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Hayman Fire Case Study: Summary

Russell T. Graham, Technical Editor

Abstract

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This publication summarizes the findings in the 400-page companion document, *Hayman Fire Case Study*, Gen. Tech. Rep. RMRS-GTR-114. This summary document's purpose is to convey information quickly and succinctly to a wide array of audiences.

In 2002 much of the Front Range of the Rocky Mountains in Colorado was rich in dry vegetation as a result of fire exclusion and the droughty conditions that prevailed in recent years. These dry and heavy fuel loadings were continuous along the South Platte River corridor located between Denver and Colorado Springs on the Front Range. These topographic and fuel conditions combined with a dry and windy weather system centered over eastern Washington to produce ideal burning conditions. The start of the Hayman Fire was timed and located perfectly to take advantage of these conditions resulting in a wildfire run in 1 day of over 60,000 acres and finally impacting over 138,000 acres. The Hayman Fire Case Study, involving more than 60 scientists and professionals from throughout the United States, examined how the fire behaved, the effects of fuel treatments on burn severity, the emissions produced, the ecological (for example, soil, vegetation, animals) effects, the home destruction, postfire rehabilitation activities, and the social and economic issues surrounding the Hayman Fire. The Hayman Fire Case Study revealed much about wildfires and their interactions with both the social and natural environments. As the largest fire in Colorado history it had a profound impact both locally and nationally. The findings of this study will inform both private and public decisions on the management of natural resources and how individuals, communities, and organizations can prepare for wildfire events.

Keywords**:** Wildfire, fuel treatments, wildfire behavior, social and economic wildfire effects, ecological effects of wildfires

Acknowledgments

The Hayman Fire Case Study involved the timely assembling, analyzing, and reporting on large volumes of data. A project of this size cannot be accomplished without the help and understanding of the families, friends, and coworkers of all of those involved. We, the Study Team, thank them all. We thank the many people who attended our public meetings and those who provided critical reviews of our Interim Report and the peers who reviewed our final reports. The devil is in the details of a study such as this, and the Publication Team is thanked by the other Team members for their excellent work in producing the publications.

Cover photo: Photograph taken from the headquarters of the Manitou Experimental Forest located on the eastern perimeter of the Hayman Fire, as the fire approached on June 18, 2002.

Hayman Fire Case Study: Summary

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Hayman Fire Case Study: Summary

Introduction

Historically, wildfires burned Western forests creating and maintaining a variety of forest compositions and structures (Agee 1993). Prior to European settlement lightning along with Native Americans ignited fires routinely across many forested landscapes. After Euro-American settlement, fires continued to be quite common with fires ignited by settlers, railroads, and lightning (Pyne 2001). In August 1910 came a pivotal change in how Westerners in particular, and policymakers in general, viewed fire. Starting early in that summer, fires were ignited and continued to burn throughout western Montana and northern Idaho. By mid August over 1,700 fires were burning throughout the region, but most forest managers figured the area could weather these fires if no dry strong winds developed. On August 20 and 21, the dry winds did blow, and by the time the flames subsided over 3.1 million acres of the northern Rocky Mountains burned (fig. 1). These fires killed 78 firefighters and seven civilians and burned several communities including one-third of Wallace, Idaho (fig. 2) (Pyne 2001; USDA 1978). This event solidified the negative aspects of wildfires in the view of the public and policymakers and led to the strong

Figure 1—The wildfires of the Northern Rocky Mountains in 1910 burned over 3.1 million acres, destroying valuable timber resources.

Figure 2—Over one-third of Wallace, ID, burned during the wildfires of 1910.

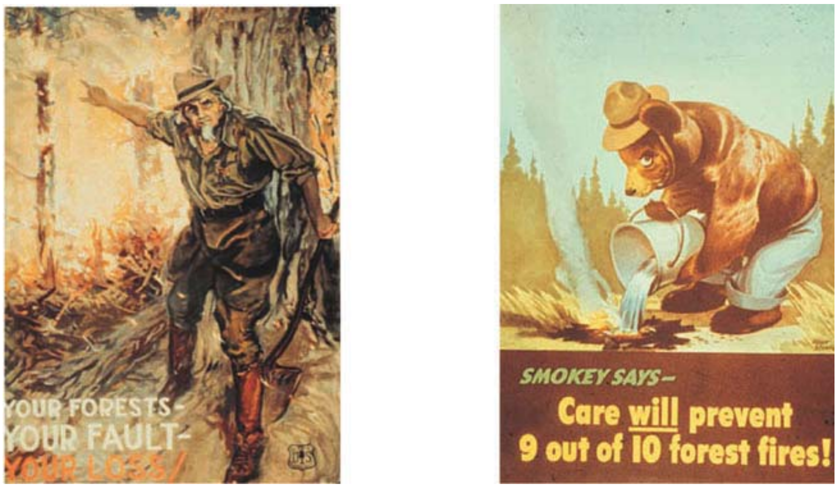

Figure 3—Early fire prevention posters showing the urgency of suppressing wildfires.

firefighting ethic that prevails yet today (fig. 3) (Pyne 2001).

Wildfires continue to be aggressively extinguished with smoke-jumpers, hot-shot crews, retardant bombers, and sophisticated firefighting organizations. Even with this aggressive approach, wildfires continue to burn throughout the West, and the total area burned in the United States decreased until the 1960s when the trend reversed with the number of acres burned each year increasing (Agee 1993). This trend was exemplified by the fires that burned in and around Yellowstone Park in 1988 and once again brought under scrutiny the wildfire policies in the United States (fig. 4) (Carey and Carey 1989). What appears to be different about the recent fires is the number of ignitions that contributed to burning large areas. More than 1,700 fire starts were responsible for burning the 3.1 million acres of the Northern Rocky Mountains in 1910, and 78 starts burned more than 350,000 acres in the Bitterroot Valley in western Montana in July 2000 (fig. 5) (USDA 1978, 2000). Contrast these fire events to the Rodeo-Chediski Fire where only two fire starts burned

Figure 4—Photograph showing one of the many wildfires that burned in Yellowstone Park during the summer of 1988.

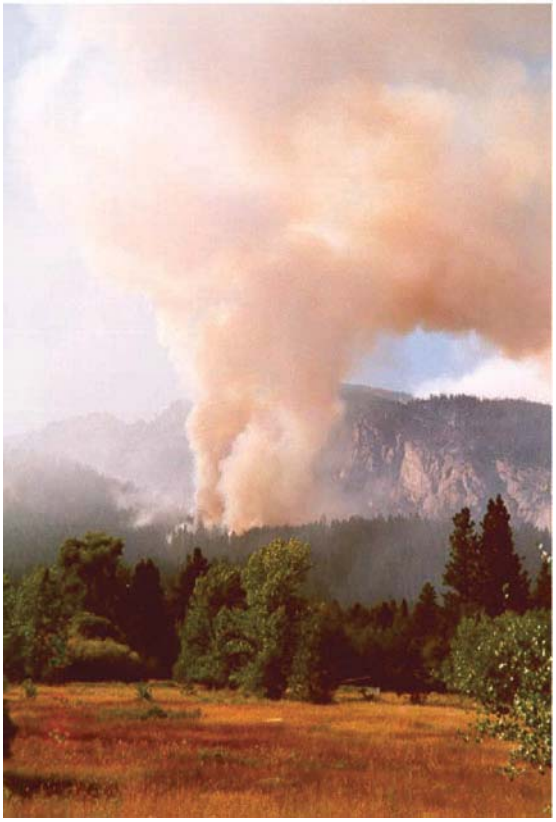

Figure 5—Seventy-eight wildfires burned in the Bitterroot Valley of western Montana during the summer of 2000. (Photo by Karen Brokus)

more than 450,000 acres in 2002 in Arizona. Similarly, on June 8, 2002, one start along the Colorado Front Range of the Rocky Mountains led to the Hayman Fire burning more than 138,000 acres in 20 days (fig. 6).

The weather systems along the Colorado Front Range beginning in 1998 tended to bring below-normal precipitation and unseasonably dry air masses. These conditions occurred approximately the same time as the phenomenon known as La Nina began forming in the eastern Pacific Ocean. The winter of 2001 and 2002 saw a marked worsening of drought conditions. The predominantly ponderosa pine and Douglas-fir forests throughout the region became drier with each passing season, and by the spring

Figure 6—The Hayman Fire was ignited on afternoon of June 8, 2002, and by the morning of June 9 it was uncontrollable.

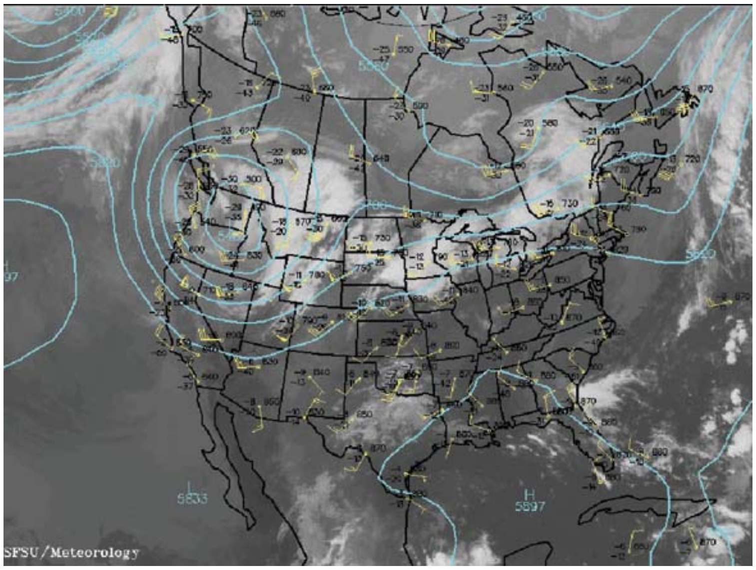

Figure 7—On June 8, 2002, the winds in Colorado, created by a low pressure system centered in eastern Washington, were consistently exceeding 15 mph and gusting to over 30 mph.

of 2002 the fuel moisture conditions were among the driest seen in at least the past 30 years. The moisture contents of the large dead logs and stems along the Front Range were extremely low: most less than 10 percent and some less than 5 percent moisture content.

During the first week of June 2002 a weak weather system passed through forests west of Denver and Colorado Springs, Colorado, dropping some precipitation, but this rain had virtually no effect on the parched surface and dormant live fuels. On Saturday, June 8 the air mass over Colorado was extremely dry and an upper level low pressure system centered over eastern Washington brought winds exceeding 15 mph all day with gusts exceeding 30 mph (fig. 7). The counter clockwise winds circulating around this low aligned perfectly with the topography of the South Platte River corridor (fig. 8). At approximately 4:55 p.m. just south of Tarryall Creek and Highway 77 near Tappan Mountain, the Hayman Fire was reported (fig. 9). An aggressive initial attack response consisted of air tankers, helicopters, engines, and ground crews, but they were unable to contain the fire (fig. 10). Within a few hours torching trees and prolific spotting advanced the fire to the northeast, allowing it to burn several hundred acres.

