed burn (1998) near Phantom Creek.

Fuel Treatments: A total of only 13 acres, in two separate units, were classified as fuel treatment with no prescribed burning. Both units occurred near the southeastern edge of the fire (south of point 6 on fig. 63) and burned on June 18. The first area treated since 1990 (8 acres) was classified as low severity, identical to surrounding stands, so there was no basis for assessing its effectiveness (fig. 75). The second area was 5 acres in size and treated before 1990. It burned with low intensity and was adjacent to untreated areas that burned with moderate and high intensity (table 25). Effectiveness of these treatments at reducing severity or changing fire behavior could not be determined conclusively due to of the small sizes of these areas and ambiguous contrast in severity compared to neighboring areas.

Timber Stand Improvements Followed by Activity Fuel Treatment: The Hayman Fire burned over 939 acres of timber stand improvements that were followed by treatment of the surface fuels produced by the management activities (fig. 76). About 395 of these acres burned on the afternoon of June 9. This included a fuel break along the road north of Cheesman Reservoir (point 37 on fig. 63) the Goose Creek sanitation harvest (point 32 on fig. 63) and release weeding treatment (point 34), and the

Switchback dwarfmistletoe treatment. The GIS analysis indicates that collectively these activities did little to influence fire severity.

The Cheesman fuel break (point 37 on fig. 63) was accomplished in 2000. The prescription was a thinning from below that removed all but the largest trees in the stand. The harvest was accomplished by a feller-buncher with slash piled. Most of the slash piles were subsequently burned. The Hayman Fire killed or torched most of the trees along the ridge and in the fuel break (fig. 77). However, in a different section, trees along the Reservoir entrance road still supported green foliage (fig. 78). The latter effect is likely related to several factors including (1) the fire crossing this valley as a flanking fire rather than a heading fire, (2) the treatment location within the lower topographic position compared to surrounding ridges, (3) the lee-side blocking effect of Cheesman Reservoir that had been partially responsible for dividing the main head fire on June 9, and (4) the protection afforded by the Schoonover wildfire to the east that did not reburn in the Hayman Fire.

Several treatments occurred in the vicinity of the Goose Creek sanitation harvest and the nearby weeding treatment; these are discussed separately in sections below. Both the sanitation harvest and weeding

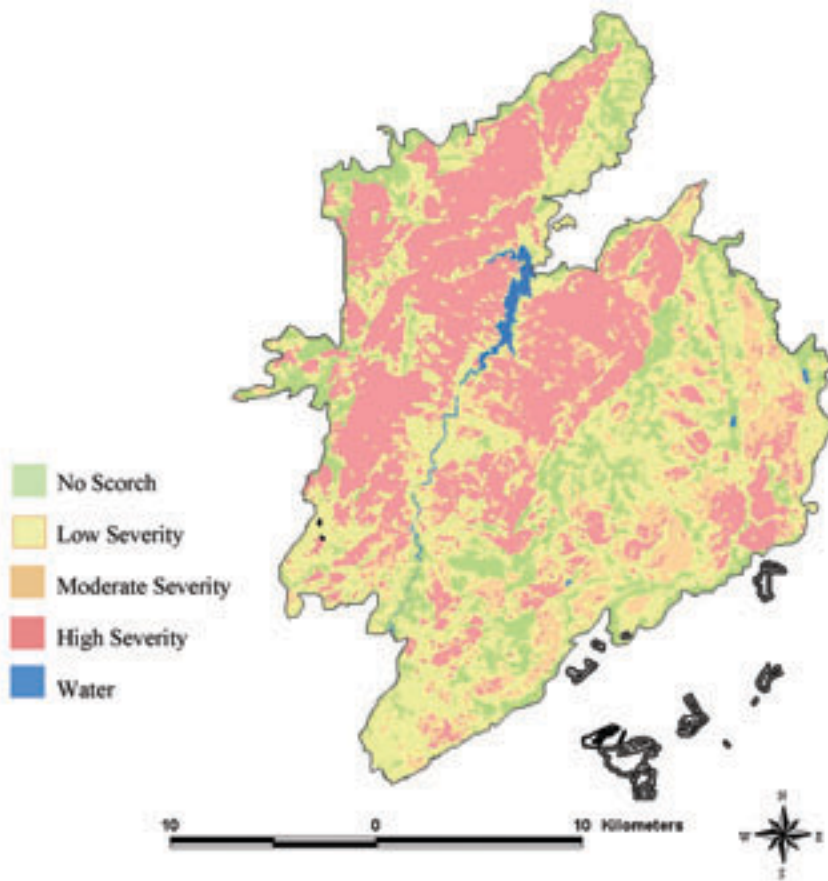


Figure 75—Fuel treatments (other than prescribed burns) in relation to the Hayman Fire perimeter and severity.

