Section 11

Section 11
FIRE HISTORY, WILDLAND FUELS, AND FIRE MANAGEMENT

TABLES

FIGURES

Section 11
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INTRODUCTION

The objective of this section is to present a general overview of fire and fuel issues in the Tehama West Watershed. Additional detail on fire management and planning specific to the Tehama West Watershed is included in the Tehama West Fire and Fuels Management Plan (FFMP) prepared by the Tehama County Resource Conservation District (TCRCD), which is being written concurrently with this assessment. The Tehama West FFMP is included as an appendix to this section.

SOURCES OF DATA

A variety of literature provided general information on fire and fuels management in areas with similar characteristics to the Tehama West Watershed. The general information included published results of regional, statewide, or national research on issues such as fuel, fire severity, policy, and protection.

- The California Department of Forestry and Fire Protection (CDF) was the primary source for watershed specific information on fire history and fuel loading within the Tehama West Watershed.

- The CDF Fire and Resource Assessment Program (FRAP) data for fuel ranks and fire hazard severity zones were the sources used to categorize fuel distribution and potential fire severity areas.

- FRAP data also provided fire severity and vegetation hazard and density rankings for the area within the watershed boundaries.

The Draft FFMP for the Tehama West Watershed was used as a primary reference to ensure consistency between documents and the final report will be included in the final Tehama West Watershed Assessment

A complete bibliography of references is included at the end of this section. The watershed assessment for the Thomes Creek Watershed, was also used to prepare history and risk evaluation.

FIRE HISTORY

Fire frequency, and its subsequent management, has had a significant effect on the landscape of ecosystems in the Tehama West Watershed. Throughout California, including the Tehama West Watershed, early Native Americans, sheepherders, and cattlemen used fire as a tool to manage natural landscapes. Since fire suppression in the 1920s much ground once open is now over-dense brush or timber (Menke et al 1996).

Pre-European Fire History

Over 300 years of dry, cool weather preceding the arrival of European man, coupled with Native American fire use, resulted in many frequent, low-intensity fires. The hot, dry summer climate provided suitable weather conditions and dry fuels for burning. Lightning provided a ready ignition source, supplemented by Native Americans, who used fire for a variety of purposes. Fires could spread until weather conditions or fuels were no longer suitable.

Fire-scar records in tree rings have shown variable fire-return intervals in pre-settlement times. Median values are consistently less than 20 (and as low as 4) years for the ponderosa pine and mixed conifer zones of the Sierra Nevada (McKelvey et al 1996). Only one study in high-elevation red fir found a median fire-return interval greater than 30 years (see Table 11-1).

Table 11-1
HISTORICAL FIRE-RETURN INTERVALS
SIERRA NEVADA

Forest Type	Pre–1900
Red fir	26 - 30
Mixed conifer-fir	12
Mixed conifer-pine	15
Ponderosa pine	11
Blue oak	8

Source: McKelvey et al 1996

Studies of past fire occurrence have been conducted on several areas within the Klamath and Six Rivers National Forests. Prehistoric fire dating with slabs was done on the Six Rivers National Forest in Douglas-fir clearcut areas, where trees dated back to 1750 (Salazar 1994). Preliminary results from this unpublished study on the Mad River District showed mean intervals of 12.7 years between fires intense enough to leave scars. From the multi-aged nature of the old-growth Douglas-fir stands that they surveyed, and the scarring of trees, the persons conducting this study concluded that frequent, low-intensity ground fires were the common type of fire, rather than stand-replacing, high-intensity fires.

In the Siskiyou Mountains, Agee (1993) analyzed fire slabs for the period 1550 to 1930. He found natural fire rotations varying from 37 years in the Douglas-fir-oak type, to 54 years in the white fir-herbaceous type.

On the Salmon River Ranger District of the Klamath National Forest, Salazar (1994) analyzed fire slabs within the Douglas-fir/hardwood forest. This study involved three sites and split the analyzed time periods into pre-settlement, settlement, and suppression periods. Table 11-2 shows the range for the mean fire return interval for the three periods.

In a small study within the Middle Fork Eel watershed, examination of stump scars indicated that, on average, a fire intense enough to scar trees occurred every 30 years. Additional small studies conducted in the Sugarfoot Fire area of the Corning Ranger District and on the Upper

Lake District showed a fire return interval between 10 and 21 years for low-elevation ponderosa pine-dominated forest. Slab analysis is limited to detecting fires that were intense enough to leave scars on trees. It is possible that many low-intensity fires occurred that did not leave scars. Based on these studies it is reasonable to state that the average interval between scarring fires prior to effective fire suppression was likely between 10 and 30 years for most of the lower elevation forest ecosystems.

Table 11-2
FIRE RETURN INTERVALS IN DOUGLAS-FIR – HARDWOOD FOREST

Time Periods	Fire Return Intervals (years)
Pre-settlement (1745 – 1849)	10.3 – 17.3
Settlement (1849 – 1894)	9.2 – 15.0
Suppression (1894 – 1987)	28.7 – 45.5

The variable nature of pre-settlement fire helped create diverse landscape forest conditions. In many areas frequent surface fires minimized fuel accumulation, keeping understories relatively free of trees and other vegetation that could form fuel ladders, to carry fire into the main canopy. The effects of frequent surface fires would largely explain the reports and photographs of those early observers who described Northern California forests as typically "open and park-like." However, such descriptions must be tempered by other early observations emphasizing dense, impenetrable stands of brush and young trees.

Almost all scientists agree that fire played a significant role in shaping the vegetative patterns and systems of California vegetation. There is a significant divergence of views as to fire frequency and vegetative composition of pre-settlement fire. The differences in point of views center on the belief that there were probably many variations in the return frequencies and fire intensity patterns that contributed to the mosaic of vegetation patterns on the landscape today.

A second major point of difference relates to the relative "openness" of forests before the disturbances caused by settlers. Alternative views conclude that forest conditions were not largely "open or park-like" in the words of John Muir; rather they were a mix of dark, dense, or thick forests in unknown comparative quantities. Select early accounts support an open, park-like forest, but there were many similar accounts that describe forest conditions as dark or dense or thick. J. Goldsborough Bruff, a forty-niner who traveled the western slopes of the Feather River drainage between 1849 and 1851, kept a detailed diary. He clearly distinguished between open and dense forest conditions and recorded the dense condition six times more often than the open. Many other accounts of early explorers (e.g. John C. Fremont, Peter Decker, and William Brewer) identify dark or impenetrable forest; the pre-settlement forest was far from a continuum of open, park-like stands. From these records, it seems clear that Northern California forests were a mix of different degrees of openness and an unknown proportion of dark, dense, nearly impenetrable vegetative cover with variations from north to south and foothill to crest.