Saturday night remained warm and dry (60 °F and 22 percent humidity at Lake George near fire start) and by 8:00 a.m. on June 9, the fire was estimated

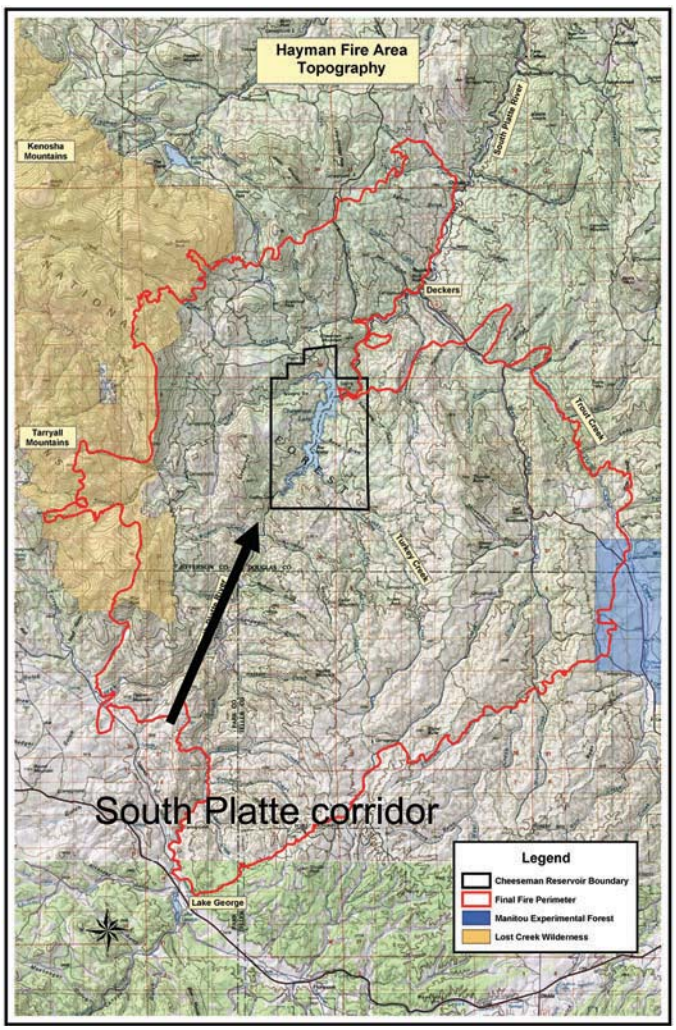

Figure 8—The southwest to northeast orientation of the South Platte River corridor aligned perfectly with the winds blowing from the southwest.

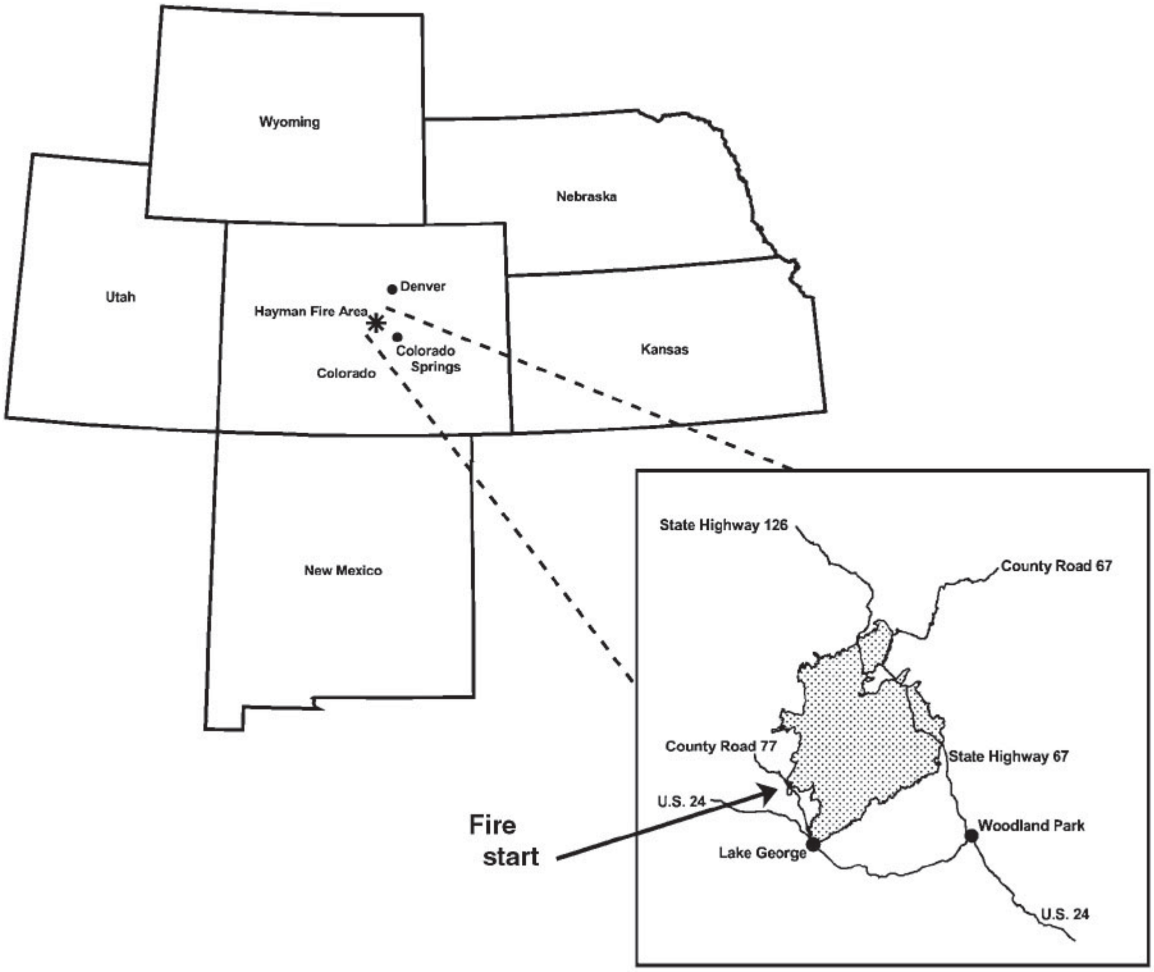

Figure 9—The Hayman Fire started just south of Tarryall Creek and County Highway 77 near Tappan Mountain on the Front Range of the Rocky Mountains between Denver and Colorado Springs, CO.

Figure 10—An aggressive initial attack of the fire consisting of ground crews, fire engines, helicopters, and air tankers could not control the fire. (Photo by Karen Wattenmaker)

at 1,000 to 1,200 acres in size. Downwind from the ignition location for at least 10 miles fuels were generally continuous with little variation in both structure and composition. Surface fuels generally consisted of ponderosa pine duff and needle litter, short grasses, and occasional shrub patches. Low crowns of the ponderosa pine, Douglas-fir, and blue spruce facilitated the transition of the fire from the surface to burning tree crowns (fig. 11).

As the day progressed, the southwest winds gusted to 51 mph and the relative humidity hovered around 5 to 8 percent (fig. 12) enhancing the

Figure 11—The fuels down wind from the ignition point were continuous, consisting of trees with low crowns, shrubs, and a deep layer of needles on the forest floor.

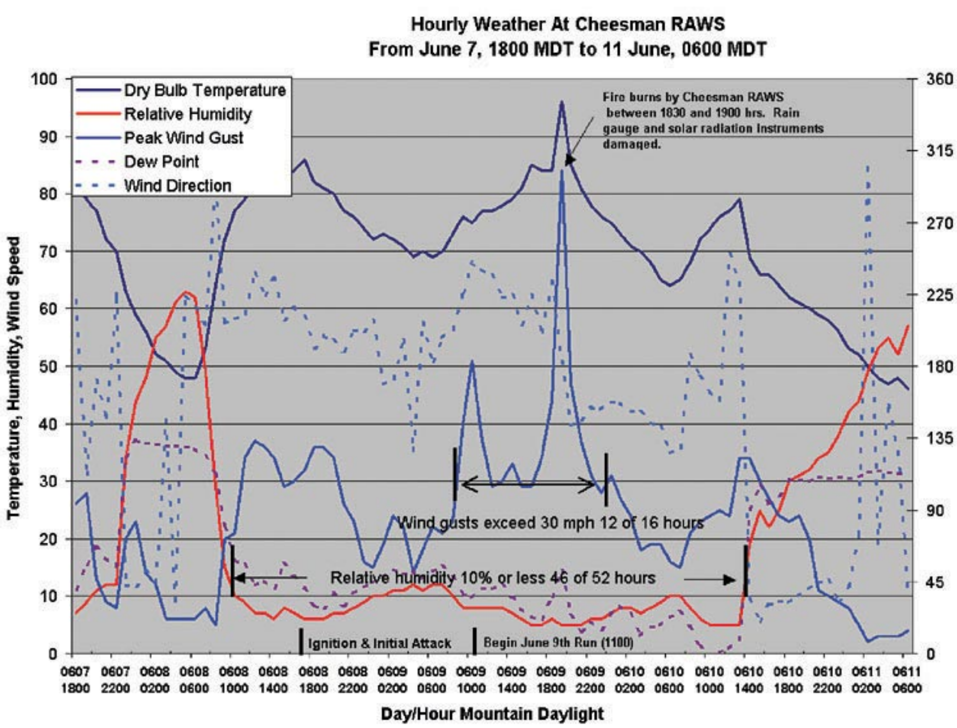

Figure 12—During the first days of the fire the winds were gusty, and the relative humidity of the air was dry, hovering below 10 percent.

