Chapter 9

Fire History and Management

Situation

The distribution of wildfire threat to the watershed is determined by the hazard (all the things that make a fire burn relatively more or less intensely and spread relatively more or less quickly), the risk of a fire ignition, and the values that might be damaged by fire.

Hazard

Flame length represents the energy released per foot at the flaming front per second. The flame length determines the difficulty and danger to fire fighters of controlling the fire (other things equal), the damage the fire will do to trees, soils, and other forest components, and the fire's potential to ignite structures at a given distance. Flame length is a measure of the potential destructiveness of a wildfire. Flame length is the one best measure of fire hazard.

A second measure of fire hazard is rate of spread. Although a rapidly spreading fire in grass may do little resource damage, it's perimeter will grow rapidly, increasing suppression costs, potential losses, and making escape more difficult. Rate of spread is a measure of the fire's threat to human life.

The Butte Creek Watershed above Highway 99 can be divided into three major vegetation types: grass and oaks, chaparral, and timber. Within the timber zone, the forest grades from a pine dominated, mixed conifer forest at the lower elevations to fir dominated mixed conifers in the upper reaches. Most of the brush is old and highly flammable. The mixed conifer forests are, for the most part, crowded with dense accumulations of suppressed reproduction and down, dead woody material in the understory and on the forest floor. The forest crown is typically closed with sufficient bulk density[1] to support crown fires. Outside the wildland-urban intermix[2] residential areas, surface fuels are continuous over large areas interrupted only rarely by non-flammable materials. Fire ladder[3] is well developed so that the vertical arrangement of fuels links the surface with the crowns of trees.

Typically the forested portion of the watershed is represented well by fuel model 10[4]. The brush areas are represented best by fuel model 4. The grass and oak-grass woodlands by fuel model 1. These fuel models were used along with slope and weather data to estimate flame lengths and rate of spread for a fire that might

[1] Bulk density is the weight per unit volume of a fuel.
[2] The wildland-urban intermix is that area where structures are under and among wildland vegetation and wildland resource uses such as logging and grazing are intermixed with more urban land uses such as residential properties and retail centers.
[3] Fire ladder exists when sufficient flammable vegetation fills the space between the surface of the forest floor and the crowns of the overstory trees to permit fire to climb from the surface into the tree tops where torching or crown fire may occur.
[4] Fuel models are described in US Forest Service, Intermountain Forest and Range Experiment Station. (1982) *Aids to Determining Fuel Models for Estimating Fire Behavior*. (General Technical Report INT-122). Ogden, Utah: Hal E. Anderson.

be typical of one burning during the height of the fire season.[5] Flame lengths were plotted to create a fire hazard map of the watershed.

In addition to the native fuels, a significant part of the watershed is in the wildland-urban intermix where structures are built into and among the native forest vegetation. These developments represent high values but also an important increase in the fuel available to a wildland fire and the potential for dangerous fire behavior. In the wildland-urban intermix, surface fuels continuity tends to be broken up by roads, irrigated gardens and lawns, and other less flammable materials. The crowns, however, tend to be continuous and sufficiently dense to sustain crown fires. The vertical arrangement of fuels in the wildland-urban intermix-- both native vegetation and structures -- plus the heavy fuel loading imposed by structures, vehicles, fire wood piles, gas tanks and the like mean that fire will very likely be in the tree crowns very quickly. For purposes of the analysis, the wildland-urban intermix in the forested areas was assigned fuel model 10 and in the brush fuel model 4.

Risk

The best measure of the probability of ignition is the recent history of ignitions for an area modified to take into account changes in human behaviors that will increase or decrease potential ignitions for a specific area. At the time or writing of this report, ignition history is incomplete for the watershed. A good second alternative is to locate where human activity is concentrated. There the probability of ignitions is high. Where there Is little human activity, ignition probabilities are relatively lower although lightning strikes are not associated with human activity and they do represent a significant proportion of ignitions in the watershed.

For purposes of the analysis, residential densities were mapped for the watershed. High fire risk was assigned to high density areas and relatively lower risk of ignition was assigned to areas of fewer residents. In addition, heavily traveled roadways and heavily used recreation areas were assigned high risks of ignition. Power lines, less used roadways, and lesser used recreation resources were assigned relatively lower risk. Areas where wood cutting and industrial forest uses are common were assigned a moderate level of risk.