A third point of departure has to do with the frequency of stand-terminating fires in pre-settlement times. One group concludes that such events were rare or uncommon. The alternative view is that stand-threatening fires were probably more frequent. They were heavily dependent upon combinations of prolonged drought; an accumulation of dead material resulting from natural causes (e.g., insect mortality, windthrow, snow breakage); and severe fire weather conditions of low humidity and dry east winds coupled with multiple ignitions, possibly from lightning associated with rainless thunderstorms. Such fires were noted during the last half of the nineteenth century by newspaper accounts, official reports (Leiberg 1902), and diaries. Settlers, stockmen, or miners caused most fires. Fuel loads were sufficient at that time, even before suppression policies had affected fuel loads, thus strongly suggesting that similar conditions existed in earlier times with unknown frequencies (Leiberg 1902).

It is now widely accepted that early Native Americans used fire as a tool, both for hunting and to manage the resources needed for survival (Blackburn and Anderson 1993). There is evidence for almost every tribe in the western Unites States having used fire to modify their respective environments. This included burning grasslands to improve basket materials, foothills to assist in hunting small game and to encourage new edible shoots, and in the coniferous forests to assist in hunting and to keep the forests open and passable. In addition, use of seeding and oak management to augment food supplies is documented (Blackburn and Anderson 1993). Within California at least 35 tribes used fire to increase the yield of desired seeds; 33 used fire to drive game; 22 groups used it to stimulate the growth of wild tobacco; while other reasons included making vegetable food available, facilitating the collection of seeds, improving visibility, protection from snakes, and "other reasons" (Blackburn and Anderson 1993). While the use of fire is noted for almost every Native American group in California, little is known about the timing or method of fire.

In Northern California there is much historical evidence that many of the tribes inhabiting the area used fire for a variety of uses. Some, such as the Wintu, Karuk, and Shasta are reported to have burned grass, brush, and riparian areas of valley and hill slopes to improve basket-making raw materials. Hazel sticks, required for ribs of baskets, had prime shoots available 1 to 2 years after fire (Blackburn and Anderson 1993). Especially common in the fall, fire was also used as a tool to improve habitat for deer and other animals, and to move mammalian game and insects to be collected for food. Deer were driven into snares or circled by fire and killed. The Wintu are reported to have collected grasshoppers "by burning off large grass patches" in chaparral, woodland grass, and coniferous forest areas (DuBois 1935). Unfortunately, neither the specific vegetation cover nor the time of year in which the burning took place is mentioned. Holt discusses the use of fire by the Shasta people:

> The second method was used on the more open hills of the north side of the river, where the white oak grew. When the oak leaves began to fall, fires were set on the hills. Then they came down... in the late Fall... It was at this time they had the big drive, encircling the deer with fire (Blackburn and Anderson 1993).

Blackburn and Anderson (1993) document general features of Native American patterns of burning. Fall, and secondarily spring, burning involved not simply an intensification of the natural pattern of fires, but a pronounced departure from the seasonal distribution of natural fires. The pattern previously shown for the woodland, grassland, and coniferous forest involved the intensification of the natural pattern. Ethnographic data strongly indicate that such a pattern of environmental manipulation and control did exist. Most important, by creating and maintaining openings within the chaparral, the Native Americans increased the overall resource potential of an area and created the enclosures, or "yarding areas," where these resources were readily exploited.

Post-European Fire History

Conservation, since its beginning with Gifford Pinchot in the late 1890s, has led many to believe that fire is the bane of the forest (Williams 1999). The national firestorms of 1910 cemented the exclusion of fire from national forests. It was believed that fire should be suppressed and eliminated to allow young forests to grow. The understanding that humans influenced ecosystems through the use of fire shifted after European settlement in North America, when it was believed that fire should and could be controlled to protect both public and private land (Williams 1999).

At the turn of the century, some settlers used "light-burn" as a farm management tool. The United States Forest Service (USFS) experimented with the same theory in the 1910s, but determined that it was too damaging to young seedlings needed for regeneration (Williams 1999). By 1933, with the advent of the Civilian Conservation Corps (CCC), fire fighting and the suppression of wildfires became a fulltime occupation. Thousands of men were trained to fight fire on public and private lands. The primary fire-related mission of land management agencies was to stop fires whenever possible, and to prevent large fires from developing (Moore 1974). Indiscriminate use of fire by sheep ranchers and miners from approximately 1870 to 1900 resulted in significant environmental damage and furthered the developing cause for fire suppression (Moore 1974).

The decision to exclude fire from public lands came about as a result of a debate over whether to permit light fire, such as Indian burnings, or use complete suppression. Logging and grazing interests held that light fires were beneficial because they reduce fuel loading and created more open forests (Ayers 1958; Cermak 1988). The USFS excluded fire in national forests after the "Big Blow Up" in 1910, a firestorm that "incinerated 3 million acres in Idaho and Montana". The California Forestry Commission was created to hear disagreement on both sides of the argument. Finally, a study completed by Show and Kotok in 1923 showed that although repeat burning maintained an open and park like condition, it killed young trees and discouraged regeneration of forests. The argument continued that if forests were to provide a sustainable timber supply, regeneration was required. In 1924 the Clarke-McNary Act was passed by Congress and clearly established fire exclusion as national policy. Decades ago, Aldo Leopold warned that working to keep fire out of the forest would throw nature out of balance and have untoward consequences. "A measure of success in this is all well enough," he wrote in the late 1940s, "but too much safety seems to yield only danger in the long run."

In the specific areas of the Mendocino National Forest, suppression activities did not begin "in earnest" until establishment of the forest reserve in 1910. The USFS (1997) states that the 1922 grazing chapter of the Supervisor's Annual Working Plan for the California National Forest (later renamed the Mendocino National Forest) included:

> Since the creation of the Forest, there have been few serious fires on sheep ranges and the oak brush has, over large areas, grown so high and thick that it does not furnish the sheep feed it formerly did. During these years of fire protection, it is undoubtedly true that coniferous reproduction has come in very extensively and in places is further decreasing the forage capacity. While damage to the reproduction is noticeable here and there, there is undoubtedly a large amount of reproduction coming in on the sheep ranges. While the condition of the ground feed may have deteriorated, there is no doubt but that the timber

stand has increased in area and density, so that from a timber standpoint we are gaining (barring insect depredation).

Fire suppression became progressively more effective in the Mendocino National Forest in the 1930s with the availability of Civilian Conservation Corps personnel, and after World War II with an increase in mechanized (bulldozer) and aerial equipment. Success in fire suppression has contributed to changes in forest cover and density which in turn have caused changes in fire frequencies and intensities.

The story on the first airtanker in fire fighting history follows (for more information on the program, see www.airtanker.com).