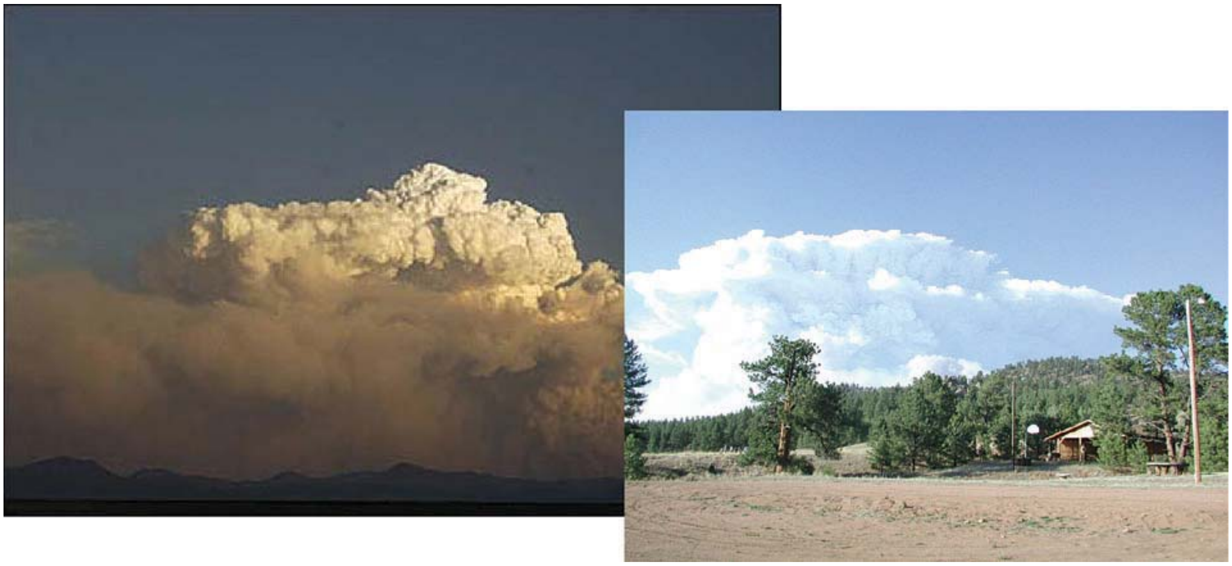

Figure 13—Photographs on June 9 showing pyrocumulus clouds developing to 21,000 feet over the fire.

spread of the fire to the northeast. The combination of fuels, weather, and topography positioned the fire for a major run lasting the entire day and burning 60,000 acres along the South Platte River corridor for 16 to 19 miles. Evacuations were performed in front of the fire, but no suppression actions were possible forward (east) of Highway 24 (fig. 9). The fire burned with extreme intensity with long crown fire runs and long-range spotting (1 mile or more). Fire spread rates averaged more than 2 mph and pryocumulus clouds developed to an estimated 21,000 feet (fig. 13).

On the afternoon of June 10, the high winds decreased and the relative humidity increased, moderating the weather (fig. 12) and persisting until the afternoon of June 17. During this period, the fire advanced mostly to the south and several miles to the east (fig. 14). The high winds and low humidity returned on June 17 and 18, increasing the fire intensity across the entire east flank of the fire, driven by west to northwest winds

Figure 14—From June 11 through the afternoon of June 17 the weather moderated as did the fire intensity.

Figure 15—On June 17 and 18 gusty winds and low humidity returned, facilitating intense fire behavior as the fire advanced to the east.

(fig. 15). The fire advanced to the east 4 to 6 miles on June 18, crossing Highway 67 and encircling more than 137,000 acres. Because moist monsoon weather arrived, the fire burned small amounts of additional acres after June 18. By June 28, the Hayman Fire impacted more than 138,000 acres of the Colorado Front Range (fig. 16).

The mountains and forests of the Front Range between Denver and Colorado Springs are critical for supplying water to communities and cities, prized for their scenery, provide numerous recreational opportunities, are home to many fishes and animals, and are the setting for many homes, businesses, and communities. Because of the setting, the Hayman Fire attracted intense local, regional, and national interest. Before the flames had died, Congressman Mark Udall of Colorado on June 26, 2002,

Date	Acres
June 8	290
June 9	60,878
June 10	86,725
June 11	99,689
June 12	104,638
June 13	102,897
June 14	100,186
June 15	104,415
June 16	114,674
June 17	140856
June 18	137,762
…	
June 28	138,114

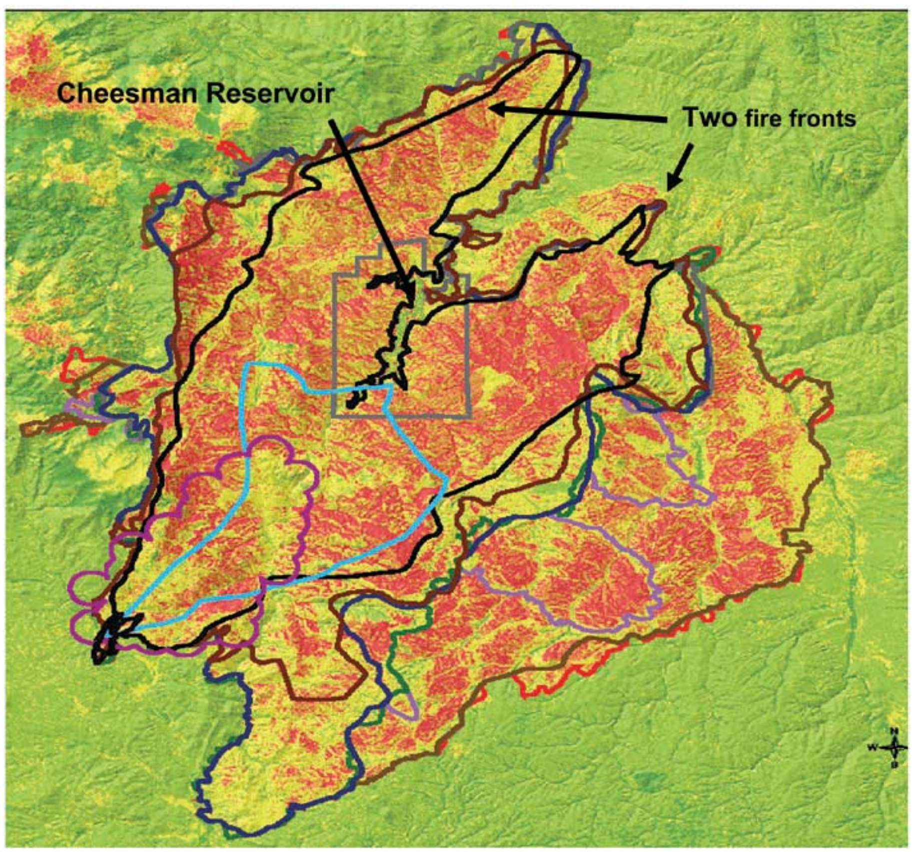

Figure 16—By June 28 the Hayman Fire had impacted over 138,000 acres of the Front Range.

indicated that it would “be instructive to take a close look at the behavior of the fire, examine the factors that led to its intensity, and see if the way it behaved when it encountered previously affected or treated areas can be instructive in designing future risk-reduction projects.” He went on to suggest that the Chief of the Forest Service establish a Hayman Fire Review Panel. Its purpose would be to focus on the future rather than attempt to assign blame for past events.

Congressman Udall raised several issues ranging in scope from how the fire behaved to how the fire impacted the soil and water resources of the Front Range. Using Congressman Udall’s suggestion as a basis, on July 22, 2002, the USDA Forest Service Rocky Mountain Research Station in cooperation with USDA Forest Service Rocky Mountain Region, and the State of Colorado Forest Service assembled the Hayman Fire Case Study Team. This Team of Federal, State, and local experts from throughout the United States came together and developed an analysis to address the Congressman’s issues. Analysis questions were divided among subteams addressing fire behavior, home destruction, social and economic impacts, fire rehabilitation, and ecological effects. Using the Congressman’s issues each team developed a set of analysis questions and study direction. Techniques used by the subteams included interviews, analysis of existing data, expert opinion, Hayman Fire reports, and other available information. In November 2002 the Team presented its interim findings to the Congressman, public, forest managers, nongovernmental organizations, and the scientific community. These groups and individuals provided critical input to the findings, and in February 2003 the subteams began assembling their final reports incorporating these reviews and criticisms. The reports underwent scientific peer review before the final drafts were prepared. The following highlights each subteam’s findings addressing the analysis questions.

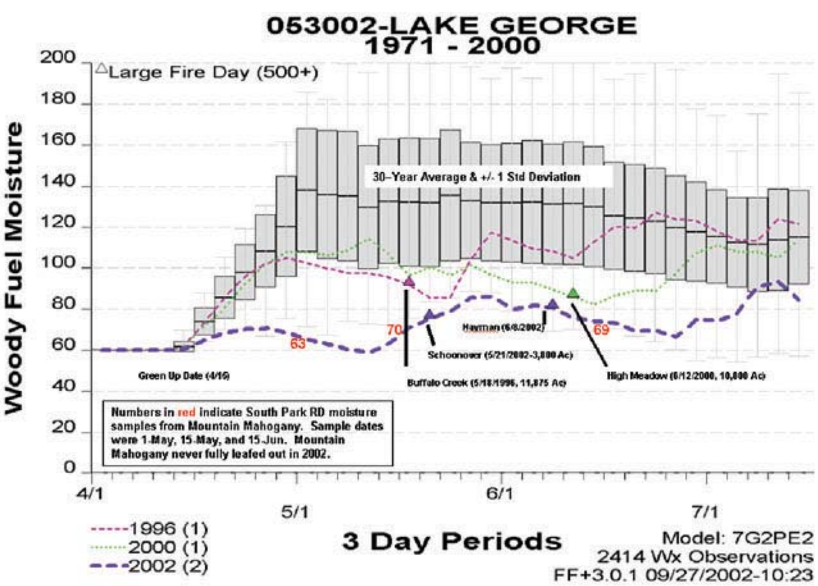

Figure 17—The moisture contents of the woody fuels within the Hayman Fire area in 2002 were much drier than those occurring over the previous 30 years.

Fire Behavior

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This team used existing and new data on fire climatology and meteorology, fire behavior, fuel treatments, road density, fire suppression activities, and fire emissions. Selected findings of the team:

- The potential for extreme fire behavior was predisposed by drought. Below normal precipitation the past several years and the acute drought in 2002 brought about excedptionally low moisture contents of live foliage, duff, and dead fuels of all size classes (fig. 17).

- The Hayman Fire began and ended with extreme weather episodes lasting about 2 days each (June 8 and 9, and June 17 and 18). More moderate weather occurred during the intervening 6 days. Extreme weather conditions consisted of high winds (20 to 50 mph) and low humidity (5 percent). Widespread crown fire and long-range spotting lead to rapid growth and ultimately the large size of the fire. Abatement of winds and higher humidity during less extreme weather moderated fire behavior and effects, even with the abnormally low fuel moisture contents (fig. 12).
- Different wind directions associated with the two extreme weather episodes increased the size of the fire. The east flank of the fire that developed under southwest winds of June 8 and 9 became a heading fire on June 17 and 18 when winds shifted from the northwest and west (fig. 15).
- Continuous surface and crown fuel structure, both horizontally and vertically, in many ponderosa pine and Douglas-fir stands rendered them susceptible to torching, crown fire, and ignition by embers, even under moderate weather conditions (fig. 11).
- Continuous fuels across the landscape surrounding the South Platte River drainage afforded only limited opportunity for significant disruption of growth of the fire or for improved suppression. The few large areas on the Hayman landscape that recently experienced wildfires or management activities (Schoonover wildfire 2002, Polhemus prescribed burn 2001, Big Turkey wildfire 1998) produced significant but isolated effects on fire growth.
- Orientation of the South Platte River drainage was aligned with the strong southwest winds on June 8 and 9 and likely enhanced the direction and rapid spread of the fire on those dates (fig. 8).
- The presence of Cheesman Reservoir and the adjacency of the recent Schoonover wildfire (May 2002) in the center of the spread path created and maintained the characteristic forked shape of the Hayman Fire, which had formed two distinct heads by the afternoon of June 9 (fig. 16).
- The Hayman Fire encountered most of the fuel treatments, prescribed burns, and previous wildfires within the perimeter on June 9 when the weather was extreme. Continuous crown fire and long-range spotting dominated the burning of approximately 60,000 acres that day from late morning through late evening. These extreme conditions and fire behaviors permitted intense surface fire through treated areas, leaving them with high levels of overstory crown damage. Fuel breaks and treatments were breached by massive spotting and intense surface fires.
- The fire was perhaps 20,000 acres when it encountered its first fuel treatments toward the southeastern side of Cheesman Reservoir toward mid-afternoon on June 9. At that time it was in the middle of the burning period and had developed a large convection column (fig. 13).
- Weather conditions were relatively moderate beginning on June 10 through 16 as the fire burned through Turkey Rx1990, Rx1995, Rx1987, and the 1998 Big Turkey wildfire. Fire behavior these days was predominated by surface fire, although torching and some crown fire occurred in some drainages and hillslopes (fig. 14).