Values

The distribution of value in the watershed is difficult to do if only one variable must be defined. Values range from market values such as the assessed value of homes and the worth of timber to non-market values such as environmental aesthetics, wildlife, and recreation. They range from the highly intangible but certainly very high value of human lives and safety from injury to the very tangible worth of inventories in wildland-urban intermix retail businesses. Combining these different measures of value is difficult.

Instead, it is recognized that values tend to be concentrated where people live. Human life, property and even the less tangible values associated with landscape aesthetics have higher values in and around settlements. Heavily used recreation resource settings similarly rate highly on value. But high resource values such as timber and water catchment for down stream use are examples of two important watershed values not necessarily linked to population densities.

For purposes of this analysis, areas of the watershed are classified as relatively high, medium, or low value. However, the best approach to assessing the threat of wildfire is to select the values of interest, map their

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[5] Weather and fuel conditions used were those existing at the time of the Maidu Fire which occurred in Butte Creek Canyon on September 22, 1992.

Time = 1400
Temperature = 95°F.
Relative Humidity = 21
Wind Speed = 15 mph
Ten Hour Fuel = 4
Live Fuel = 100%
A cross-slope wind vector of 45° was assumed

distribution, determine their limitations to exposure to fire intensities, and compare that distribution to the flame length hazard map. Trying to combine a great many different values with different susceptibility to fire and different degrees of quantification into one value variable will prove to be of only limited usefulness. The assessments of threats to values are easy to make once a hazard map has been prepared as long as the susceptibility to fire of each relevant value is known. Information on susceptibility to fire can be found for many forest plants on the Fire Effects Information System[6] available on the world wide web. Research is underway by the US Forest Service to determine the susceptibility of structures to different fire intensities. Recent studies by the Forest Service have determined the minimum acceptable separation between fire fighters in safety zones and flames of different intensities[7]. These same data can be applied to resident safety.

Results

Results of the wildfire threat assessment are presented by areas of the watershed with similar conditions of risk, value, and hazard. These areas are

The grass dominated slopes below Paradise and south and east of the canyon

The Paradise wildland-urban intermix along Paradise Ridge from the south border of the town to Paradise Reservoir and from the rim of Butte Creek canyon to the rim of the West Branch Feather River canyon

The bottom of the Butte Creek canyon up to approximately a mile below the confluence of Butte Creek and West Branch Butte Creek where brush converts to timber in the canyon bottom.

The wildland-urban intermix along Highway 32 above and below Forest Ranch and on Doe Mill Ridge.

The timbered lands of the upper part of the watershed.

The Grass Dominated Slopes

Between Highway 99 and the southern edge of the town of Paradise, Paradise Ridge is wide and slopes relatively gently (less than 30 %) to the south and west. The slope is cut by numerous steep-sided ravines tending southwest. The ridge between the ravines is covered mostly with grass and oaks. The ravines are filled with brush.

Risk. The grass is easily ignited. The principal risks of fire starts in the area are from vehicles using the Skyway, Clark Road, Neal Road, and Highway 99. Risk along these routes is considered to be high. Additional risk is posed by homes located along the rim of the canyon west of the Skyway and the businesses at the edge of Chico. Again this risk is high. High fire risk results from activity associated with the Neal Road land fill. Moderate risk is associated with the high voltage transmission lines that cut across the bottom of the slope. Risk throughout the rest of this unit is low.

Values. Values within the subdivision along the canyon rim are very high as a result of expensive properties and the presence of human life both of which are susceptible to loss by fire. The remainder of the area has very little of value that can be damaged by fire. Grazing and browse values may be destroyed for a year but grasses are well adapted to frequent fire and growth will return with the rains. The chaparral will also be renewed by fire, increasing its value for wildlife and cattle. Aesthetic values will be reduced until rains re-green the area. Losses to fires on the grassy slopes and in the ravines will be minor.

However, fires in the grass and especially the brush filled ravines pose serious threats to homes and businesses in Paradise. Fires starting in the grass have excellent potential for burning into the outskirts of the Town of Paradise where potential for losses is very high.