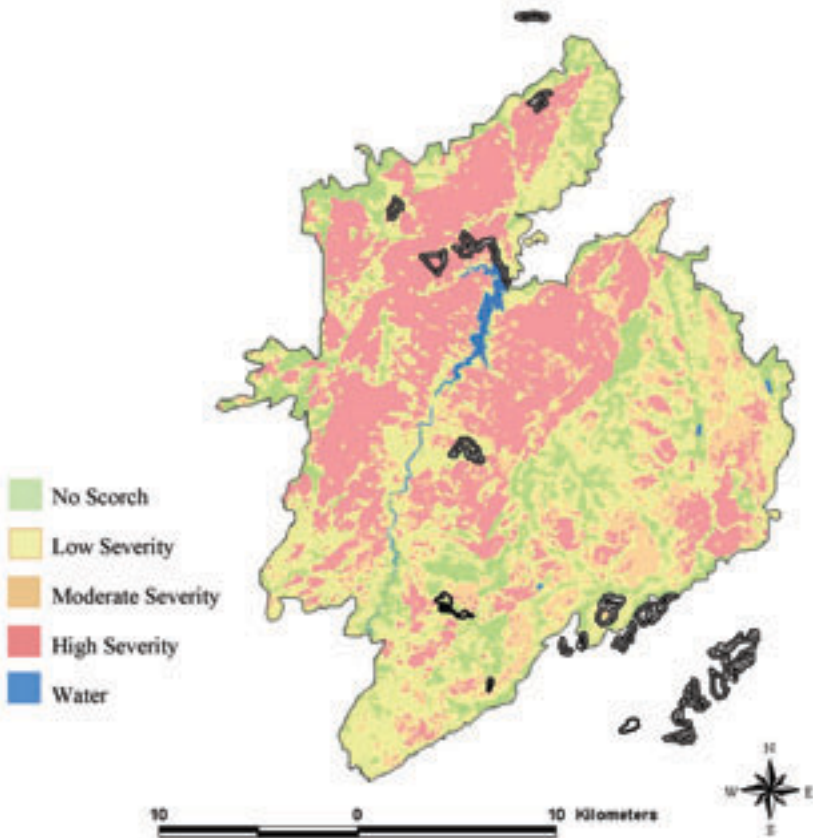


Figure 76—Timber stand improvements followed by activity fuel treatment in relation to the Hayman Fire perimeter and severity.



Figure 77—Photo point 37 looking west at Cheesman fuel break north of Cheesman Reservoir. All tree foliage was severely scorched although not consumed.

treatment were accomplished in the early 1990's and were followed by removal or burning of the resulting slash. Neither treatment had any discernible effect on the spread of the Hayman Fire on June 9 or the severity of overstory effects.

The Switchback mistletoe treatment was accomplished in 1998 with the slash piled and burned (northwest of point 32 on fig. 63). The treated areas exhibited low severity effects from the fire on June 9 as it flanked across this area. Most of the adjacent areas were also classified as having low severity effects, perhaps because they were within the Wigwam timber sale (discussed below). By contrast, areas south of the treatment were burned severely, possibly reflecting a treatment effect.

Several other areas receiving recent stand improvements followed by treatment of activity fuels burned in

the Hayman Fire on subsequent days. A small area in the 1992 Northrup prescribed burn was pre-commercially thinned the year before (mid-way between point 10 and 21 on fig. 63). This area was burned by the Hayman Fire on the morning of June 9 and experienced lower severity than most of the adjacent fuels, though these had been modified by the Northrup prescribed burn and perhaps by the 1963 Wildcat fire as well.

An area of Christmas tree sales in 1992 and 1993 was followed by the Brush Creek prescribed fire in 1996 (north of point 41 on fig. 63). This area was burned by the Hayman Fire on June 10 and appears to have reduced burn severity. On the other hand, an area east of Signal Butte (point 6) was classified as having greater severity from the fire burning on June 18 than the surrounding unmodified stands despite a



Figure 78—Photo looking north at Cheesman Reservoir and thinning operation along southern edge.

sanitation harvest in 1995 to 1996 and slash removal (fig. 79). Two sanitation harvests were also done a few years prior to being burned by the North Divide prescribed fire adjacent to the southeast perimeter of the Hayman Fire, but as discussed above, it appears that Phantom Creek probably stopped the Hayman Fire unless spot fires were unable to initiate inside the North Divide treatment unit.

The Hayman Fire also burned over 153 acres of older modifications of this type, all after June 9. One area was pre-commercially thinned in 1984 with the slash piled and burned (point 7 on fig. 63). This area sustained low to moderate burn severity on June 18, but is adjacent to unmodified forest that was completely scorched or consumed (fig. 80). Another area received a weeding treatment in 1983 with slash piled and burned (northwest of point 7). This treatment unit burned in the Hayman Fire on June 11, also sustaining low severity and adjacent to areas with unmodified fuels that were burned more severely.

Timber Stand Improvements Without Treatment of Activity Fuels: The Hayman Fire burned over 1900 acres of recent timber stand improvements

that had received no follow-up treatment of activity fuels (fig. 81). Of this area, 625 acres were affected on the afternoon of June 9 and included in our GIS analysis. Most of these modifications were part of the Goose Creek and Switchback activities described above. There is also an area of on the east side of Cheesman Reservoir where ladder fuels and trees less than 8 inches in diameter were removed in 2001 and 2002, but the slash had not yet been treated. Other areas include diseased tree removals in 1999 east of point 23 on figure 63 and a year 2000 weeding treatment southeast of point 25. The results of the GIS analysis suggest that these areas fared slightly worse than unmodified fuels that burned during the June 9 run (table 25).