- Extreme weather returned on June 17 and 18. Crown fire and long-range spotting was occurring just before the fire burned into fuel treatments in the Manitou Experimental Forest and the North Divide prescribed burns (fig. 15). Observations and weather records suggest a wind shift occurred just before fire entered Manitou.
- Extreme environmental conditions (winds, weather, and fuel moisture) and the large size of the Hayman Fire that developed on June 9 overwhelmed most fuel treatment effects in areas burned by the heading fire that day. This included almost all treatment methods including prescribed burning and thinning.
- Several exceptions to this included the Polhemus prescribed burn (2001), the Schoonover wildfire (2002), and the Platte Springs wildfire (2002) that occurred less than 1 year earlier. These areas did actually appear to stop the fire locally, illustrating that removal of surface fuels alone (irrespective of thinning or changes to canopy fuels) can dramatically alter fire behavior within 1 year of treatment. The potential for prescribed fire to mitigate wildfire behavior will undoubtedly decrease over time. Thus, the recent occurrence of fuel modification in these areas suggests caution in trying to generalize about fuel treatment performance over many years. Fuel treatments are expected to change fire behavior but not necessarily stop fires (fig. 18).

Figure 18—The Polhemus prescribed fire (fall 2001) altered the behavior of the Hayman Fire. Note the boundary between the Polhemus prescribed burn unit and the Hayman Fire (moving from the foreground away from the camera). (Photo by Karen Wattenmaker)

- Fire behavior was modified but not stopped by stand thinning operations conducted at Manitou Experimental Forest. The operations apparently moderated fire behavior and effects during extreme weather on June 18 (fig. 19). A fortuitous shift in winds also contributed to the changes in fire behavior at Manitou. The fire burned rapidly through areas of the Wildcat wildfire (1963) and the Northrup prescribed burn (1992) south of Cheesman Reservoir, but the open forest structure of these areas probably increased the survival of trees and stands within them.
- Under more moderate wind and humidity conditions (June 10 through 16), recent prescribed burns appeared to have lower fire severity than

Figure 19—A low intensity surface fire minimally scorched even the smallest trees in a ponderosa pine stand that had been thinned.

older burns. This is consistent with trends in fuel accretion and changes in forest fuels over time. Examples include the sequence of Turkey (Rx1987, Rx1990, Rx1995) prescribed burns.

- Cutting treatments where activity fuels were not removed experienced high surface fire intensities but were less likely to support crown fire. For example, residual trees in the Sheepnose timber sale (2001) were scorched and probably killed, but their foliage was generally not consumed by crown fire. When these needles fall they mulch the forest floor reducing soil erosion (fig. 20). However, the Goose Creek timber sale was followed by prescribed fire but made little difference to severity on June 19 (fig. 21).
- Several 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 (fig. 20), the Big Turkey wildfire (1998) and adjacent prescribed fires (Rx1990, Rx1995), which prevented initiation of crown fire along a 2 mile segment of the perimeter when extreme weather returned on June 17 (fig. 22), and the Schoonover Wildfire (May 2002),

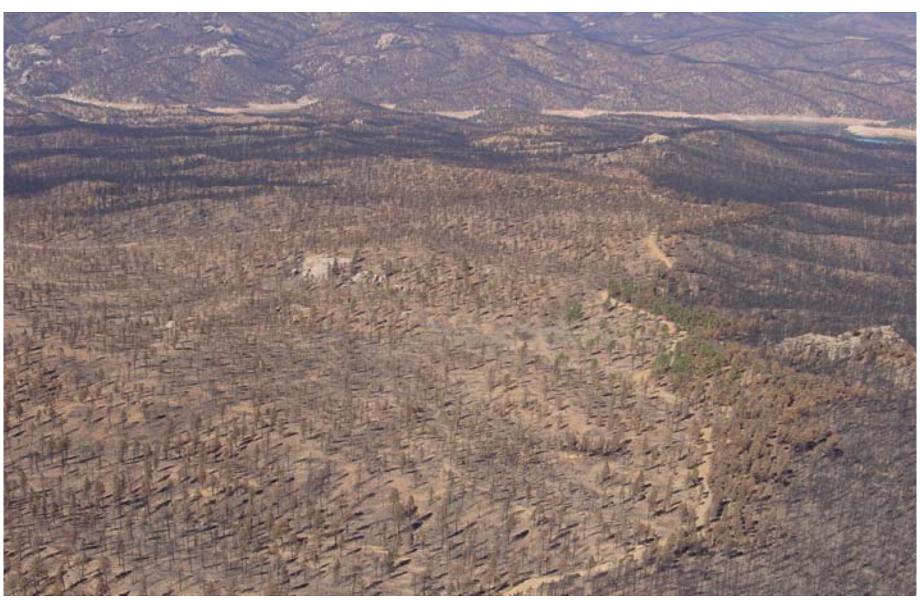

Figure 20—The Sheepnose timber sale where the surface fuels consisting of logging slash were not removed prior to the Hayman Fire. The area burned as an intense surface fire on June 9 rather than a crown fire because of the stand structure created by the treatment.

Figure 21—The Goose Creek timber sale area in the foreground (1986 through 1993) in which the logging slash was piled and burned in 1993 through 1995. Even with these fuel treatments, adequate surface fuel was available for a high intensity surface fire to occur on June 9, 2002.

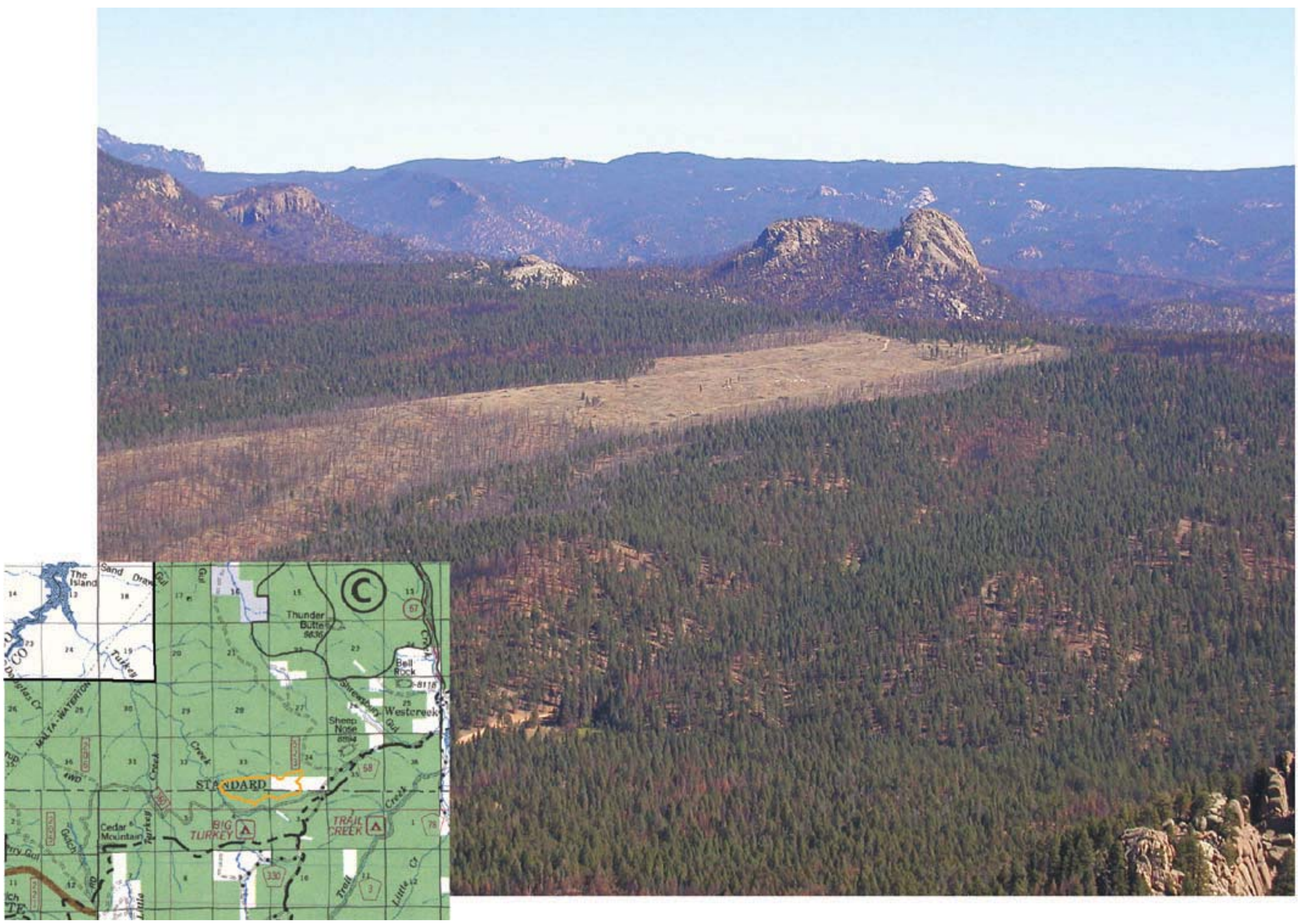

Figure 22—Oblique view of area burned by the Big Turkey wildfire (1998, oriented approximately along an east-west axis) looking northeast. Area in the foreground was inside the prescribed fire unit Turkey 1990. This area was burned between June 10 and 13. (Photo by Rick Stratton)

which, together with Cheesman Reservoir, split the head of the Hayman Fire on June 9 (fig. 23) and prevented it from flanking toward the town of Deckers (fig. 24, 25).