During the 1950s, Joe Ely was the Fire Control Officer at the Mendocino National Forest headquartered in Willows, California. In July 1953, 15 firefighters died during a flare-up of the Rattlesnake Fire because of a sudden change of wind in the thick, dry chaparral. Mr. Ely began actively looking for a way to gain control over backcountry fires without putting ground forces at such great risk. Due to the large number of "ag" flying services located near the Mendocino National Forest headquarters, Mr. Ely immediately envisioned the use of modified crop dusting aircraft for fighting wild fires using a similar "water cascade" technique. "Ag" biplanes were rugged, highly maneuverable, and used to carrying liquid cargo. Combined with the skilled "ag" pilots, these "water tankers with wings" could fly at slow speeds close to the ground while releasing their liquid cargo with a reasonable degree of accuracy. In July 1955, Mr. Ely met with several of the local "ag" service operators to discuss the idea. He recalls asking Floyd Nolta, of the Willows Flying Service, if he could effectively drop water on a forest fire. Mr. Nolta, a resourceful stunt pilot for the motion picture industry, became enamored with the idea. He cut a hole in the bottom of a Boeing Stearman 75 Kaydet (N75081) underneath the rice hopper (in lieu of a front seat) that was used for seeding operations. He added a 1-foot square water release gate with hinges, a snag and pull-rope so the pilot could open and close the gate when required. The first air drop on an actual wildfire was made during the Mendenhall Fire, August 13, 1955, in the Mendocino National Forest. Vance Nolta flew this historic mission in the Stearman, dropping six loads of water in support of firefighters on the ground trying to contain the blaze. This operation was considered so successful, America's first "fire pilot" Vance worked another fire the very next day.

In 1956, more water drop tests revealed that on hot or windy days, plain water barely made it to the ground unless the pilot flew hazardously low. USFS personnel created a more effective solution, using a slurry of sodium calcium borate mixed with the water. After the 1956 season, it was discovered this borate mixture sterilized the ground upon which it landed. The Forest Service then switched to mixing bentonite with water for a few years (however, the airtanker industry was stuck with the term "borate bomber" by the media for many years after). Some fires were so large, the airtanker loads were mixed in cement trucks sent to the airstrip to assist!

By the summer of 1956, seven biplane "borate bombers" had been modified to handle retardant drops during the dry summer and fall months. Local USFS rangers requested air support by just radioing their needs into the dispatch office. Charlie Lafferty, the dispatcher, would then call one or more of the contracted flying services to provide the location of the fire plus what airstrip might have reloading capability. Soon, rangers from all across the state began dialing "Willows 80" to reach Mr. Ely and Mr. Lafferty, asking for help. The fledgling Aero Fire Squadron fought 25 fires all over the state that summer, and their success was duly noted.

By 1957, the USFS realized air attack was a valuable weapon to have in its fire control arsenal. But these biplanes were just too small to carry more than 120 gallons of the heavy bentonite retardant and were useless on large project fires. To increase the effectiveness of fire control operations, the USFS engaged with other better-funded contractors for more expensive, but larger and faster aircraft. Though the agricultural pilots proved that wildfires could be fought from the air, they were nudged out by the bigger, faster airtankers with specialized crews. By 1964, they had disappeared from the airtanker program.

Forests today have undergone significant changes in species composition and structure. They now contain multi-level stands with a ladder fuel structure. Fires that occur are carried into the tree crowns by the ladder fuels. Once in the tree crowns, the fires move quickly with greater intensity. In general, the trend in fire size and severity has taken an interesting turn. As noted in the National Fire Plan overview, the numbers of acres burned have decreased from the 1960s, yet the dollar damage and structures lost have more that doubled from the 1980s to the 1990s. This jump is due in a large part to two factors, the increasingly heavy fuel load caused by decades of total suppression in California's woodlands and an increase in population in areas outside traditional urban zones.

By the 1950s controlled burns to reduce fuels and improve habitat for wildlife had become commonplace in much of California's rangelands, but all other fires were vigorously controlled. The "RI" fires in Tehama County were common NRCS (then the Soil Conservation Service) and CDF assistance methods for ranching interests. In 1963 Leopold and others (Leopold 1963) published a report on the ecological conditions of the National Parks in the United States, and, as a result, managers and the public began to see the benefit of fires in the wildlands (Lyon et al. 2000). The Leopold Report stated that wildlife habitat is not a stable entity that persists unchanged, but rather a dynamic entity. Suitable habitat for many wildlife species and communities must be renewed by fire. As a result of the Leopold Report, by 1968, the fire policy of the National Park Service changed as managers began to adopt the recommendations of the report (Lyon et al. 2000).

Table 11-3
ACREAGE BURNED SUMMARY

Date	Fire Events	Total Acres Burned	% Watershed Burned
1920-1929	4	17,446	3%
1930-1939	6	17,178	2%
1940-1949	14	5,878	Less than 1%
1950-1959	8	3,356	Less than 1%
1960-1969	13	4,453	Less than 1%
1970-1979	7	25,437	3%
1980-1989	5	5,175	Less than 1%
1990-1999	11	8,130	1%
2000-2003	12	10,093	1%

Source: CDF
Note: These figures have been modified from the source file and acreages have been recalculated to show only acres burned in the watershed.

Wildfire History

There is considerable variability in the seasonality of fires in the Tehama West Watershed. Fuels are driest and ignition sources are most frequent in the summer. Thus, the vast majority of fires occur in summer, while winter and early spring fires are relatively uncommon. The watershed is broken up into CDF fire hazards severity zones as shown on Figure 11-1. A summary of acreage burned in the Tehama West Watershed from 1930-2003 can be found in Table 11-3. A map depicting historical and recent fire boundaries can be found in Figures 11-2 and 11-3.

In the 10 years from 1993 to 2003, Tehama-Glenn CDF zones 1, 6, and 9 that cover the watershed area reported 787 fires. Of those, 71 percent were determined to have been caused by humans. Of that 71 percent, the leading cause of fire was equipment use, at 41%, followed by vehicle use at 22 percent. Table 11-4 shows the breakdown of fires and their origins within these zones.

Table 11-4
FIRES AND CAUSES, 1993-2003

Cause	Zone 1	Zone 6	Zone 9	Total
Undetermined	13	9	90	102
Lightening	15	2	20	37
Campfire Escapes	2	2	6	10
Smoking	3	7	29	39
Burn Barrel/Pile Escapes	5	15	43	63
Arson	3	19	28	40
Equipment Use	21	46	185	252
Playing With Fire	4	3	9	16
Other	8	19	48	75
Vehicle	20	12	93	125
Power lines	0	2	8	10

Source: CDF

FUELS, WEATHER, AND TOPOGRAPHY

Understanding basic fire behavior is helpful in better comprehending the current and historical role of fire in the watershed. Fire behavior is a complex science, but can be generally described as the speed a fire travels or rate of spread, and the intensity with which it burns. There are three key factors that influence fire behavior:

- Fuel
- Weather
- Topography

All three factors can influence fire behavior independently, but they are all interconnected and accounted for in assessing fire behavior (NWCG 2001). For figures containing fuel ranks and fire severity, please see Figures 11-4 and 11-1.

Fuels

Fuel loading is the most dynamic factor affected by human activities through our impact on species, utilization, and indirectly through suppression and impacts on wildlife. Fuel arrangement and fuel moisture are key characteristics that can influence fire behavior. The intensity with which a fire burns is often dictated by the type and amount of fuel available to burn (NWCG 2001). Fuel loading pertains to the amount of fuel over a given area and is a significant factor in determining the fire behavior. Grass vegetation types, which have a fuel loading significantly lower than heavy timber types, ignite more readily and support fires of more rapid spread, but generally burn with a lower intensity than fuels with a higher load (Anderson 1982). Fuel arrangement pertains to the compactness and continuity of fuels. Less compact fuels tend to ignite easier than those that are more compact. Fuel continuity describes the distribution of fuels. It is further described by both horizontal and vertical continuity. Horizontal continuity pertains to the amount of ground covered by fuel and the distance between surface fuels. Vertical continuity relates to the spatial relationship between surface fuels and aerial fuels such as brush and tree canopy (NWCG 2001).