Fire severity appears to have been reduced in the northern part of the Cheesman treatment (fig. 82) but this could also have been a result of its location on the downwind (lee-side) of the Reservoir which was protected from fire moving from the southwest. The southern half of this area was treated most recently and contained red slash that probably increased fire intensity. The 1998 Goosecreek weeding treatment at point



Figure 79—Area east of Signal Butte (photo point 6) with sanitation harvest and slash removal showed burned severely by the Hayman Fire on June 18.

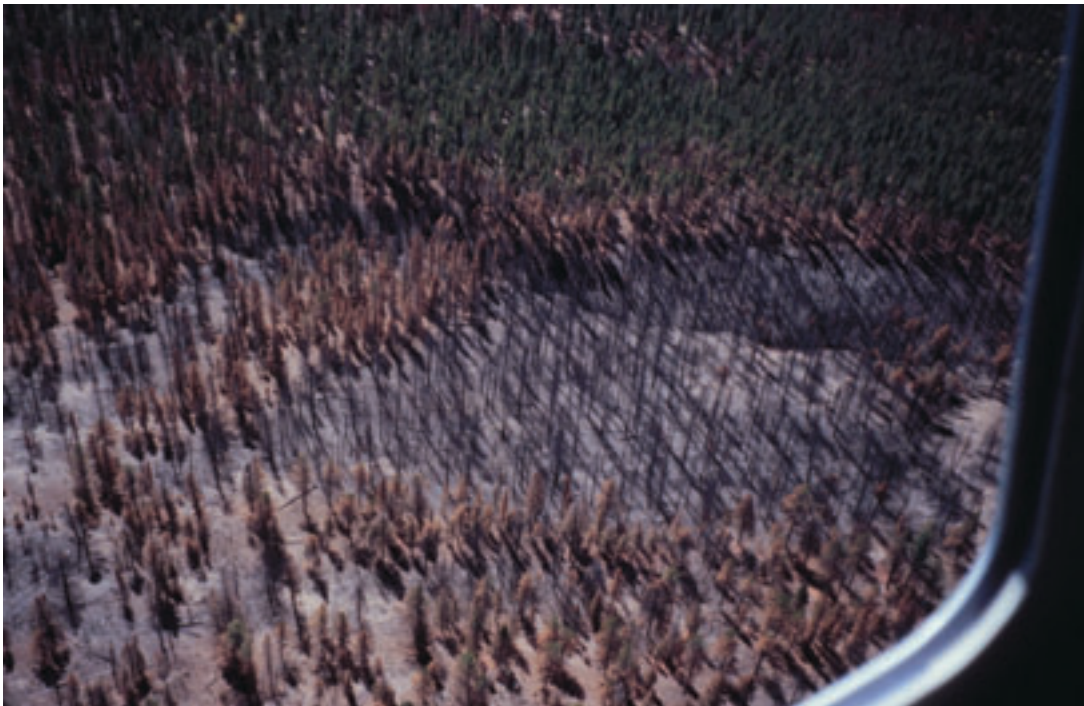


Figure 80—Photo point 7 showing area precommercially thinned in 1984.