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[6] The Fire Effects Information System can be reached at [http://www.fs.fed.us/database/feis/]
[7] Butler, B. W. & Cohen, J. D. (1998). Firefighter Safety Zones: A Theoretical Model Based on Radiative Heating. *International Journal of Wildland Fire, 8*, 73-77.

Hazard. Fuel model 1 was used to predict fire behavior for the grass and fuel model 4 to predict fire behavior in brush. Fires starting in the grass will spread up-slope and with the wind toward Paradise. Under weather conditions typical of the height of the fire season, grass fires will spread at speeds approaching six miles per hour. (5.7 mph on slope on the level, 5.8 mph on 20 percent slopes, and 6.1 mph on 40 percent slopes.) Flame lengths will be approximately 10.7 feet.

The brush will burn with flame lengths exceeding 47 feet and will spread at about five and one half miles per hour.

Fuels on the south through west facing slopes will be preheated by hot summer sunshine reaching peak flammability between noon and 4:00 p.m. The prevailing winds are from the south and are augmented by up-slope winds developing as the valley heats. Winds will be stronger in the ravines. When the slope and winds line up with hot fuels, fires can be explosive

Fires starting along Highway 99, Neal Road, and Clark Road will spread rapidly up-slope with the wind. Fires will be very intense in the brush filled ravines and on the slopes. Control at the head of the fire will be difficult especially in brush. Attacking the head of a fire of this intensity in brush is likely to be ineffective and is certainly dangerous. Aircraft applying retardant may be effective, especially in grass. There are no significant natural breaks in the fuels between the bottom of the slope and Paradise from which to attack the fire.

At the top of the slope, just at the border of the Town of Paradise, grass fires will ignite dense brush which, in turn, will ignite the surface and ladder fuels under the pines. Fire in the ravines has the potential of pushing into the heart of Paradise.

The Paradise Wildland Urban Intermix

The Paradise wildland-urban intermix covers the relatively flat-topped Paradise Ridge between Butte Creek canyon and the West Branch Feather River canyon from about where the timber starts to Paradise Reservoir. The area can be divided into the south area from the southern town border of Paradise to the Magalia Reservoir, the Paradise Pines and vicinity, and Nimshew. Descriptions of the fire threat in these areas applies also to the smaller clusters of structures elsewhere in the middle elevations of the watershed.

Risk. Risk of ignitions within the wildland-urban intermix is very high. potential sources of ignition include structure fires, construction work, landscape maintenance activities (equipment fires), children experimenting with fire, vehicles, door yard burning, smoking, barbecues, arson, and many others. The concentration of people using fire for all kinds of purposes makes vegetation ignitions likely.

Values. A large number of very high values are located in this area. First among these is human life. The numbers of people living in the wildland-urban intermix is large and concentrated. The threat to life is exacerbated by the large numbers of elderly and disabled persons including a hospital and care facilities. Many people will have considerable difficulty evacuating in the event of a major fire.

Property values are also very high in the wildland-urban intermix. Homes, businesses (and their contents), automobiles, trailers, motor homes; equipment, utilities, government buildings, and a large number of the expensive cultural developments associated with a small city are threatened by fire.

The landscape and climate are principal reasons people have chosen to live in Paradise and the other communities of the watershed's wildland-urban intermix. Were the forest removed, there is no doubt that the value of the land for residential purposes would be greatly reduced and the local economy would decline materially as fewer people chose to live there and recreational use diminished.

Natural resource values including potential timber values, water quality, and wildlife habitat are threatened by intense wildfire within the wildland-urban intermix. Certain cultural resources would also be damaged or destroyed.

Hazard. The lowest elevations of the wildland-urban intermix and portions of the canyon rim, especially on the point between Honey Run and Butte Creek are chaparral mixed with structures. Fuel model 4 applies to these locations. The remainder of the wildland-urban intermix is better represented by fuel model 10.

Chaparral on the southern edge of the wildland-urban intermix grows on relatively gently slopes typically less than 20 % Flame lengths there are predicted to be 47.3 feet. Rates of spread will be about 5.4 miles per hour.