Another factor in defining fire behavior is fuel moisture as based on fuels in a given vegetation community. Fuel moisture pertains to both live and dead fuels and how it fluctuates slowly over a season for heavier fuels or drastically over just a few hours for fine fuels. Current weather conditions can greatly affect fuel moisture of fine dead fuels such as small twigs and leaf litter; this concept will be described in more detail below. Vegetation type also can dictate the fluctuation of live fuel moisture based on a plant's physiology. Drier fuels burn more readily and with greater intensity than do fuels with higher moistures (Anderson 1982).

Recognizing fire's natural role in and effects to different vegetation types is imperative to understanding not only the different fire management practices and policies that are implemented within the watershed, but also the potential effects to the ecosystem of total fire exclusion. See Section 8, "Vegetation Resources," for a more detailed description of the various vegetation types within the watershed, information on their distribution, and other factors that influence them.

Weather

Weather can be the most erratic of the three key factors in influencing fire behavior. During the fire season, fire managers continuously monitor weather patterns to assess burning conditions of on-going fires or in the event of a new start. However, it is important to keep in mind that local weather patterns often differ greatly from the regional pattern. Furthermore, a large fire can also influence the local weather. Wind speed and direction can dictate not only the rate of spread but also the direction of a fire. Higher winds bring not only additional oxygen to a fire, increasing its intensity, but also assist in drying fuels ahead of the fire. Relative humidity also influences fire behavior primarily by affecting fuel moisture of fine dead fuels, as mentioned above. These fuels are often the primary carrier of surface fires and are receptive fuel beds for spot fires. Wind and lower relative humidity can independently or jointly dry fine dead fuels, increasing the fire behavior in these fuels. Ambient temperature is a major factor in controlling relative humidity, particularly the changes in humidity that occur throughout a 24-hour period. Within the Tehama West Watershed, summers are typically hot and dry, and the dominant wind direction typically blows from the southwest to the northwest. Fires in the watershed can be severely affected by the high winds pushing fire through the grasslands and chaparral. Although south winds dominate 75 percent of the summer, the north winds are also a factor. North winds have much lower relative humidity, 10–18 percent, instead of a 24–30 percent south wind. Consequently, north winds cause 75 percent of the big fire acreage. North wind events usually last three to four days.

Topography

Topography describes the lay of the land, and the three components of topography that are of particular interest to fire managers are slope, aspect, and elevation. With all other factors held constant, the steeper the slope, the faster fire travels up it. Aspect of a slope describes the direction that slope is facing. In the United States, south and west facing slopes receive greater portions of the hotter afternoon sun. This heats up the fuels and lowers the fuel moisture on these slopes, allowing for an increased rate of fire spread and fire intensity. Shifts in elevation affect ambient air temperature and relative humidity, which, as mentioned above, affect fuel moisture. Topography can often influence local weather conditions, particularly wind. Thus, as mentioned above, local wind direction and speed may be quite different from the regional conditions. All of these topographical influences can alter fire behavior as fire moves across the landscape. Tehama West Watershed is predominately comprised of rolling to steep hills with poor accessibility over much of the area.

FIRE MANAGEMENT

Both CDF and USFS use fuel models to combine the elements above to predict fire behavior. For the Upper Thomes Creek area, the USFS estimated flame length and intensity (see Table 11-5). Flame length and fire intensity are important in the ability to suppress and control wildfire.

Table 11-5
FLAME LENGTHS EXPECTED IN MID-SUMMER BY FUEL MODEL

Vegetation Type	Flame Lengths (feet)
Grass	5 – 10
Mature chaparral	10 – 20
Oak or pine woodland	4 – 10
Old-growth forest	8 – 14

Source: USFS 1997

Exact flame lengths for any given site and day are dependent on weather, topography, time of day, and actual fuel loading. The fuel models can also be used to predict the type of resources needed for effective fire suppression by comparing the flame length predicted and the specific conditions. The rates of spread and flame lengths are grouped into four categories. The flame length groupings conform to the values used in fire behavior charts which reflect the ability to succeed at fire suppression as indicated (Rothermel 1972). Table 11-6 shows effectiveness of fire suppression activities at various intensities.

Comparison of the flame lengths predicted (under uniform burning conditions) shows that change of vegetation from fuel of open stands with little understory vegetation to stands with a great deal of understory vegetation greatly increases the flame lengths and suppression difficulty. Longer flame lengths (which indicate higher intensity) also increase firefighter risk and damage to vegetation and soils. Given late fire season weather situations, this would result in a stand-replacing fire.

Table 11-6
EFFECTIVENESS OF FIRE SUPPRESSION FOR FIRES OF VARIOUS INTENSITY

Fire Intensity	Rate of Spread (ft/min)	Flame Length (feet)	Effective Suppression Resources
Low	0 – 10	0 – 4	Hand crews
Moderate	11 – 50	4 – 8	Engines and dozers
High	51 – 100	8 – 12	Aerial suppression
Extreme	> 100	> 12	All suppression efforts ineffective
Source: USFS 1997			

The USFS believes that change in the fire regime from one of frequent, low-intensity fires to one of infrequent moderate- to high-intensity fires brings on changes in vegetation which will tend to be self-perpetuating. When fires of severity sufficient to replace entire stands (or portions of them) occur, the vacant areas are occupied by pioneering vegetation. As a consequence, these fire-adapted plants develop densities that discourage reestablishment of native coniferous vegetation and encourage the retention of fire disturbance-dependent plant communities. In many cases, these plant communities will reach a stable state with the new fire regime that will be difficult or impossible to change without active management.

WATERSHED VALUES AT RISK

Uncontrolled stand replacing wildfire is detrimental to both watershed function and quality, and can negatively impact all aspects of the watershed. In a catastrophic wildfire, typically all vegetation is removed or damaged, including seeds, soil microorganisms, minerals, and nutrients. Prescribed or planned fires generally remove some vegetation but soil micrograms and many elements of the ecosystem remain unaffected. All fires produce a range of conditions across the landscape, from benign to stand-replacing. A "catastrophic" fire is large in acreage and a higher proportion of it is stand-replacing. The high intensity and high acreage causes a multiplier effect on water quality sedimentation, wildlife, and damage to human infrastructure.

Soil

The frequency and severity of wildfire affects the magnitude of accelerated erosion. The potential for accelerated erosion is primarily through its effects and removal of vegetation. During an intense wildfire, all vegetation may be destroyed and organic material in the soil may be burned away or decomposed into a water-repellent substance that prevents water from percolating into the soil (hydrophobic soils). The potential for fire to increase erosion increases with fire severity, soil credibility, steepness of slope, and intensity or amount of precipitation.