- The size of the fuel treatment unit 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 (approximately 8,000 acres) were more effective than small fuel breaks (Cheesman Ridge, 51 acres) in changing the fire progress. Under extreme conditions of June 9, spotting easily breached narrow treatments, and the rapid movement of the fire circumvented small units (fig. 26).
- No fuel treatments were encountered when the fire was small. The fire had time and space to develop a broad front and generate a large convection column before encountering most 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 before mass ignition was possible.

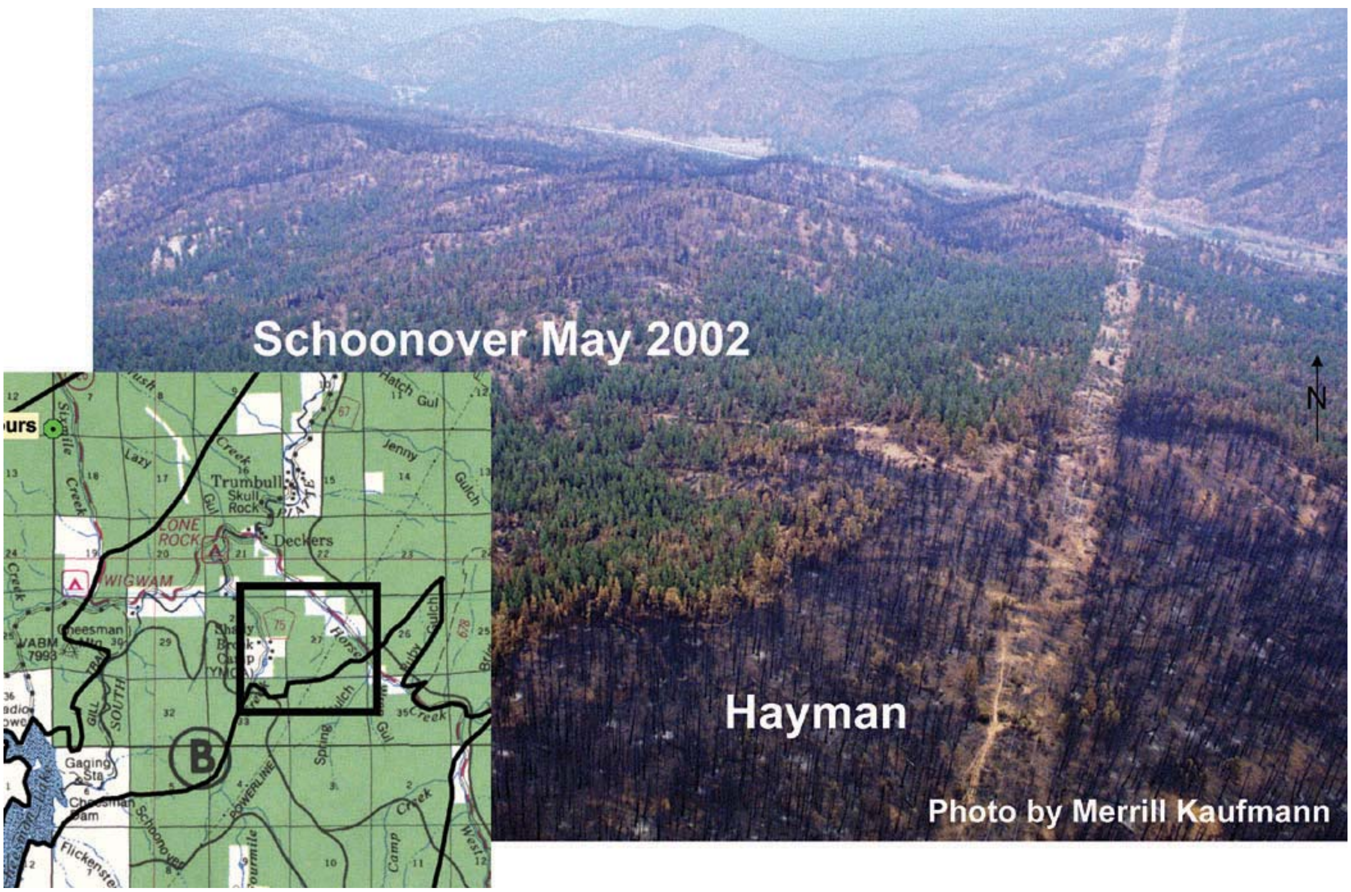

Figure 23—Green strip of underburned forest divides the Hayman Fire (left) and Schoonover wildfire (May 2002, right). The green strip was underburned by the Schoonover Fire 3 weeks before the Hayman Fire occurred and was not reburned by the Hayman Fire. Note the power line corridor in the picture and the inset map. (Photo by Merrill Kaufmann)

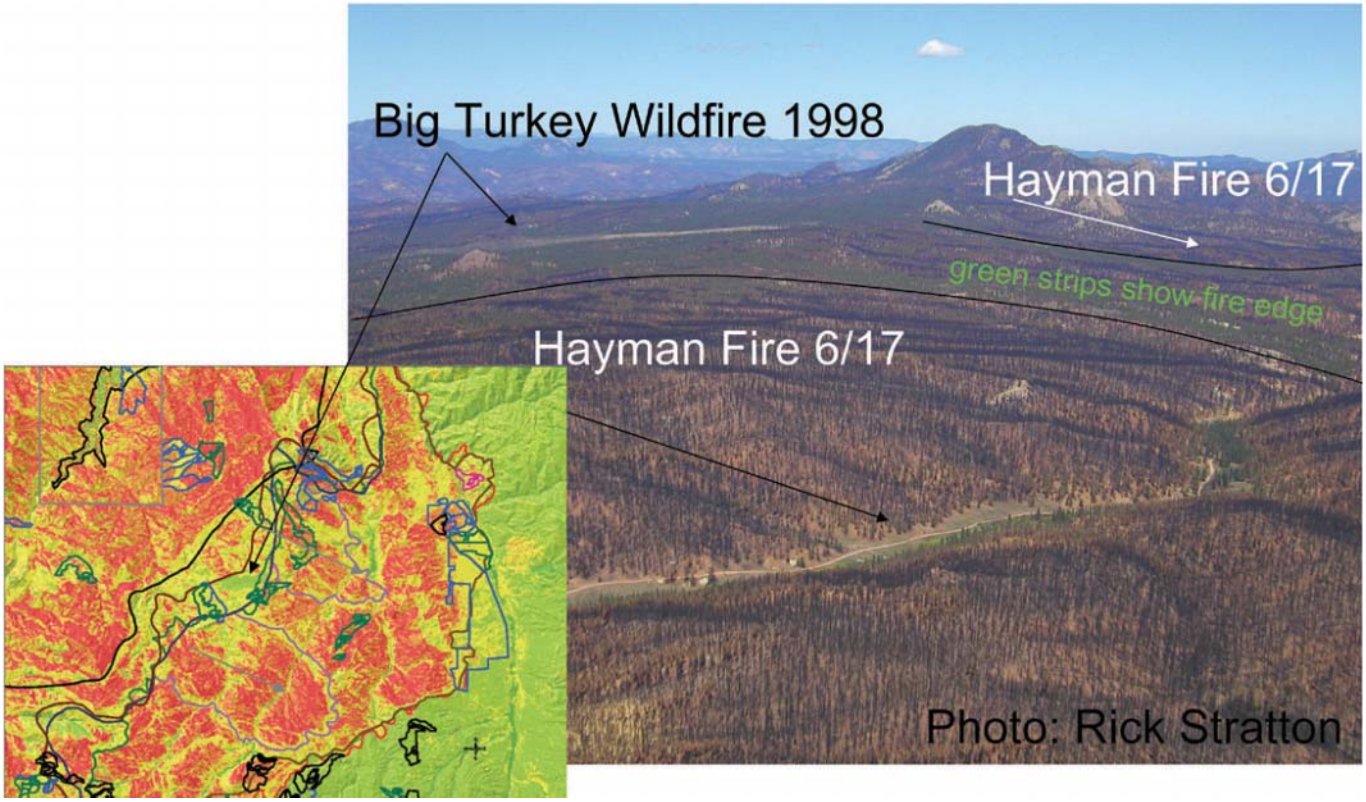

Figure 24—Oblique photograph showing the green bands of conifer forest at the locations where the two heads of the fire stopped after the burning period on June 17. Note that these heads originated from the north and south of the Big Turkey wildfire and adjacent prescribed burns (Rx1990, Rx1995). (Photo by Rick Stratton)

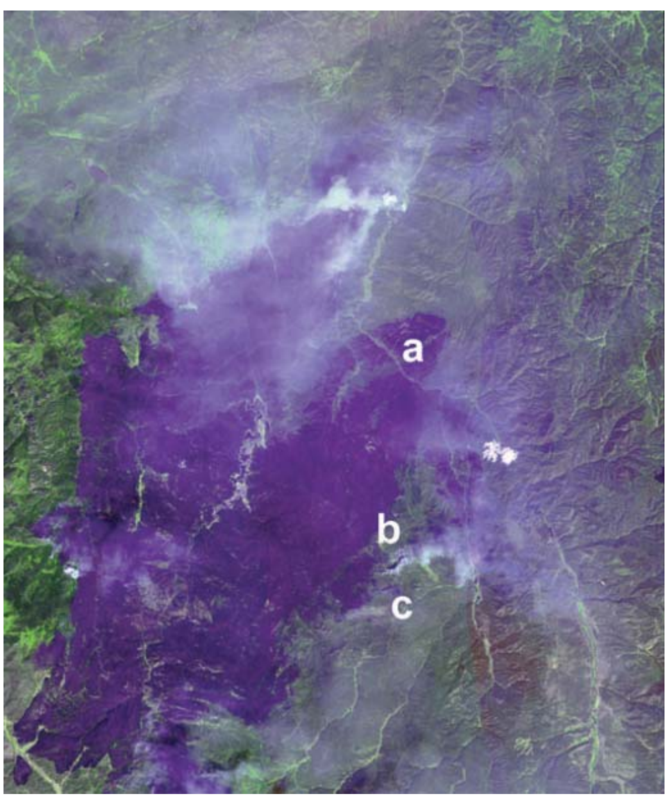

Figure 25—Satellite imagery showing burned area within the Hayman Fire on June 13. Several points are visible, (a) green strip separating the Schoonover wildfire on the north (May 2002) from the Hayman Fire on the south, (b) the green diagonal strip indicating the edge of the fire at the end of the June 9 burning period, and (c) the Big Turkey wildfire (1998).

Figure 26—Strong winds on June 8 and 9 flattened the smoke column, obscuring fire position and making fire progression estimation difficult. Photo is from June 9.