On the Butte Creek side, slopes leading up to structures on the rim are much steeper, typically 40 to 80 percent with some 100 percent or more. Flame lengths here will range from 47 to 52 feet or more. Rates of spread will range from 5.5 mph to 6.7 mph. Fire intensity and rate of spread along the west facing slopes of Butte Creek canyon will be increased in the afternoons by solar heated fuels and increasing up-canyon winds. That will be particularly true on the south and southwest facing slopes of the west tending draws that cut into the escarpment. Structures are built at the head of many of these draws and are in particular danger.

Along the east perimeter of the wildland-urban intermix the slopes are timbered, the timber containing a considerable component of highly flammable live oak. In the lowest reaches of the wildland-urban intermix, brush covers the slopes. These slopes will burn with flame lengths similar to those of the west side of the wildland-urban intermix except that the east slope is not as exposed to direct solar radiation. Fuels will not be hot after mid-morning. Any benefits of less intense burning are largely lost because many homes along the east perimeter are built on the slopes and are virtually in the canopy of the live oaks.

The wide top of the ridge is in timber with heavy accumulations of suppressed understory vegetation and well developed fire ladder. While the surface fuels are broken up by roads and other non-flammable openings, the crowns are closed and of sufficient bulk density to support crown fires. In addition, structures, vehicles, fire wood piles, and fuel storage add to the potential intensity of surface fires. Burning structures often produce large numbers of brands and convection columns that easily carry them aloft. This greatly increases the potential for spotting and the consequent rapid leap-frog of the fire through the wildland-urban intermix and spread to surrounding wildlands.

Fuel model 10 does not adequately describe the conditions of the Paradise wildland-urban intermix but is the best available model. Surface rates of spread are probably over estimated because roads and other breaks will slow it down and fire intensities are probably underestimated. Flame lengths are predicted to be around 12.5 feet within the forest covered wildland-urban intermix. Rates of spread are predicted to be about 0.6 miles per hour. However, the flames will impinge directly among the lower branches of most of the forest cover. Torching and crowning is very likely in which case flame lengths and rate of spread will increase dramatically.

Scorch heights will exceed 90 feet. The scorch height is the distance above the ground in which all vegetation is killed. A 90 foot scorch height would result in the death of virtually all trees and understory vegetation leaving the ridge barren much as happened in the Fountain Fire that burned in similar fuel and terrain east of Redding.

There are portions of the lower Paradise wildland-urban intermix that were once in agriculture or for other reasons are now covered sparsely with timber and where grass will be the principal fuel carrying the fire. Rates of spread and flame lengths in these areas will be similar to that in the grass dominated areas below Paradise. Because grasses in these areas are intermingled with brush and urban fuels fire effects may be more pronounced. Fire will certainly spread more quickly through these areas than in the timber.

Within the Town of Paradise, draws of Clear Creek, Dry Creek, and Little Dry Creek and head water tributaries produce fingers of unbroken, dense surface fuels in conjunction with steeper slopes. The risk from children experimenting with fire is high in these pockets of fuel and the potential for fires to become well established before being detected is higher.

Under existing conditions within the Paradise wildland-urban intermix wildfire is likely to start. Under the right weather conditions common in late summer, such fires have excellent potential to become large and destructive. Even a small fire by wildland measures will result in exceptional losses in a densely settled area including, very likely, the loss of life.

Fires starting in the wildland-urban intermix are likely to be found and reported quickly. Fire fighter response times are relatively short. The many breaks in the surface fuels provided by roads and other non-flammable areas will help slow the rate of spread as long as the fire stays on the ground. Terrain in the wildland-urban intermix is not particularly steep except in some of the ravines and along the rims of the canyons; steep slopes typically will not contribute to fire spread.

These advantages are offset by the fact that fire fighters must deal with evacuation of residents from the danger area. Accumulations of dense, suppressed vegetation under the forest crown and well developed and wide spread fire ladder will often allow fires to build to dangerous intensities forcing fire fighters to immediately go on the defensive protecting structures instead of attacking the spreading fire itself. If the fire burns into the settled area from outside, the number of spot fires starting in the community might easily exceed the ability of fire fighters to deal with them under existing fuel conditions.

Butte Creek Bottoms

This area encompasses the bottom of the Butte Creek canyon and the slopes on each side from the outskirts of Chico to the timber beginning approximately one mile downstream from the confluence of Butte Creek and West Branch Butte Creek.