In most cases, hydrophobic layers are not created. The extreme temperature gradient just below the surface layer protects dormant seeds in the soil allowing them to germinate during the spring after the fire.

As the temperature of the wildfire increases, quality of soil decreases. Minerals and nutrients at temperatures 220 to 460°C begin to mineralize, nitrogen vaporizes, organic materials oxidize, and more sand size particles are formed. At temperatures greater than 460°C, permanent changes in structure, texture, porosity, plasticity, and elasticity occur.

Soil pH may increase after a wildfire. This is a result of the addition of ash minerals leaching out after precipitation events. Many fungi and bacteria thrive in basic conditions, and with the increased pH levels and the scarring effect of fire, may increase the likelihood of disease to the forest (Ahlegren and Kozlowski 1974).

Wildfires result in the net loss of nutrients from the ecosystem. Although there are few estimates of such loss, Christensen (1994) proposed four mechanisms to account for these losses:

- Oxidation of compounds to a gaseous form (gasification), nitrogen and sulfur, easily oxidized, are directly proportional to the loss of organic matter

- Vaporization of compounds that were solid at normal temperatures, nitrate

- Convection of ash particles in fire generated winds, loss of important plant development nutrients

- Leaching of ions in solution out of soils

Water

The increase of sediment into streams and rivers is often one of the most dramatic responses associated with fire. Loss of ground cover such as needles and small branches and the chemical transformation of burned soils make watersheds more susceptible to erosion from precipitation events. High precipitation events in the watershed, where at least 75 percent of the vegetation has been removed, can increase sediment discharge. Depending upon the amount of precipitation, the discharge to the basin can range from 0.1 to 0.8 acre-feet per acre of burned forest. Additional sediment storage can alter a stream's form and function in a deleterious manner. Studies in the Stanislaus National Forest indicate large intense fires produce an average of 20 to 50 tons of sediment per acre per year of erosion for the first 2 years (CDF 1995).

Changes in water quality due to wildfire are thought to be minimal and short-lived. However, in some cases, increases in specific ions or pH can cause fish mortality. Large woody debris jams will likely increase post-fire because of fire-killed snags falling into the stream, but new recruitment of debris will be reduced in subsequent years. In addition, retention of woody debris (which creates pools and habitat for fish) may be decreased post-fire because of increased flow.

Turbid waters tend to have higher temperatures and lower dissolved oxygen concentrations. A decrease in dissolved oxygen levels can kill aquatic vegetation, fish, and other aquatic organisms.

Increases (or decreases) in water temperature outside the tolerance limits can be detrimental or even lethal to aquatic organisms, especially cold-water fish such as trout and salmon (Brown 2000). Elevated temperatures may also occur due to loss of protective canopy.

Large intense fires have a much greater effect on stream ecology than smaller, less-intense fires. In addition, the proportion of the burned area within the watershed also influences the effects of the fire on stream ecology. Tree removal reduces evapotranspiration, which increases water availability to stream systems. Increased stream flows can scour channels, erode stream banks, increase sedimentation, and augment peak flows. Hoyt and Troxell first documented the effects of wildfire on stream flow in 1932. They found that burning chaparral caused the average annual stream flow of one specific creek to increase 29 percent. In addition they found that peak discharges and sediment loads carried by the streams also increased.

Air

National Ambient Air Quality Standards (NAAQS) are defined in the Clean Air Act as the amount of pollutants above which detrimental effects to public health or welfare may result. NAAQS has established criteria for particulate matter (PM) also called total suspended solids (TSP), based upon size. PM10 is particulate matter less than 10 microns in diameter and PM2.5 is less then 2.5 microns in diameter. The major pollutant for wildfire in smoke is fine particulate matter, PM10 and PM2.5. Studies show that 90 percent of all smoke particles emitted during wildland burning are PM10, and 90 percent of PM10 is PM2.5 (Sandberg et al. 2002).

Suppression of wildfires provides a short-term benefit to air quality by reducing the amount of vegetation consumed, which reduces smoke emissions. However, by delaying a natural event to a later date, poor air quality is simply pushed to a future time. Estimating the impacts from air pollutants is difficult in general, and is more complex in a wildland setting. Wildfire smoke, and in some cases prescribed burning, can affect visibility, human health, and vegetation. Overall air quality impacts of smoke are important, especially given the fact that the Sacramento Valley Air Basin has a non-attainment status for PM10. Wildland fires are categorized as an "area source" by many pollution agencies, since they tend to release pollutants over large areas (CDF 1999). A single wildfire that consumes 100 acres of heavy forest fuels can emit as much as 90 tons of particulate matter into the atmosphere. Wildfires generally occur during the time of year, Summer and Fall, when smoke and particulate matter is trapped in lower lying areas, increasing exposure to the effects of smoke and reducing visibility.

Health issues contributed to prescribed burns and wildfires affect the younger and older generations, as shown in Table 11-7. Reactions to smoke exposure range from itchy and scratchy throat to more serious reactions such as asthma, emphysema, and congestive heart failure (DEQ 2003).

Ozone, a product of biomass combustion, is a precursor to greenhouse gases. Although ozone produced by prescribed fire usually is quickly diluted and dispersed into the air, it may bring wildland fire under scrutiny as a contributor to the greenhouse effect.

Wildlife

Assessing the economic implication of fire on wildlife without a recognized valuation technique makes quantifying problematic. However, wildlife can be generally expressed in terms of the value of a consumptive use (i.e. hunting) or non-consumptive use (viewing, bird watching). Due to wildland fires, loss of revenue may be seen in hotels, restaurants, gasoline stations, and grocery stores because patrons are not visiting the area.

Table 11-7
HEALTH EFFECTS BASED ON VISIBILITY

Visibility	Health Category	Health Effects	Cautionary Statements
10 miles and up	Good	None	None
6 to 9 miles	Moderate	Possibility of aggravation of heart or lung disease among persons with cardiopulmonary disease and the elderly.	None
3 to 5 miles	Unhealthy for sensitive groups	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly.	People with respiratory or heart disease, the elderly and children should limit prolonged exertion.
1 to 2 miles	Unhealthy	Increase aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid prolonged exertion; everyone else should limit prolonged exertion.
1 mile	Very unhealthy	Significant aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; significant increase in respiratory effects in general population.	People with respiratory or heart disease, the elderly and children should avoid any outdoor activity; everyone else should avoid prolonged exertion.
Under 1 mile	Hazardous	Serious aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; serious risk of respiratory effects in general population.	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly and children should remain indoors.

Source: Air Quality: Department of Environmental Quality, Oregon

The major impact of wildfire on wildlife centers is its influence on vegetation structure and composition. The loss of down and dead woody material, during wild and prescribed burns, removes essential structural habitat components for a variety of wildlife and reduces species diversity. Loss of brush fields and forestlands restrict the ability of wildlife to forage for food and find shelter. Fire has the potential to accentuate impacts on fish and wildlife associated with other landscape fragmentation and development (timber harvesting, road building, and forest management practices). For fish, the primary concerns relative to fire are increases in water temperature, sediment loading, stream cover, and the long-term loss of woody debris from stream channels. Vegetation also decreases the rate of erosion along stream banks.