- Few fuel treatments had been performed recently, leaving most of the landscape within the final fire perimeter with no treatment or only older treatments. This is significant because the high degree of continuity in age and patch structure of fuels and vegetation facilitates fire growth that, in turn, limits the effectiveness of isolated treatment units.
- Road density varied considerably within the perimeter of the Hayman Fire but was not found to be associated with fire severity or bio-physical conditions related to fire behavior.
- At the time of initial attack, even the unusually strong compliment of firefighting resources (air and ground) was not sufficient to contain or stop the fire due to extreme weather conditions and fuel structures that facilitated crown fire and spotting (fig. 10).
- On the days of extreme fire growth (June 8 and 9, and June 17 and 18), burning conditions and weather dictated an indirect attack strategy with efforts focused on evacuation, structure protection where safely allowable, and direct methods on the heel and flanks of the fire.
- In the Lost Creek Wilderness little active suppression took place. Efforts were primarily directed at aerial observation, patrolling, and location and evacuation of hikers.
- Suppression efforts had little benefit from fuel modifications within the Hayman Fire. Exceptions include the Polhemus prescribed fire (2001), two previous wildfires (Schoonover 2002 and Big Turkey 1998), and thinning operations at Manitou Experimental Forest. One of the only sections of fireline indicated as controlled through June 16 (fig. 18) was in the Polhemus burn.
- On active burning days direct line was often not held and crews retreated to safety zones until fire conditions moderated, then returned to mop up around structures or defend structures where safely obtainable (fig. 27).
- On days with moderate weather and fire growth, the lines were defendable and structure protection was successful. For example, on June 12 structures in the Sportsman Paradise as well as in the Cedar Mountain, Turkey Creek, and along Turkey Creek were defendable even when fire behavior picked up in the afternoon hours.

Figure 27—A fire crew protecting a structure when the weather conditions allowed. (Photo by Karen Wattenmaker)

- Indirect tactics were used when fire behavior dictated for safety reasons and when access and rough steep terrain came into play. At times, burnout operations did not take place due to unfavorable weather conditions, were not completed due to changing weather conditions, or interrupted during operational periods because work-rest ratio guidelines would have been exceeded.
- Nightshifts were used, but only on focused areas, usually around subdivisions. Night operations primarily focused on patrolling of subdivisions where burnout operations had taken place during the day, structure protection in areas that had recently experienced fire activity, patrolling of divisions, and improving and extending anchor points (fig. 28).
- After overall weather moderated with arrival of monsoon conditions after June 20, construction of and holding of direct firelines was successful (fig. 29).
- The Hayman Fire was a significant source of atmospheric carbon monoxide (CO) and fine particulates (less than 2.5 μm). For Colorado, the CO emitted by the Hayman Fire was at least five times the annual (1999) amount produced by industry, and the fine particulate emitted by the Hayman Fire was about twice that produced annually by Colorado industries (fig. 30).

Figure 28—Night-time operations burning fuels within the fire line that were not consumed. (Photo by Karen Wattenmaker)

Figure 29—When the weather moderated, direct fireline construction was possible and firelines held. (Photo by Karen Wattenmaker)

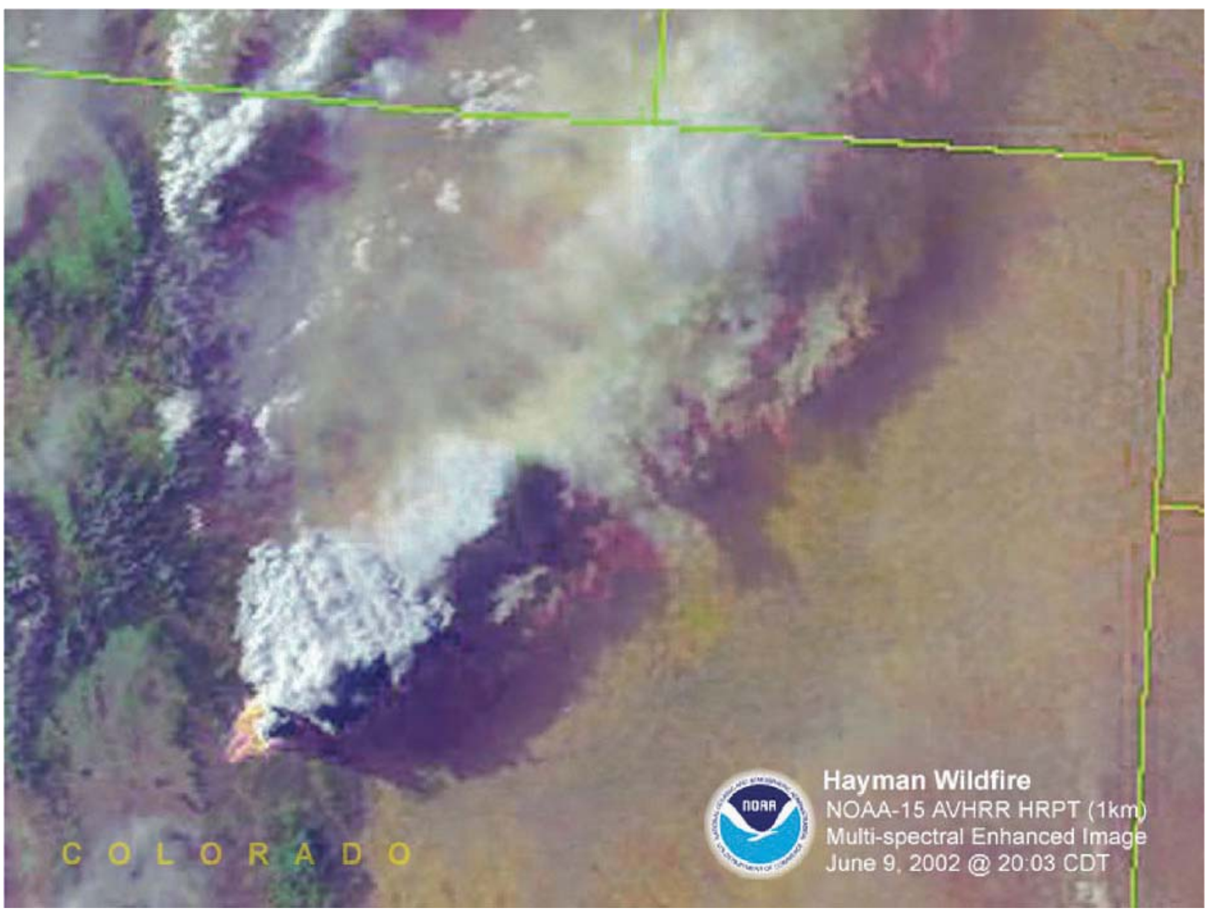

Figure 30—Satellite image of Hayman Fire on June 9 shows the convection column and smoke plume extending across Denver into Wyoming carrying carbon monoxide and fine particulates.

Fire Ecology and Fire Effects

Team Leader Bill Romme, Department of Forest, Rangeland, and Watershed Stewardship, Colorado State University, Fort Collins, Colorado

The ecology and fire effects team used existing data collected in and around the Hayman area, limited observations by team members within the burned area, and expert opinion. Fire ecology, terrestrial plant ecology, aquatic ecology, soil science, wildlife ecology, and geospatial sciences were included in the information they gathered in 2002 and 2003. This information was supplemented with information from the fields of fire and ecosystem management. Selected findings of the team:

- We have a high degree of confidence in many of our interpretations, but some are offered as tentative hypotheses rather than firm conclusions because of limited prefire research.
- Reconstructions of fire history and forest dynamics in the Cheesman landscape, located near the center of the Hayman burn, reveal (1) an average fire interval of about 50 years during the period 1300 through 1880, but no major fires between 1880 and 2002; (2) a mix of nonlethal surface fire and lethal, stand-replacing fire in the historic burns; and (3) a striking increase in forest density from 1900 to 2002.
- The extent of high-severity burn in 2002 within the Cheesman landscape was unprecedented in the past 700 years, in part because of the dense forest conditions that had developed during the 20th century and in part because of the extreme fire weather conditions that existed in 2002 (fig. 31).

Figure 31—The extent of the high severity burn in the Hayman Fire was unprecedented as exemplified by the large expanses of trees totally blackened.

Figure 32—In many areas within the Hayman Fire area, dense forest conditions existed with tree crowns extending to the forest floor. These conditions facilitated the transition of fire from the surface to the tree crowns.

- Although the extent of high fire severity in the Cheesman landscape was unprecedented, fires of comparable size and severity have occurred elsewhere in the Front Range during the last several centuries (for example, in 1851), especially in high-elevation forests (spruce, fir, and lodgepole pine) and possibly also in ponderosa pine forests. Infrequent but large, severe fires are a normal component of many forests in Colorado and are not an artifact of 20th century fire suppression in all forests.
- In the Colorado Front Range as a whole, 20th-century fire suppression probably has altered fuel conditions and fire regimes most significantly in low-elevation ponderosa pine forests where fires were relatively frequent prior to the late 19th century. In contrast, impacts of fire suppression probably are minimal in high-elevation forests of spruce, fir, and lodgepole pine, where fires have never been frequent but where high-severity fires have always been the norm. Within the middle forest zone of ponderosa pine and Douglas-fir, the extent to which fire suppression has altered forest structure and fire regimes is uncertain, and probably varies from place to place (fig. 32). Additional research is needed to clarify historical fire regimes in mid-elevation forests of the Colorado Front Range.
- Areas of high severity burn are likely to have the greatest alterations in soil characteristics, including loss of surface soil organic matter and fire-induced synthetic water repellency. Areas where organic matter was entirely burned off may not return to the prefire state for decades or centuries, but water repellent soil layers will be more ephemeral, persisting for 2 to 6 years (fig. 33).
- Reduced ground cover in places of high fire severity will likely result in decreased infiltration of water, increased surface runoff and peak flows, and the formation of pedestals, rills, and gullies. Erosion rates should substantially decline by the third summer after burning, and erosion from winter storms is expected to be minimal.

Figure 33—In addition to burning the vegetation of the area, the Hayman Fire in many places burned organic materials in and on the soil surface, decreasing productivity and creating water impermeable layers. (Photo by Theresa Jain)

- The aquatic ecosystems of the South Platte River within the Hayman Fire area represent a highly altered landscape that has been influenced by a variety of activities including mining, vegetation management, road building, urbanization, recreation, and water development.
- The recovery of the hillslope and riparian vegetation will influence how quickly the aquatic environments recover. Clearly, areas that were less severely burned will likely recover to prefire conditions most rapidly. Recovery of aquatic ecosystems within severely burned watersheds will be most dependent on riparian recovery, the juxtaposition to high quality habitats that can provide sources for re-colonization, and the mitigation of additional chronic disturbances.
- Rehabilitation of the aggrading perennial streams downstream from the fire will be difficult and costly because of the large volume of sediment in the system and poor access in many areas. Efforts to accelerate the recovery of the hillslopes will help by reducing the future inputs of sediment, but so much sediment has already been mobilized, or is poised to move into the downstream areas, that relatively little can be done to stop the problem. Hence large amounts of sediment will continue to be delivered into Cheesman Reservoir and the South Platte River, reducing reservoir storage capacity and potentially affecting fish and macroinvertebrate habitat (fig. 34). Over a longer period, however, the trend will likely be toward recovery of aquatic ecosystems if other kinds of chronic disturbances can be minimized.