Risk. Risk of ignitions in the canyon bottom is high due to the combination of recreational traffic along Humbug Road, the prevalence of party activity along Honey Run Road, and the number of homes along Humbug Road and in the small settlements in the canyon.

Values are high where homes are located. Cultural resource values may be threatened by fire at the covered bridge and at historic mining locations in the canyon. Riparian vegetation could be damaged by intense fire. Aesthetic values can be damaged especially in riparian areas. The slopes of the canyon are covered with grasses, oaks, and brush. Fire in this vegetation will cause short term aesthetic damage but have little impact after one year.

Hazard. Lower reaches of the area are represented by fuel model 1. The bottom of the canyon and the slopes north and east of Chico are relatively flat. Canyon walls are steep, however. Slopes in the bottoms are typically less than 20% but slopes become steeper quickly toward the canyon walls. In the lower reaches of the canyon, slopes increase up to 80%. Higher in the canyon, slopes increase from the flats in the bottom to more than 100% in places.

Grass is the fuel that will carry fire on both the canyon bottom and walls up to about the junction of Honey Run Road and Humbug Road. Some brush is found along the canyon walls and the creek bottoms have riparian vegetation. Grass fires burning into accumulations of berry bushes and grape vines will become locally more intense. Accumulations of vegetation, downed wood and fire ladder in the riparian areas will intensify fire and killing or top killing many trees.

Rates of spread in the bottom of the canyon will be approximately 5.7 mph increasing to more than 6.5 mph as the slopes become steeper toward the canyon walls. Flame lengths will range from about 10.7 feet to more than 11.5 feet.

In the upper portion of the area, chaparral will burn with flame lengths of approximately 47 feet in the bottom of the canyon and more than 52 feet on slopes of 100% or more. Rates of spread will increase from 5.3 mph in the canyon bottom to 6.7 mph or more near the tops of the canyon sides.

The most important values in this portion of the canyon are concentrated in the bottom along the creek and Humbug Road. Fire threat is reduced somewhat by that fact. Homes in the bottom may still be threatened by fire burning down slope or by fires started down canyon. The threat from down canyon will increase as canyon winds increase later in the day. Orientation of the canyon to the south means solar heating will raise the temperatures of fuels and dry them out. East facing slopes will be somewhat less flammable than west facing slopes.

The danger of fires starting in the canyon bottom to values there is not trivial. However, the greatest threat is that posed to structures and other values along the canyon rims and timber and watershed values up canyon by the high risk of ignition and potential for rapid spread and high intensity combustion.

Highway 32 Wildland-Urban Intermix

A fire protection plan was prepared by Bob Cermack for the community of Forest Ranch. The plan addresses the wildland fire threat. Copies can be viewed at the California Department of Forestry and Fire Protection, Butte Unit, Oroville, CA.

This area includes the outskirts of Chico south of Highway 32, the Little Chico Creek drainage, Doe Mill Ridge, and extends north to the narrows between the West Branch Butte Creek and Big Chico Creek.

The fire threat is similar to that faced by the Paradise wildland-urban intermix. The ridge top between Big Chico Creek and Little Chico Creek and West Branch Butte Creek is narrower and there are fewer structures.

Risk. Between the outskirts of Chico and 12 Mile House on Highway 32, the principal risk is from travel along Highway 32. Residential areas on the outskirts of Chico present a high risk of ignitions. Recreational uses of Bidwell Park in the Big Chico Creek watershed may ignite fires that spot into the little Chico creek watershed and threaten Doe Mill Ridge and Forest Ranch.

Above 12 Mile House, risk of ignition is very high among the concentrations of residential structures and moderate from occasional small scale timber harvest activities.

Values. Below 12 Mile House and on Doe Mill Ridge, scattered structures and human life create areas of very high values that can be seriously damaged by wildfire. Most of the landscape is in grass and brush, however, which will be little damaged by fire so is classified as low value. Vegetation and landscape aesthetics damage by fire will be relatively small and will recover within a few years. Therefore the values in this area, with the exception of the structures, human lives, and associated property are rated low.