Change in species composition from intense wildfire favor early successional habitat and its assorted wildlife populations. Significant increases in browsing species populations (such as deer) are common following severe fire. Physical movement of animals is also enhanced after wildfire. However, in chaparral, mountain lions are attracted to the edges of the burned area where deer tend to congregate (Lyon et al. 2000). Low intensity fires do not generally result in significant changes to vegetation composition and resulting wildlife species, but may have similar benefits by increasing the diversity of vegetation mosaics providing better food and cover border areas. Low intensity fires tend to modify species composition and seral stage, thus affecting habitat elements used by wildlife. The overall effect on the wildlife population depends on the landscape distribution of those habitat components.

Bird populations generally respond to changes in food, cover, and nesting caused by fire. Fire effects on insect and plant-eating bird population depend on alterations in food and cover. Some species of birds may increase in numbers after a fire, such as the swallow, swifts, and flycatchers, allowing greater access to forage. Several species such as the California gnatcatcher require structure and cover provided by mature scrub (Lyon et al. 2000). Bird nest site selection, territory establishment, and nesting success can be affected by season of fire. Spring burns may destroy active nest (Lyon et al. 2000).

Direct effects on wildlife population due to wildfires vary, depending on body size, mobility of the species, and intensity of the fire. The majority of animals move away from wildfires, but some (insectivorous birds, raptors) may be attracted, to take advantage of available prey (Lyon et al. 2000). Large mammal mortality most likely occurs when fire fronts are wide and fast moving, fires are actively crowning, and thick ground smoke occurs (USGS 2000). Although few studies have been conducted, it is believed that losses to wildlife caused by fire are negligible. The large fires of 1988 in the greater Yellowstone area killed about 1 percent of the elk population. Most of the larger animals died of smoke inhalation (Lyon et al. 2000). However, like birds, spring fires may impact mammal population due to limited ability of cover and the availability of food. Carnivores and omnivores are opportunistic species and although little increase in species occurs, they tend to thrive in areas where their preferred prey or forage is most plentiful, often in recent burn areas (Lyon et al. 2000).

Recreation

Wildfire impacts recreation values through loss of use, reduced wildlife habitat, and change in species mix of vegetation. Areas burned that attract visitors for hunting and fishing will diminish in value after wildfire, as visitors are not attracted to burned forests. Wildlife that loses habitat and forage will disperse to other locations, resulting in lower hunting numbers for several years.

While direct economic loss from land use can be measured, it is more difficult to estimate losses to recreational activities. Recreation use numbers tend to display visitors in terms of users per day and are detailed toward specific attractions (campgrounds, park, and forests). Three National Park Service (NPS) studies determined that air quality conditions affected the amount of time and money visitors are willing to spend at NPS units.

Within the watershed boundaries the most important industries are related agricultural and grazing. With over half of the watershed covered by grasslands and oak woodlands, this is an area historically devoted to rangeland. Fires in this type of vegetation can move quickly and can cover large areas. As the population of Tehama County grows, urban areas are being stretched and pushed outward into these traditional rangelands. In the Tehama-Glenn Unit Fire Plan, CDF notes that these circumstances have required them to place a greater emphasis on the protection of structures and lives (CDF 2004).

In addition to human loss, ranchers in the watershed also face the loss of feed. If the rangelands burn in the summer, the grasses will not regenerate until the spring. With the loss of feed, ranchers then have to truck in outside feed to their cattle.

CDF FIRE ZONES

The California Department of Forestry and Fire Protection has divided Tehama County into a number of fire zones (shown on Figure 11-5). Zones within the Tehama West Watershed are shown on Table 11-8.

Table 11-8
CHARACTERISTICS OF CDF ZONES

Zone	CDF Battalion	Fuels	Topography	Access	Water Supply	Level of Service	Primary Assets
1. Red Bank, R-Ranch, Paskenta	3 4	Oak-woodland, chaparral, brush	Rolling to steep hills	Poor: mostly rugged, difficult	Poor: steep drainages, seasonal ponds and streams	3 fire stations, 1 conservation camp	Communities, ranches, rangeland, and ag lands
1. Bowman, Dibble Creek, Lake California, Wilcox	2 3	Grass rangeland, oak woodland, brush	Rolling to steep hills	Moderate to poor: some rugged terrain	Moderate: water sources range from adequate to poor	3 fire stations	Homes, ranches, structures, rangelands, watersheds
6. Live Oak, West Red Bluff	3	Grass rangeland, oak woodland, brush	Rolling hills	Good (moderate in western portion of zone)	Variable poor to good	2 fire stations	Rural homes, ranches, rangelands
9. Flourney, Rancho Tehama	3 4	Grass rangeland, oak woodland, brush	Rolling hills	Moderate	Variable poor to moderate	2 fire stations	Communities, rural homes, ranches, rangelands

Zone 1

Zone 1 encompasses much of western Tehama County and includes the communities of Paskenta and R-Ranch along with the Red Bank District. Besides residences and urban infrastructure, fires in this zone threaten timberlands, rural ranches, and agricultural land. Grassy fuels at lower elevations present the primary fire threat within this zone. These fuels are often located where the threat of human caused ignition is greatest such as in developed areas and along major roads. In addition, these "flashy" fuels ignite easily and carry fire rapidly. The other vegetation types in the area that affect fire danger include blue oak and live oak-woodlands along with mixed chaparral brush. Between 1994 and 2004, the leading causes of wildfire in this zone was vehicle and equipment use. Zone 1 is particularly affected by severe weather because high winds carry fire quickly through the predominantly grass and brush covered lands. Much of the area is difficult to access with fire equipment (TCRCD 2005).

Zone 2

Zone 2 encompasses the northern valley floor of Tehama County and includes the Lake California development and rural communities of Bowman, Wilcox, and Dibble Creek. Most undeveloped land in the area is used for livestock grazing. Three vegetation types are present in the zone including grassland, chaparral, and oak-woodland. Grasses are the major fire risk. Expanding human population in this zone is accompanied by an increasing threat of fires along the wildland urban interface. Activity along roads (e.g. equipment use, vehicle exhaust, and smoking) has been the leading cause of vegetation fires from 1994 to 2004. Fires in grasslands may spread quickly into inaccessible areas (TCRCD 2005).

Zone 6

Zone 6 is located in central Tehama County. Human population is concentrated in the eastern part of the zone adjacent to the City of Red Bluff. There are many rural ranch houses and ranchettes in the area. These developments and the rangelands surrounding them are considered to be the primary assets at risk of fire. Equipment use, arson, and other human activities are a significant cause of fire in the zone (TCRCD 2005).

Zone 9

Zone 9 encompasses much of the southern portion of Tehama County and includes the residential communities of Flournoy and Rancho Tehama. Vegetation is a mixture of grassland, chaparral, and woodland. Grasses are the major carrier of fire. The zone has the second highest occurrence of fires during the period from 1990 to 2001. High winds in the zone can spread fires rapidly (TCRCD 2005).