Figure 34—The greatest risk to the soil and water resource following the Hayman Fire is erosion and sediment delivery to the streams and reservoirs.

- Because the ecosystems that burned in 2002 have a long history of fire, the native species and populations in this area generally have mechanisms for enduring fire or becoming reestablished after fire. Therefore, much or even most of the terrestrial vegetation is likely to recover normally without intervention, and in some areas our well-intentioned rehabilitation efforts actually could interfere with natural recovery processes.
- Where the vegetation is dominated by sprouting species (for example, aspen, cottonwood, many shrub species, many grasses, and other herbaceous species), a rapid return to prefire conditions is generally expected (fig. 35). We also expect a rapid return to prefire conditions in areas dominated by nonsprouting species (for example, ponderosa pine and Douglas-fir forests) wherever the fire burned at low severity and did not kill most of the forest canopy.
- Vegetation that is different from prefire conditions, but within the historical range of variability, is likely to develop in ponderosa pine and Douglas-fir forests where the fire burned with moderate severity, and also in small patches of high-severity burn. We anticipate that a new cohort of ponderosa pine seedlings will become established in these areas over the next several years.
- Development of vegetation that is different from prefire conditions and also is dissimilar to or at extremes of the historical range of variability for this ecosystem is expected in ponderosa pine and Douglas-fir forests within large patches of high-severity burn because of high local seed mortality coupled with long distances to seed sources outside the burned area. Natural reforestation of these areas may require many decades (fig. 31).
- Development of vegetation that is outside historical range of variability for this ecosystem is expected wherever invasive, nonnative species become dominant. Invasion of burned areas by nonnative species is a serious threat throughout the Hayman burn because the invasive species may cause declines of native plant species and changes in fire regimes, nutrient cycling processes, and hydrology.
- Over the short term (next approximately 5 years), riparian areas are likely to be the most vulnerable to invasion by nonnative plant species.

Figure 35—Areas within the Hayman Fire responded rapidly by sprouting new vegetation within weeks of the fire.

Figure 36—Mulch was aerially applied to reduce soil erosion. These activities have the potential to introduce nonnative species and alter natural vegetation development.

Rehabilitation activities may facilitate the invasion of nonnative species and may alter postfire dynamics of riparian ecosystems (fig. 36).

Over a longer term (approximately 50 to 100 years), without control measures, nonnative plant species would be expected to persist in riparian and drainage areas, open-canopy areas, and along disturbance corridors such as roads.

- The potential effects of the Hayman Fire on animal and plant species listed as threatened or sensitive species for the Pike National Forest are expected to vary based on the patterns of fire severity and rehabilitation implemented. In areas of mixed-severity burn, we expect that the fire will create habitat for several species such as woodpeckers, cause minimal negative impacts for most species in the short term, and may enhance habitat availability for many native species in the long term.
- Large patches of crown fire will also create habitat for several species of concern but likely will diminish habitat availability and quality in the short term for many species that prefer mature conifer forest (fig. 31). The long-term effects of the large patches of crown fire are more equivocal and will depend on postfire response of vegetation communities.
- Rehabilitation efforts (such as salvage logging, seeding, soil scarification) and hazard tree removal may remove or diminish critical structure (for example, snags, bare mineral soil) for wildlife that was created by fire.

- Concern remains for the threatened Pawnee Montane Skipper because of its restricted habitat and range. Further research is needed to determine how the skipper responds to burn-severity patterns and potential interactions with effects of the 2002 drought.

Home Destruction

Team Leader Jack Cohen, USDA Forest Service, Rocky Mountain Research Station, Missoula, Montana

An onsite assessment of each home destroyed, documentation and photographs during the fire, postfire aerial reconnaissance, and meetings with Federal, County and private individuals were the main sources of information used in the analysis. Although the team specifically assessed the homes destroyed, surviving homes were also considered. Home sites were visited 3 months after the Hayman Fire when much of the specific evidence describing the nature of home destruction and survival was lost. Selected findings of the team:

- Discussions with fire personnel and residents indicate that most homes were not actively protected when the Hayman Fire burned in the residential areas.
- The Hayman Fire resulted in the destruction of 132 homes (that is, homes on permanent foundations, modular homes, and mobile homes—both primary and secondary). Within what is now the final perimeter of the Hayman Fire, 794 homes existed. Thus, 662 homes were not destroyed. The Hayman Fire resulted in about 17 percent destruction of the total homes within the fire area.

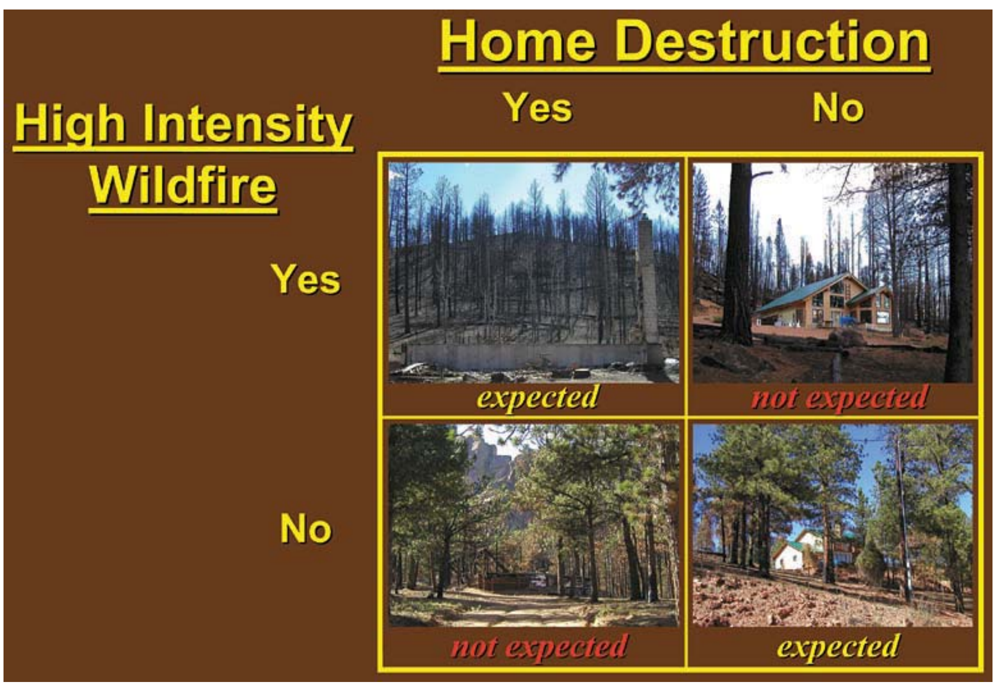

Figure 37—Expectations of home destruction as a result of wildfire. Home survival is expected if low fire intensities occur (lower right cell) and unexpected if the home is destroyed (lower left cell).

- The wildland fire intensity associated with the destroyed homes varied as much as the fire intensity associated with homes that survived. Figure 37 shows the range of wildland fire intensities associated with homes destroyed and a similar range with those that survived.
- Research has shown that the characteristics of the home in relation to its immediate surroundings (within 30 to 60 m) principally determine home ignitions during wildland fires. This area that includes the home characteristics and its immediate surroundings is called the “home ignition zone.”
- The wildland fire intensity in the general area does not necessarily cause home destruction or survival. This distinguishes the difference between the exposures (flames and firebrands) produced by the surrounding wildland fire from the actual potential for home destruction (home ignition zone) given those exposures.
- The home ignition zone implies that the issue of home destruction can be considered in a home site-specific context rather than in the general context of the Hayman Fire.
- Seventy homes were destroyed in association with the occurrence of torching or crown fire, at least in a portion of the area surrounding a home (fig. 37 upper left case).
- Sixty-two homes were destroyed with no high intensity fire, torching, or crown fire, in the area surrounding the home (fig. 37 lower left case).
- Significant site disturbance in the time lapsed between the fire occurrence and our assessment prohibited any further analysis as to whether these high intensities could have directly caused home ignition.
- Significant patterns of destruction were not observed. This can likely be attributed to the wide variety of home types, designs, building materials, the scattering of destroyed homes, the significant number of surviving homes within the fire perimeter, and the wide range of fire intensities associated with home destruction.
- Teller and Park Counties did not have regulations related to reducing wildland-urban fire risks.
- In 1994 Douglas County adopted an amended version of NFPA 299 (1991) to the Uniform Building Code, making all developments after the adoption date subject to the regulations.
- Jefferson County required “defensible space” permits on the construction of habitable space greater than 400 ft^2 since 1996, but because of little new construction, few—if any—homes fell into this category in the Hayman Fire area.

Postfire Rehabilitation

Team Leader, Pete Robichaud, USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho

Selected findings of the team:

- Postfire rehabilitation efforts in the Hayman Fire area were designed to reduce the projected increases in peak-flows and soil erosion, and thereby minimize adverse downstream impacts on structures and aquatic ecosystems. The Burned Area Emergency Rehabilitation (BAER) team report included:

1. Estimates of the potential magnitude of the increases in runoff and erosion.
2. Assessment of the risks posed by the increases.
3. Recommendations for mitigation treatments on National Forest lands.

- The recommended treatments were applied, with some modifications, as soon as fire suppression activities allowed. Land treatments included aerial and ground-based hydromulch (fig. 38), aerial dry mulch (fig. 36), and scarification with either aerial or ground-based seeding. Each of these treatments included a 70 percent barley/30 percent triticale seed mix. In addition to land treatments, road and site protection treatments were applied. By the end of 2003, approximately $18 million will be spent to provide emergency rehabilitation treatment on 45,500 acres (39 percent) of the 116,300 acres that burned.
- Most of the treatments recommended by the postfire rehabilitation team have not been systematically studied, making it difficult to predict expected effectiveness. More quantitative data on rehabilitation treatment effectiveness, based on climate, burn severity, soil types, and so forth, would enable BAER teams to refine their recommendations for each area.
- Previous experience indicates that rehabilitation treatments are least effective in high intensity rainstorms, particularly in the first 2 years after burning. Such storms are common in the Colorado Front Range, but in summer 2002 there were fewer such storms than average.
- Much of the postfire treatment effectiveness monitoring that has been done in the past has been anecdotal and qualitative. The application of such observations to current treatment decisions is difficult without specific information on site conditions, storm events, and measured responses (runoff, erosion rates, and so forth). Without quantitative measurements of runoff and erosion rates, downstream sedimentation rates are difficult to estimate, and predictive models cannot be rigorously tested and calibrated to different burned forest environments. To discern treatment effectiveness, it is also necessary to monitor

Figure 38—Ground application of hydromulch aimed at reducing soil erosion.

comparable burned but untreated areas. Treated and control sites have been established in the Hayman Fire area, but these monitoring efforts need to be expanded and continued until recovery to near background conditions. The results of this monitoring need to be regularly and publicly reported.