Hazard. Above 12 Mile House, the landscape changes to forest cover. Conditions there are similar to those in the Paradise wildland-urban intermix. Homes along the canyon edges and at the head of draws of tributaries to Little Chico Creek are exposed to potentially intense and damaging fire. This is especially true on the Butte Creek side at 12 Mile House where brush below the homes can be expected to produce flame lengths in excess of 47 feet. The brush blends into pine dominated timber with dense understory of suppressed reproduction and wide spread fire ladder. Fire behavior and potential damage to the landscape and threat to lives and property are similar to that described for the Paradise wildland-urban intermix.

The Timbered Upper Watershed

The remainder of the watershed is largely timbered. Although there are scattered concentrations of structures, notably at Butte Meadows, and isolated home sites most of the land is managed for natural resource values, principally wood products.

Risk. The risk along Highway 32 and the road from Paradise to Sterling City is moderate. Other risks may be locally high while timber harvesting is occurring in a particular area or during hunting season. In general the risk of ignitions in this area is low to moderate. Lightning probably presents a risk of ignition higher than that posed by human activity.

The greatest risk of fire in this area is fire spreading from a start in the wildland-urban intermix and escaping to the wildlands. That risk is high.

Values. Timber and wildland values are the principal values in this area. Especially at mid-elevations, timber is an important resource with high economic values. Timber values are susceptible to serious damage by wildfire. The potential for loss to a large wildfire is very high as is clearly demonstrated by the losses experienced in the Fountain Fire which burned over very similar terrain and fuels.

In a major conflagration, losses of structures at Butte Meadows and other clusters of homes and isolated structures is likely to be high. The scattered nature of these properties and their integration into the wildland fuels make defense difficult.

Hazard. Nearly all of the timbered portion of the watershed is classified as fuel model 10. It is mixed conifer forest dominated by pine in the lower elevations and by fir in the higher elevations. Relatively small areas are in wet meadows, young plantations, or have been thinned from below. However, by far most of the forest is characterized by dense stands of trees with heavy accumulations of suppressed understory vegetation and dead woody fuels. The watershed was heavily logged at the end of the last century and beginning of the 20th century. As a consequence, there is very little if any vertical separation between surface fuels and tree crowns. Crown closure approaches 100% over most of the upper watershed.

Slopes in the upper watershed are generally less than 40%, most less than 20%, except some north-facing slopes of the south side of Butte Creek up stream from Butte Meadows. Below Butte Meadows the Butte Creek canyons are relatively narrow. Sides of the canyon are steep. The broken, steep country dominates the east side of the upper watershed below Butte Creek Meadows. The west side is dominated by wide flat ridges separating West Branch Butte Creek from Butte Creek.

Fires burning in the broken steep country will burn with flame lengths between 12.5 and 14 feet. Rates of spread will between 6 mph and about 8 mph when the fire burns on the surface. However, crown fires are likely because there is little separation between the surface fuels and the canopy and crown closure approaches 100% over most of the watershed. Crown fires will be very destructive and may be very large under weather conditions such as those during the Fountain Fire and the 49er Fire.

Conclusions

The wildfire threat is very high in the wildland-urban intermix areas of the Paradise Ridge and along Highway 32 on the western margin of the watershed. In those areas, the risk of ignitions if very high, the values that may be lost, including human life, are very high, and the hazard predicts potentially very destructive fire behavior. The bottom of the Butte Creek canyon contains high values and the risk of ignition is high. However, the topography means that intense fire is much less likely in the canyon bottoms. The danger there is not trivial but is much less than it is on the ridge top, especially at the canyon rim. Indeed, the greatest danger in the canyon bottom is that fires that start there will rush to the canyon rim and destroy homes and landscapes there.

The upper part of the watershed is in timber. The hazard is high, especially in the steep, broken terrain. Timber values are high and there are scattered clusters of structures and individual homes. Risk is relatively low. An important danger is that fires that start in the wildland-urban intermix will spread to the wildlands and develop into a large destructive fire on the order of the Fountain Fire dominated by crown fires. In that case, destruction of timber values and both tangible and intangible watershed values will be very great.

The potential for loss is relatively low in the grass lands south of Paradise and Forest Ranch. Fires are likely here because the risk is high especially along the roads. However, the grass and chaparral are well adapted to fire and will generally recover by the next year or so. The danger in this area is that it lies up wind and down slope from the wildland-urban intermix. Fast moving and intense fires are likely to carry flames into the southern subdivisions of Paradise.