FEDERAL RESPONSE AREA WEST

Federal Response Area West (FRA) consists of federal lands managed by the Mendocino and Shasta-Trinity National Forests. Within the Tehama West Fire Plan project area FRA lands are exclusively within the boundaries of the Mendocino National Forest. Portions of these lands are protected from wildfire through cooperative response agreements with CDF. Under this agreement, the firefighting agency having available equipment and manpower closest to a wildfire incident will respond. In addition, some federal lands are protected on a permanent basis utilizing CDF firefighting resources, and some non-federal land adjacent to the National Forest is protected by USFS resources.

LOCAL RESPONSIBILITY AREA

In addition to lands within Tehama County under direct state fire protection responsibility and those protected through intergovernmental agreements established between the State of California and federal firefighting agencies, portions of the county, particularly in the valley regions closest to the Sacramento River, are classified as Local Responsibility Areas (LRA). Within these LRAs, fire protection is provided by the County Fire Department, other local firefighting entities, or through CDF via contract. At the present time, fuels reduction efforts within the LRAs are limited to wildlands and other areas along the Sacramento River.

FIRE HAZARDS AND RANKINGS

The California Department of Forestry and Fire Protection provides fire and other resource information to the public through FRAP. California Public Resource Code 4789 requires CDF to periodically assess California's forest and rangeland resources. FRAP data layers are presented to describe graphically the fire environment within the Tehama West Watershed.

Figure 11-1 shows the average hazard rating for areas throughout the Tehama West Watershed. Zones are classified into three ratings: moderate, high, or very high. Zones were delineated based on areas with similar vegetative cover, slope, and weather. The zones are designed to give an average hazard rating for the area and do not define the exact conditions for all areas within the zones.. Variations in fuels, slope, weather, aspect, elevation, and air stability will influence hazard conditions at actual locations within each zone. For individual structures, the risk of damage from fire also depends on site-specific factors such as access, water supply, clearance, and characteristics of the structure. As a result, the fire hazard map cannot be used as a measure of risk to individual structures (TCRCD 2005).

Surface Fuels

Surface fuels are generally described as vegetative materials near the ground through which fire will spread. These fuels include downed woody material such as dead branches, longs, and other loose surface litter on the soil surface along with living plants such as grasses, shrubs, tree seedlings, and forbs. The amount, size, and moisture content of surface fuel types determine how fast a fire spreads, how hot it burns, and how high its flames reach. CDF has developed surface fuels data by translating vegetation data from a variety of sources into several fuel characteristic models used to predict fire behavior. The fuel models are based on vegetation attributes such as cover type, vegetation type, size, and crown closure, as well as other factors such as slope, aspect, elevation, and topography. Annual fire perimeter data is used to update fuel model characteristics based on "time since last burned" to account for both initial changes in fuels resulting from fuel consumption by the fire and for vegetation re-growth (TCRCD 2005) (see Figure 11-6).

Fire Threat

Fire threat is a combination of fire frequency or the likelihood that a given area will burn as well as potential fire behavior. These two factors are combined to create four threat classes ranging from moderate to extreme. Fire threat can also be used to estimate the potential for impacts on various assets and values susceptible to wildfire. Impacts are more likely to occur and/or be of increased severity for higher threat classes. CDF calculated a numerical index for fire threat based on the combination of fuel rank and fire rotation class. A one to three ranking of fuel ranks was summed with the one to three ranking from rotation class to develop a threat index ranging from two to six. This threat index is then grouped into four threat classes. Areas that do no support wildland fuels (e.g. open water, agriculture lands, etc.) were omitted from the calculation; however, areas of very large urban centers were left but received a moderate threat value (TCRCD 2005) (see Figure 11-7).

Condition Class

Condition class refers to the general deviation of an ecosystem from its pre-settlement or natural fire regime. It can be viewed as a measure of sensitivity to fire damage, or a measure of fire-related risk to ecosystem health. Classes are assigned based on current vegetation type and structure, an understanding of its pre-settlement fire regime, and current conditions regarding expected fire frequency and potential fire behavior. The conceptual basis for assigning condition classes is that in fire-adapted ecosystems much of their ecological structure and processes are driven by fire, and disruption of fire regimes leads to many alterations to the ecosystem including changes in plant composition and structure, uncharacteristic fire behavior and other disturbance agents (pests), altered hydrologic processes, and increased smoke production. Condition Class 1 is associated with low level disruption of fire regime, and consequently low risk to loss or damage to the ecosystem. Condition Class 2 indicates some degree of departure from natural fire regimes, with some loss and change in elements and processes within the ecosystem. Condition Class 3 is highly divergent from natural regime conditions, and represents the highest level of risk of loss (TCRCD 2005) (see Figure 11-8).

Fire Regime

Fire regime refers to the pattern and variability of fire occurrence and its effect on vegetation. A simple statewide fire regime classification system provides an approximate idea of the range in fire frequency and severity as it existed before European settlement. This classification is based on a similar classification system developed in conjunction with the Coarse-Scale Condition Class assessment done for the National Fire Plan, modified from the USFS National Fire Plan Condition Class Assessment. This classification, while highly generalized, can illustrate only coarse differences in fire regimes (TCRCD 2005) (see Figure 11-9).

FIRE PROTECTION

The issue of fire protection in western Tehama County is an ongoing juggling act. Most of the watershed is located within the CDF's area of responsibility. Due to budget constraints, state fire protection resources have been strained. In an effort to counteract this, the Tehama-Glenn unit analyzed the area based on asset value and fire risk. This analysis allowed the unit to identify those areas that would potentially have a higher need for emergency fire response and the effort has been made to shift emphasis to these high-risk areas. In addition to the steps taken by CDF, there are some Tehama West communities that are listed on the National Registry of 'Communities at Risk.' They are Corning, Hamilton City, Paskenta, R-Ranch, and Red Bluff. All of these communities have high fire threat rankings (CDF 2004).

Firefighting responsibilities in Tehama County are divided into a number of organizational units whose responsibilities are described below. Those fire fighting units dealing primarily with fires within Western Tehama County's wildlands and wildland/urban interface areas are listed in Table 11-9 and shown in Figure 11-10.

Table 11-9
SUMMARY OF FIRE FACILITIES WITHIN WESTERN TEHAMA COUNTY

Department	Station Name	Address	City
CDF/Tehama County Fire Department	Baker	14800 Bowman Road	Cottonwood
CDF/Tehama County Fire Department	Bowman	18355 Bowman Road	Cottonwood
CDF/Tehama County Fire Department	Corning	988 Colusa Street	Corning
CDF/Tehama County Fire Department	El Camino	9580 Highway 99W	Proberta
CDF/Tehama County Fire Department	Paskenta	P.O. Box 211	Paskenta
CDF/Tehama County Fire Department	Red Bank	15905 Red Bank Road	Red Bluff
CDF/Tehama County Fire Department	Red Bluff	604 Antelope Boulevard	Red Bluff
USFS	Paskenta	Paskenta Road	Paskenta
USFS	Log Springs	Log Springs Ridge	Tehama County
USFS	Cold Springs	Cold Springs Ridge	Tehama County

City of Red Bluff Fire Department

Primary responsibility for this department is for the City of Red Bluff and rural areas immediately adjacent to the city limits. The department operates one fire station.