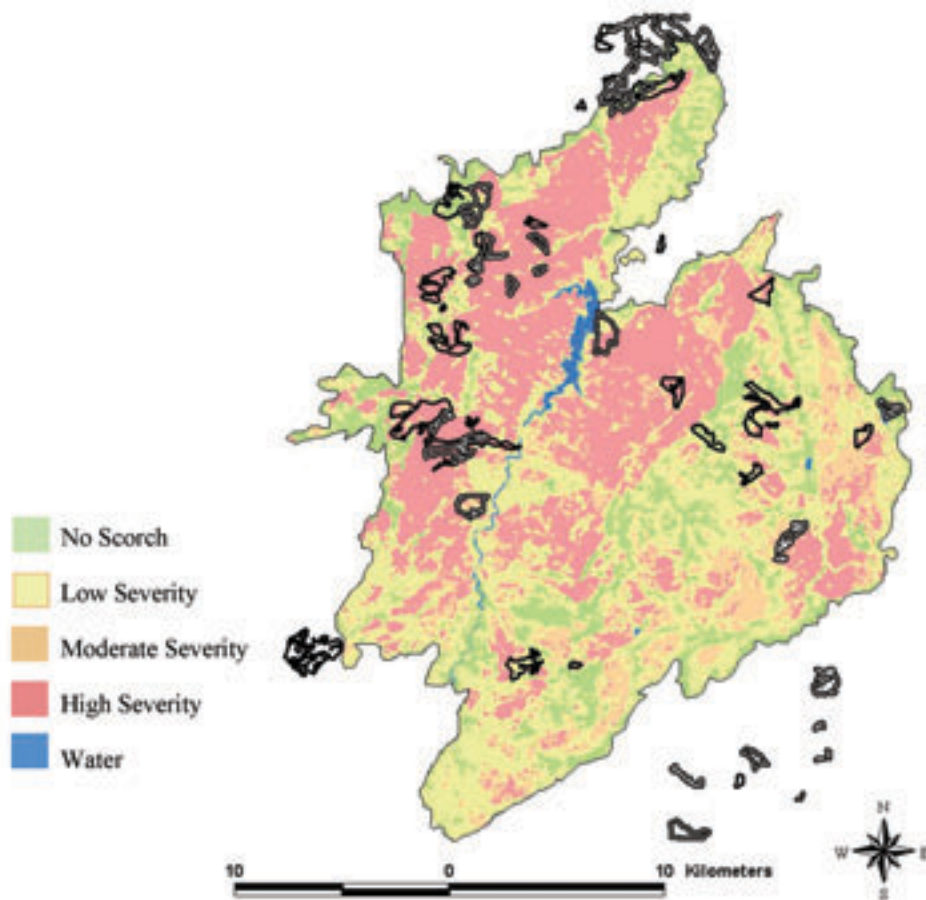


Figure 81—Timber stand improvements that received no subsequent treatment of activity fuels in relation to the Hayman Fire perimeter and severity.



Figure 82—North end of Cheesman Reservoir (southeast of photo point 37) showing thinning operation along the shoreline and lower severity, partly due to proximity to the Reservoir and lee-side protection from heading fire on June 9.

32 on figure 63 also appears to have moderated fire behavior, as does the 1998 Switchback mistletoe treatment northwest of point 33. However, the severely burned area ahead of this mistletoe treatment was modified by the Goose Creek commercial thin discussed in the next section.

Several similar fuel modifications outside of the area that burned on June 9 also appear to have affected fire behavior. An area where diseased trees were removed in 2000 was burned by the Hayman Fire on the morning of June 9 (due south of point 23 on fig. 63) and appears to have contributed to a reduction in fire severity. The parts of the Switchback mistletoe treatment that burned between June 10 and 12 experienced lower severity than adjacent unmodified fuels to the north and south. Particularly interesting is the adjacency of the northern tip of the Hayman perimeter to an area of release weedings (killing and removal of small trees) accomplished in 1991 (point 42), suggesting that these may have helped slow its forward spread. Also, another 1991 release weeding that burned on June 18 (southeast of point 16) had no apparent effect on the behavior of the Hayman Fire. An area treated to control the spread of mountain pine beetle that also burned on June 18 also had no discernible affect on fire severity (northeast of point 49).

The Hayman Fire also burned over 4,678 acres of older stand improvements that went without activity fuel treatment. The Hayman Fire encountered 1462 acres of these older fuel modifications on the afternoon of June 9 and the GIS analysis indicates that they also were affected somewhat more severely than unmodified fuels. Comparison of fire severity in these modifications to immediately adjacent unmodified fuels over the entire burned area does little to change this impression. Within the run on the afternoon of June 9 these areas include the Wigwam timber stand improvements of the 1960's (near points 25 and 28 on fig. 63), a 1985 stand improvement in the Goose Creek area, the 1981 Fourmile precommercial thin (between points 20 and 46), and a 1987 sanitation cut (point 46). Areas burned on subsequent days include the 1986 Twin Creek sanitation cut (northwest of point 28), the 1967 Thunder Butte stand improvement (east of point 48), the 1981 Thunder Butte precommercial thin (northeast of point 18), the 1981 Sheepnose precommercial thin (point 16), the 1986 Rainbow sanitation cut (point 49), and weeding treatments in the 1980's between points 7 and 10. None of these appear to have had any appreciable affect on fire behavior. However, the northernmost section of the Wigwam sale (northwest of point 32 near the Hayman perimeter) does appear to have lower burn severity than adjacent areas – a late 1980's commercial harvest to the south and a recent timber stand improvement to the east, neither of which had any subsequent activity fuel treatment.

Commercial Harvests Followed by Activity

Fuel Treatment: The Hayman Fire burned over 2,477 acres of commercial harvests that were followed by treatment of the activity fuels, with 1,622 acres affected on the afternoon of June 9 (fig. 83). This area consists of the Goose Creek commercial thinning (northeast of point 32 on fig. 63), the Y sale commercial thinning (northeast of the Goose Creek sale), and the Brush Creek shelterwood seed cut (point 41). The GIS analysis suggests that fire severity in these areas was no different from that in modified fuels that also burned on the afternoon of June 9.

The Goose Creek sale occurred in 1985 with subsequent removal of trees with dwarf mistletoe in 1986 and 1993. Activity fuels were treated by removal and jackpot burning in 1993 and 1995 (burning isolated concentrations of large fuels). The area is very evident from the air and shows evidence of multiple treatments, which left even-aged stands of openly spaced trees in several different age classes prior to the Hayman Fire. The fire appeared to have burned through the entire area, killing most of the trees near County Road 211, which passes along a broad ridge through the area. Some trees were affected less severely on west and NE sides of the sale area (fig. 84) and on the lee side of ridges away from prevailing winds at the time of the June 9 run (fig. 85, foreground). However, this fuel modification does not appear to have slowed the overall progression of the Hayman Fire.

The Y sale occurred in 1981, followed by prescribed burn in 1982. The area was also treated for dwarf mistletoe in the late 1990's with slash removed or piled and burned. As with Goose Creek, the Hayman Fire affected this area severely.