- The efficient placement of rehabilitation treatments involves the use of predictive models to locate the areas of greatest risk and greatest potential for effectiveness. The development and adaptation of climate, runoff, and erosion models for use in burned forest environments are currently hindered by several knowledge gaps that include:

  1. Improved mapping of burn severity and better characterization of postfire soil water repellency (fig. 33).
  2. Improved prediction of runoff responses at different spatial scales from short-duration, high-intensity thunderstorms.
  3. Relative magnitudes and consequences of hillslope verses channel erosion.
  4. Sediment deposition and routing within drainages.

Social and Economic Issues

Team Leader Brian Kent, USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado

The social and economic issues of the Hayman Fire were addressed by conducting four studies: (1) on economic and social effects of the fire; (2) prefire and postfire workshops with the Ridgewood Homeowners Association; (3) interviews with key informants in the Woodland Park area in August 2002, soon after the fire was suppressed; and (4) another set of interviews with Woodland Park area representatives of governmental and nonprofit organization members in February 2003, about 6 months after the fire was suppressed. Selected findings of the team:

- The effects a catastrophic wildfire such as the Hayman has on human social and economic systems are complex. Unlike many ecological effects of a wildfire, the geographic scale of influence for social/economic effects extends considerably beyond the area actually burned.
- Most likely no human alive during the Hayman Fire will live long enough to see the burned area recover to anything like it was prefire. Those who used this area have lost something and they will need to look elsewhere to replace it, and the local economies likely have lost the economic contributions those users made.
- The economic aspects of a large-scale fire occurring in proximity to human populations, such as the Hayman Fire, are difficult to measure and highly variable. Some aspects are straightforward and relatively easy to measure, such as the actual suppression expenditures or property losses. Assessing other aspects, such as the effect on a regional economy, or changes in recreation and tourism, are easily confounded by other factors, such as general economic downturns or a shift of economic activity from one location to another.

Figure 39—The costs to suppress the Hayman Fire were not that excessive on a per acre basis, but because of its size the fire was the most expensive in Colorado history.

- While the Hayman Fire was not extraordinarily expensive on a cost per acre basis, the size of the fire made it one of the most expensive fires in the last several years. No fire in Colorado's history has cost as much to suppress (fig. 39). The $38 million spent by the Forest Service on the Hayman Fire was more than three times the average annual suppression expenditures (1992 to 2001) for all of USDA Forest Service Region 2 (Rocky Mountain Region). Adding expenditures by the State and the other Federal agencies, suppression expenditures totaled more than $42 million. In addition to the money spent fighting the fire, rehabilitation and restoration expenditures (already expended and planned) connected with the fire are expected to cost at least another $74 million.
- Additional expenditures related to the fire totaled almost $2 million. These expenditures included Federal Emergency Management Agency (FEMA) reimbursements, State of Colorado expenses, and disaster relief by the American Red Cross.
- The proximity of the fire to human populations led to a loss of 600 structures, including 132 residences (fig. 40). Real property losses were substantial, totaling $24 million, with a majority of the losses occurring in Teller County ($14 million) and Douglas County ($8 million) with total insured private property losses estimated at $38.7 million. Loans and grants from Small Business Administration and FEMA for uninsured losses totaled almost $4.9 million. Additionally, damage to transmission lines was estimated at $880,000.
- More difficult to measure are the effects on resource values (including tourism and recreation) and the regional economy. The fire

Figure 40—Many structures dotted the Hayman landscape, and 600 of them burned during the fire, resulting in real property losses of $24 million.

Figure 41—The Hayman Fire occurred at the peak of the tourist season, impacting many sectors of the travel economy from daily forest visitors to destination resorts.

closure order occurred during the busiest time of the tourist season (fig. 41). Concessionaires who manage the developed recreation sites within the affected Ranger Districts of the Pike-San Isabel National Forest reported a total decline in revenue in 2002 of $382,000 from 2001 levels.

- It is possible that recreation losses occurring within the vicinity of the Hayman Fire were offset by gains to other areas of Colorado.
- On the Pike-San Isabel National Forest, financial losses attributed to water storage decreases were estimated at $37 million, and the value of timber lost was estimated at $34 million.
- There was little evidence of a substantial economic decline in the Primary Impact Area – the four affected Counties during the months of the Hayman Fire. In some areas and sectors, the Hayman Fire most likely decreased economic activity. That more substantial effects were not detected is probably due to: (1) tourism-related sectors constitute a relatively small part of the economies in the Primary Impact Area and (2) the economies of the Primary Impact Area are large, complex, and able to withstand economic shocks.
- The Ridgewood Homeowner's Association (RHOA), located adjacent to the Manitou Experimental Forest on the eastern perimeter of the fire (fig. 8, 16), comprises residents that have had notable experience with wildfire, are quite knowledgeable on these issues, and yet are still motivated to learn more. These homeowners recognize the need for active management on the Forest and realize the potential dangers that wildfire poses. The homeowners most preferred the mechanical removal of hazardous fuels (even more since the Hayman Fire). Second, they prefer prescribed fire in combination with mechanical removal, and third, they are somewhat neutral on prescribed fire. Interestingly,

this preference has remained constant from before to 6 months after the Hayman Fire.

- According to these residents (RHOA), the City and County fire departments are helpful and perceived as highly credible entities, while research reports and environmental organizations were not viewed as helpful or credible sources of help or information. The Colorado State Forest Service is only perceived as somewhat credible as an institution. The USDA Forest Service, bordering many of these residents' land, is viewed as providing somewhat helpful information and as less credible than the USDI National Park Service, County and City fire departments, State Forest Service, and neighbors and friends. This could explain some of the trepidation associated with prescribed fire; the residents may view prescribed fire as something needed but not preferable since they know the Forest Service is the entity implementing the treatments. These sentiments for prescribed fire may also reflect the knowledge of the Forest Service employee who pled guilty to starting the Hayman Fire.
- The residents of the RHOA feel highly vulnerable to the effects of fire, are highly susceptible to the consequences of fire, and feel that there is a high probability (78 percent) that a wildfire will occur near their home in the near future. Yet the measures of perceived efficiency for both specific and general risk reduction actions only explain a few of the homeowners' mitigating actions. These residents feel that mitigating actions are, for the most part, effective, and they also believe strongly in their ability to carry them out. The question then remains as to why there are not more mitigating actions being implemented on homeowners' lands.
- The residents' (RHOA) strong feelings of vulnerability from wildfire risks are enhanced by inaction of their neighbors, thereby negating the effect of homeowner risk reduction actions. The residents not only believe that they are responsible for defending their property, but also that all neighbors, including homeowners, the Forest Service, and the RHOA, should be involved in mitigating these risks.
- These findings suggest that information on wildfire issues should be disseminated through City and County fire departments, which hold more credibility with homeowners. Education should focus on including the actions of the land management agencies and other community projects so that homeowners feel it is truly a community effort and that it is not something they are doing on their own.
- To gain support for prescribed fire as a treatment option, the Federal, State, and local governments need to educate residents about the benefits of prescribed fire, and perhaps even the benefits of prescribed fire over mechanical removal.
- Postfire experience points to the importance of identifying and establishing relationships with preexisting community assets and organizations early on in a wildfire incident. This can help incorporate local knowledge into firefighting and rehabilitation efforts and establish a

recovery base that will continue once emergency Federal agency personnel and resources have left the community.

- Partnerships should be developed as early as possible during the fire by the incident command, and several interviewees thought that they should be developed by local Federal officials well before any fire. Such up front collaboration was seen as a good way to systematize actions, increase efficiency, and decrease potential contention between locals and Federal agencies by building trust.
- While trust has been shown to be important in all natural resource management matters, it is particularly important with wildfires where a crisis brings in powerful outsiders to work in a community for a limited but highly emotional period of time.
- Many evacuees expressed frustration with being forbidden to go back to their homes. There was little understanding of how thin law enforcement was stretched, and people were restricted from going back to houses not only just for safety reasons but also as the only manageable means of preventing burglaries in evacuated areas on a fire the size of Hayman (fig. 41).
- Informing the public prior to fire events about what is involved in firefighting and rehabilitation efforts, including limitations prior to a major event, should make public expectations more realistic
- The educational process should not be one way. Federal fire managers need to work to better understand the actual capabilities and limitations of volunteer fire departments.
- While agencies have developed effective means of coordinating policy and actions during a fire, similar efforts need to be made with rehabilitation work, particularly between the Forest Service and National Resource Conservation Service.
- Given the complexity and importance of rapidly developing effective solutions to minimize current and future wildfire damage, it is important to think out of the box as much as possible. Instead of relying on traditional and often engrained methods and approaches, the ability to be open to new and adaptive techniques and to meet locally identified needs will be critical.
- The mix of social and economic effects of a large fire such as the Hayman, especially when it occurs within the wildland urban interface, is both complex and far ranging.
- The Hayman Fire has taken on national significance by becoming an example of a consequence of what is wrong with current forest management policy. Consequently, the more we can learn from it, the more we can use the Hayman experience to inform future debates over both forest and wildfire management strategies.

Conclusions

The Hayman Fire was at the wrong place at the wrong time. The fires of 1910, and the resulting views of fire suppression, started the sequence of events that helped facilitate the Hayman Fire. In 2002 much of the Hayman area was rich in dry vegetation as a result of fire exclusion and the droughty conditions that prevailed in recent years. These dry and heavy fuel loadings were continuous along the South Platte River corridor on the Front Range of Colorado. These topographic and fuel conditions combined with a dry and windy weather system centered over eastern Washington to produce ideal burning conditions. The start of the Hayman Fire was timed and located perfectly to take advantage of these conditions, resulting in a wildfire run in 1 day of over 60,000 acres at a distance of 16 to 19 miles.

The Hayman Fire Case Study revealed much about wildfires and their interactions with both the social and natural environments. As the largest fire in Colorado history it had a profound impact both locally and nationally. We hope the findings of this study will inform both private and public decisions on the management of natural resources and how individuals, communities, and organizations can prepare for wildfire events. This study was part of a learning process that began in 1910 and continues today, to provide knowledge on the behavior, severity, and impact of wildfires.

References

Agee, James K. 1993. Fire ecology of Pacific Northwest forests. Washington, DC: Island Press. 493 p.

Carey , Alan; Carey, Sandy. 1989. Yellowstone's red summer. Flagstaff, AZ: Northland Publishing. 114 p.

Pyne, Stephen J. 2001. Year of fires: The story of the greast fires of 1910. New York: Penguin Books. 322 p.

USDA Forest Service. 2000. Bitterroot Fires 2000, an overview of the events, effects on people and resources, and postfire recovery priorities. Hamilton, MT: U.S. Department of Agriculture, Forest Service. 108 p.

USDA Forest Service. 1978. When the mountains roared. Coeur d'Alene, ID: U.S. Department of Agriculture, Forest Service, Coeur d'Alene National Forest. 39 p.

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The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals.

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