The Brush Creek sale occurred in 1989 and was followed by prescribed burning in 1990. Although overstory density appeared to be low, the Hayman Fire burned over the entire area on June 9 with high severity. The only effect on fire behavior observable from the air was that some trees in more open areas were killed by crown scorch, rather than consumption (fig. 86), indicating intense surface fire rather than crown fire occurred there. Treatments of this type that burned on more moderate subsequent days may have been more successful in moderating fire behavior and consequent severity. The 1984 Turkey Rock commercial thin (point 13 on fig. 63) was subsequently treated by the Turkey prescribed burn in 1990 and was not affected severely by the Hayman Fire when it was burned over on June 11 and 12. However, neither were surrounding areas, though these had mostly been treated by the Turkey Rx1990 burn.

The 2002 Trout Creek timber sale on the Manitou Experimental Forest (point 1) showed significantly less overstory damage compared to untreated stands. This was a ponderosa pine restoration treatment that

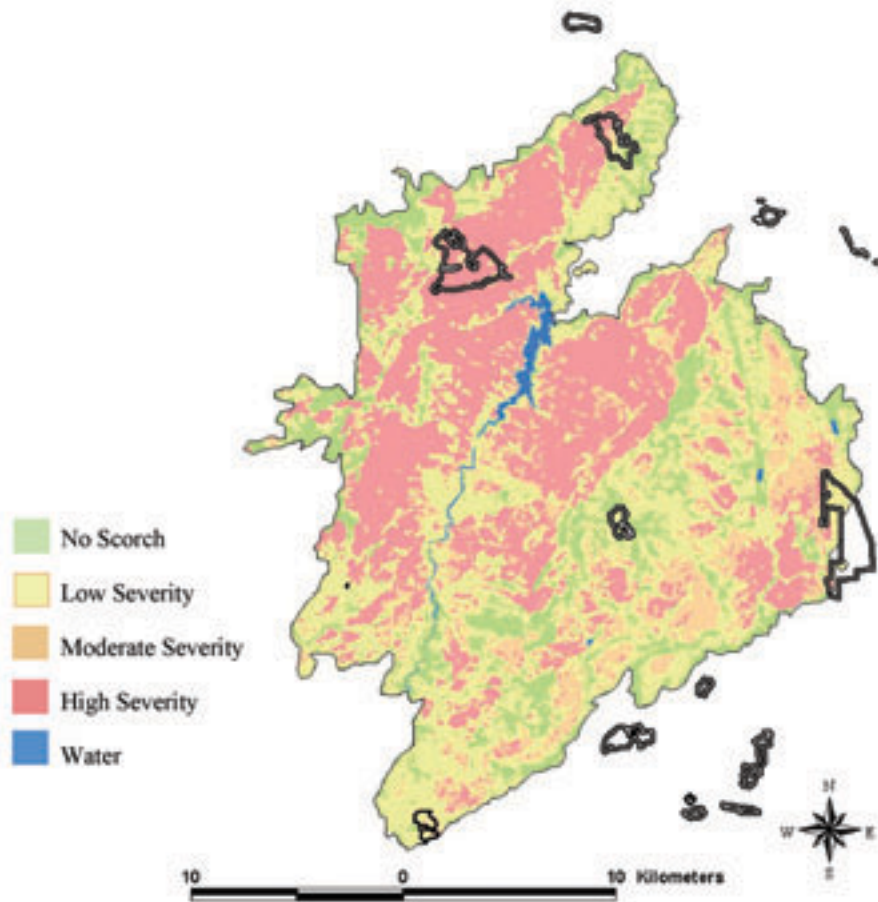


Figure 83—Commercial timber harvests followed by treatment of activity fuels in relation to the Hayman Fire perimeter and severity.



Figure 84—Photo points 30 and 31 showing Goose Creek timber sale area in foreground (1986-1993). Activity fuels were pile-burned in 1993-1995. The Hayman Fire burned here the afternoon of June 9 as a high intensity surface fire.



Figure 85—Photo points 34 and 35 showing Goose Creek timber sale area in foreground (1986-1993). Activity fuels were pile-burned in 1993-1995. The Hayman Fire burned here the afternoon of June 9 as a high intensity surface fire.



Figure 86—Photo points 39 and 40 showing the Brush Creek timber sale that was followed by prescribed burning. The Hayman Fire burned here the afternoon of June 9 in crownfire and high-intensity surface fire.

variously included commercial thinning, irregularly spaced individual tree selection, and complete overstory removal of mistletoe-infected trees. Slash had been piled but not yet burned when the Hayman Fire arrived on June 18. The fire resulted in lower severity to the overstory trees when it entered the sale area (fig. 87). Detailed information on this fuel modification and its effect on the Hayman Fire is presented in a separate section (below).

The fire encountered 240 acres of older commercial harvests where the slash was treated, with 3 acres affected on the afternoon of June 9. This was a small 1979 clearcut followed by piling and burning in 1980. It appears to have been burned more severely than adjacent unmodified fuels, though the GIS analysis indicates that it contains a distribution of severities that is similar to that of unmodified fuels over the entire area burned on the afternoon of June 9. The other older modification of this type was the Trail Creek shelterwood seed cut of 1988 with slash piled and burned. This area appears to have burned with similar severity as adjacent unmodified fuels (fig. 88).

Commercial Harvests Without Treatment of Activity Fuels: The Hayman Fire burned over 583 acres of commercial harvests that had no subsequent treatment of activity fuels, all on the afternoon of June 9 (fig. 89). This consisted entirely of the Sheepnose shelterwood seed cut in the year 2000, which was intended to be a ponderosa pine restoration treatment (point 20 on fig. 63). The treatment consisted of mechanically harvested smaller trees, leaving a scattered, open overstory. Trees were skidded to landings and processed, leaving large slash piles throughout the area, which had not yet been burned when the Hayman Fire arrived. Additional removal of submerchantable small stems had not been completed either. The GIS analysis indicates that this area had a higher proportion of moderate burn severity than unmodified fuels that burned during the run on the afternoon of June 9, but a lower proportion in the high and low severity classes. However, this area is especially striking when compared to adjacent unmodified fuels (fig. 90). Most trees within the Sheepnose area were killed by scorch rather than by consumption,



Figure 87—Trout Creek timber sale on the Manitou Experimental forest (photo points 1 and 2). This area was burned the afternoon of June 18.



Figure 88—Photo of the 1988 Trail Creek shelterwood seed cut of 1988 where slash was piled and burned. The area inside and outside of this unit did not experience severe effects from the Hayman Fire.

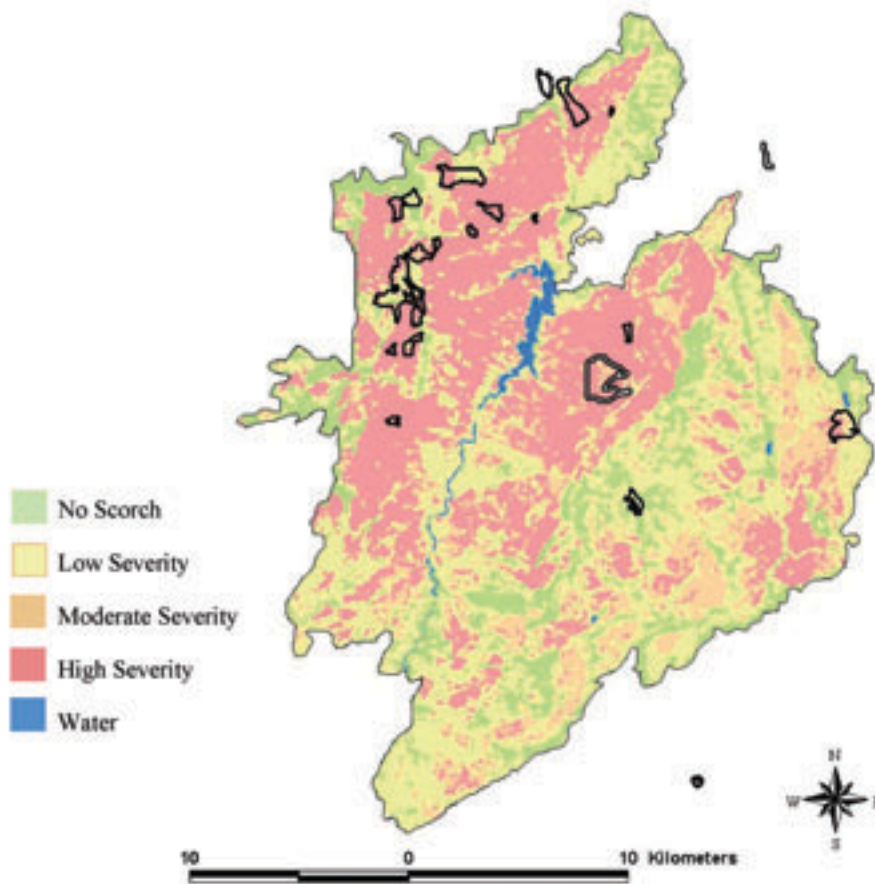


Figure 89—Commercial timber harvests that received no subsequent treatment of activity fuels in relation to the Hayman Fire perimeter and severity.



Figure 90—Photo of 2001 Sheepnose timber sale (photo points 19 and 20). Slash fuels were not removed prior to the Hayman Fire (June 9) which burned as an intense surface fire rather than a crown fire because of the treatment.

while tree crowns in adjacent areas on all sides were completely consumed. A few trees survived at the back of the treatment and protection appears to have been provided for a short distance behind the treatment as well (the road in the fig. 90 is the sale boundary).

The fire also burned over 2,329 acres of older fuel modifications of this type, with 948 acres affected on the afternoon of June 9. These areas include the 1989 Brush Creek clearcut (point 39 on fig. 63), the 1985 Cheesman commercial thin (point 38), the 1985 Cabin Creek clearcut (due west of point 38), the 1982 Webster commercial thin (northwest of Cabin Creek), the 1983 Wigwam commercial thin (southwest of Cabin Creek), the 1987 Flying G shelterwood seed cut (north of point 28), the 1982 Fruit commercial thin (southwest of the Flying G sale), the 1989 Sheep Rock commercial thin (point 28), the 1984 Molly Gulch commercial thin (point 26), the 1989 Wildcat commercial thin (west of point 23), and the 1987 Schoonover commercial thin (northeast of point 20). The GIS analysis indicates that collectively these modifications experienced slightly lower severity than unmodified fuels that burned in the same period. However, when compared to immediately adjacent fuels, the only areas that appear to have had an effect

on fire severity are the Cheesman, Webster, Molly Gulch and Sheep Rock (fig. 91) commercial thinning.

Areas of this type that burned on subsequent days are mostly parts of the previously mentioned sales that burned on June 10 or June 11 with similar burn severity as in adjacent unmodified areas. However the 1982 Rainbow Falls shelterwood seed cut north of Manitou Experimental Forest (point 1 on fig. 63) burned on June 18 (fig. 92). The objective of this treatment was to initiate regeneration of a new stand of mixed Douglas-fir/ Ponderosa pine. Subsequent regeneration had created an open multistoried structure. The Hayman Fire burned through this area early on June 18th, when winds were out of the west. Most trees below the highway were killed, but trees in more open areas were scorched, not consumed (fig. 92). Fire intensity decreased to the east as it progressed through the area, eventually stopping near Rainbow Falls.

Trout Creek Timber Sale, Manitou Experimental Forest: This area lies between map points 1 and 2 (fig. 64) on the southeast perimeter of the Hayman Fire. The sale was being harvested at the time of the Hayman Fire and was about 80 percent complete. The objective was a ponderosa pine restoration treatment, which variously included commercial



Figure 91—Photo points 28 and 29 showing the 1989 Sheep Rock commercial thinning burned on June 9. Fire severity was somewhat more variable and moderate than surrounding untreated stands.



Figure 92—Photo of smoke direction oriented toward advancing column near Manitou Experimental Forest June 18.

thinning, irregularly spaced individual tree selection, and complete overstory removal of mistletoe infected trees. Residual stocking varied, but most stands had been thinned to less than 60 square feet of basal area per acre. Presale surface fuel loadings were 3.27 tons per acre within the sale area. Logging did not increase this, because all trees were skidded to landings for delimiting and processing. Harvesting was by mechanical feller-buncher with a landing-based processor, which resulted in all slash being deposited in large piles within the sale area.

On Tuesday, June 18, the fire crested the ridge west of Manitou. We believe that it burned across Highway 67 on the north end of the forest in late morning as a heading fire driven by a westerly wind. No one on the Manitou staff was present to witness it, as this is about 4 miles north of headquarters and crews had been pulled out of the area.

Later on Tuesday, June 18 at 1300 hours the fire crested the ridge directly west of Manitou Experimental Forest (MEF) headquarters. At this time, flame lengths on the ridge were greater than 150 feet (fig. 93). The fire then dropped down to the lower ridge, and the flames were no longer visible. Steve Tapia discussed the fire behavior on the burn as it came onto

MEF with the Fire Behavior Analyst on the Incident Team. The analyst said two fire heads approached MEF: the fire was coming from the northwest out of Turkey Rock area, and the other from the southwest out of Trail Creek. The two heading fires merged, sucking the air in the area into the center behind where they met, consuming the fuel. As Steve and other firefighters watched at MEF Headquarters, there was a 20 mph wind into their faces, then when the flames dropped it became very still. After 10 minutes, a slight breeze from the east developed. The fire dropped from the crowns to the ground, about where harvesting had been completed in the Trout Creek Timber Sale west of MEF Headquarters (fig. 94). The thinning kept it on the ground moving very slowly except where it encountered piles of unskidded trees, where it flared up (fig. 95). The fire crept slowly enough that a dozer could be brought in to cut a line around the fire. This stopped the fire in MEF. This also enabled the fire crew to save Casey's lumber mill which was/is a huge potential fuel source.

About 1,000 acres of MEF were burned in the Hayman Fire. However, only about 100 acres burned as a crown fire that resulted in complete overstory mortality. This area was mostly on the northwest corner of the



Figure 93—Looking west toward fire and column advancing on Manitou Experimental Forest on June 18.



Figure 94—Photo point 1 showing the Rainbow Falls shelterwood seed cut north of Manitou Experimental Forest that suffered high severity the afternoon of June 18.



Figure 95—Mixed severity in Manitou Experimental Forest thinning plots. Areas with high severity still had fallen trees that had not been skidded yet.

Forest. Fire in this area burned seven replications of a ponderosa pine regeneration study under an open canopy structure. It also burned three replications of a ponderosa pine spacing study containing eight 10 ft. trees. Elsewhere, the fire burned through the Trout Creek Timber Sale as an underburn, consuming few large trees, but pruning lower branches and eliminating some seedlings and saplings (fig. 96). The change in fire severity experienced in the treated areas of MEF cannot be unequivocally be attributed solely to the altered stand structure because of the observed 180 degree shift in the wind that occurred immediately prior to fire encountering MEF. However, the absence of small understory trees undoubtedly limited the torching and crown damage that could have otherwise occurred under the moderate wind conditions.

Plantations: The Hayman Fire burned over 136 acres of recent plantations, all on the afternoon of June 9 (fig. 97). The GIS analysis indicates that these burned with greater severity than unmodified fuels affected during this burning period. The plantation north of point 34 in particular appears to have burned with greater severity than surrounding areas. The fire

also burned over 1,477 acres of older plantations, with 314 acres affected on the afternoon of June 9. Not surprisingly, the GIS analysis indicates that these older plantation areas fared substantially better than the younger ones and even somewhat better than unmodified fuels that burned on June 9. Many of these older plantations seem to be burned less severely than surrounding areas, though they are mostly surrounded by other types of fuel modification, so it's difficult to attribute an effect directly to them. The 1986 plantation at point 28 on figure 63, for example is within the Sheep Rock commercial thin area (center of fig. 91). The fire burned into about a third of the plantation, which did appear to protect the forest on a southwest facing slope downwind of the plantation.

Older plantations that burned after June 9 generally do not appear to have had an appreciable affect on burn severity. However an older plantation that was thinned and cleaned in 1985 appears may have contributed to the effect of the Big Turkey wildfire in splitting the head of the June 17 run (point 14). This treatment also appeared to have influenced the spread of the Big Turkey Fire itself.



Figure 96— Underburn on June 18 of a thinned stand unit resulted in very little scorching even to small trees.

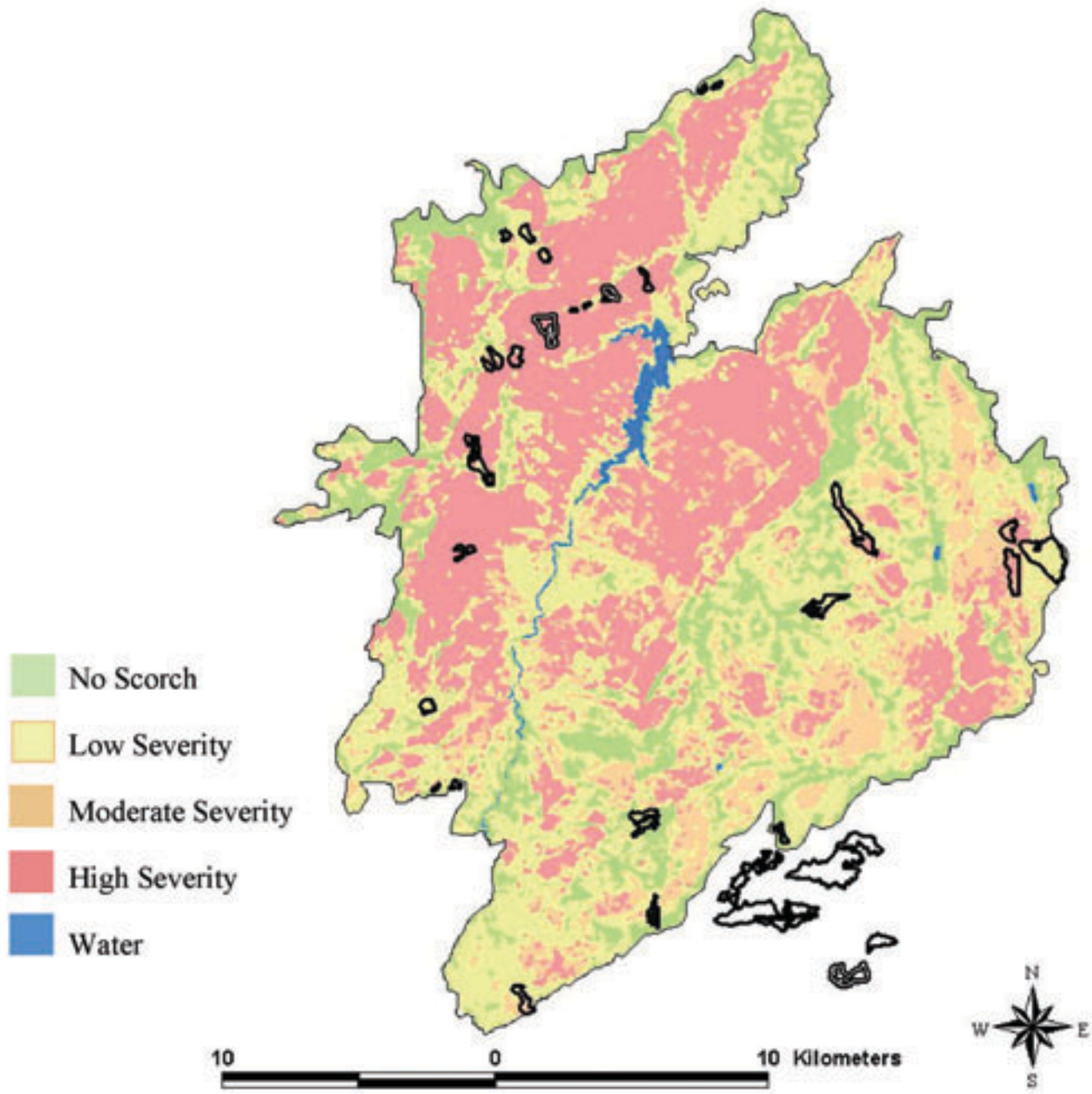


Figure 97 – Forest plantations in relation to the Hayman Fire perimeter and severity