City of Corning Fire Department

Primary responsibility for this department is for the City of Corning and areas immediately adjacent to the city limits. The department operates one fire station.

Tehama County Fire Department

Primary responsibility for this department is for Tehama County's LRA. The department operates seven fire stations within the watershed. One of these (Bowman Station) shares facilities with the CDF.

Gerber Fire Protection District

The Gerber station is run by volunteers from the Gerber community. It is a separate entity from the Tehama County Fire Department and is dispatched by the Tehama-Glenn Unit of CDF.

California Department of Forestry and Fire Protection

The California Department of Forestry and Fire Protection is responsible for controlling wildland fires on 283,778 acres of SRA lands throughout Tehama County and has fiscal responsibility over an additional 10,767 acres of SRA lands, which are directly protected by the USFS. California Public Resources Code 4125 establishes that local and federal agencies have primary responsibility for fire prevention and suppression in all county areas not classified as SRA. In addition to the stations within the county with which the CDF either operates or is responsible for, other firefighting resources are available in neighboring counties including aerial attack bases.

The California Department of Forestry and Fire Protection and the California Department of Corrections operate the Salt Creek Conservation Camp minimum-security facility jointly. The camp provides inmate fire crews, which can be dispatched throughout the county as well as the entire state. At the present time, the camp has one wildland engine, a bulldozer, as well as various service and transportation equipment.

U.S. Forest Service

The Mendocino National Forest manages the majority of lands within the westernmost portion of the watershed. The primary responsibility of this agency is for the control and suppression of wildland fires (not structural fires) on federal land. Within the watershed, the USFS operates three fire stations (Paskenta, Log Springs, and Cold Springs). Crews and fire equipment are also available at stations located within the Mendocino National Forest boundaries in Glenn, Mendocino, Colusa, and Lake Counties. In addition, the agency has access to substantial firefighting personnel and equipment throughout the region, utilizing operating agreements established between the national forests.

Bureau of Land Management

The Bureau of Land Management (BLM) oversees the management and operation of 23,300 acres within its Yolla Bolly Fire Management Unit located in Western Tehama County. At the present time, either the USFS or CDF conduct all fire suppression operations on these lands. In the event of a wildfire, BLM fire management and fuels personnel would serve as duty officers and agency representatives to an interagency team. In addition, a number of local BLM staff has Red Cards, which allow them to join fire suppression forces if needed.

Interagency Approach to Firefighting in Tehama County

Wildland fires ignore civil boundaries. Consequently, it is necessary for cities, counties, special districts, as well as state and federal agencies, to work together in order to minimize the adverse impacts of wildfires. All Tehama County fire fighting organizations are coordinated through automatic mutual aid agreements to assist one another as needed. This interagency array of firefighting forces is dispatched by the Tehama-Glenn Emergency Command Center (TGECC) in Red Bluff according to a Standard Response Plan (SRP). The TGECC will dispatch fire engines, other emergency equipment, and personnel from the closest resources available to fill the requirements of the SRP, regardless of jurisdiction.

Communities at Risk

In an attempt to improve this situation, federal fire managers authorized state foresters to determine which communities adjacent to federal lands were exposed to a significant threat from wildland fire originating on public property. The CDF undertook the task of generating a state list of at-risk communities that, in the case of California, included developed areas located away from the immediate vicinity of federal lands. In developing the California list, CDF assessed all areas of the state regardless of ownership.

Three main factors were used to determine fire threats to wildland urban interface areas within the state:

- Fuel hazards ranking (ranking vegetation types by their potential fire behavior during a wildfire)
- Assessing the probability of fire (the annual likelihood that a large damaging wildfire would occur within a particular vegetation type)

- Assessing housing densities in wildland urban interface areas (areas of intermingled wildland fuels and urban environments that are in the vicinity of fire threats)

Out of this statewide assessment, a list of 1,283 fire threatened communities was developed. Of these threatened communities, 843 were found to be adjacent to federal lands. Table 11-10 lists the officially recognized communities in the watershed. The Hazard Level Code designates the fire threat level for the communities with a "3" indicating the highest level of threat.

Table 11-10
OFFICIALLY RECOGNIZED COMMUNITIES AT RISK WITHIN THE TEHAMA WEST WATERSHED

Community Number	Community Name	Federal Threat	Hazard Level
85	Bend	F	2
257	Corning		3
283	Dairyville		2
656	Los Molinos	F	2
920	Red Bluff	F	3
1204	Wilcox	F	2
835	Paskenta	F	3

FUEL REDUCTION METHODS AND MAINTENANCE

Tehama County RCD is currently in the process of compiling a Fire Plan. Within the Tehama West Watershed the RCD has been focusing their attention on the Elder Creek Watershed. The hope is to expand their efforts to other drainages such as Reeds, Red Bank, and Thomes Creeks, as additional funding and time are made available. Since the Fire Plan is not yet completed for the watershed, the following fuel management plans and policies have been taken from a variety of sources that address general concerns, fuel loads, and fuel management issues of a nature similar to those faced by public and private entities within the watershed. These sources include CDF's 2004 Tehama-Glenn Unit Fire Management Plan, the Shasta West Fire Plan, and other various local and national fire plans.

Fuel Management Plan

One of the first steps in fuel management strategy is the development of a fuels management plan. The Tehama County Resource Conservation District is in the process of completing a Fire Plan with the help of the Tehama-Glenn Fire Safe Council. Based upon the goals and desires stated by the Tehama-Glenn Fire Safe Council, the plan will focus on fire management, fuel reduction and fire prevention issues within Tehama and Glenn Counties. Specific attention will be focused on the Elder Creek drainage located within the Western Tehama Watershed. The goal is to develop a plan that deals with both wildland and urban interface issues such as smoke regulation, coordination between agencies and landowners in regards to prescribed burning and wildland fire incidents, fire prevention and public education, fire training for land managers, and fuel break and vegetation treatment projects (CDF 2004). The Council will adapt the plan designed for Elder Creek to other drainages located in Tehama West Watershed as funding and time allows. As the plan has not yet been concluded, this section draws upon solutions brought forth by other agencies that have responsibility areas within the watershed, as well as from other Fire Safe and Resource Conservation Districts in Northern California, facing the same issues and situations as those faced in western Tehama County.

The Tehama West Watershed faces the growing problem of expansion of development into increasingly remote and historically fire prone areas. This mix is known as urban interface areas. These areas usually fall outside the boundaries of local fire districts and in State Responsibility Areas (SRA) that are handled by CDF. This adds a new complication to standard wildland firefighting tactics as the focus is shifted to include the need to protect human life and property. As such, CDF has recognized the need to educate residents in the urban interface areas on topics such as fuel management, proper clearance around structures, and responsible, fire safe behavior during fire seasons. The Tehama-Glenn Unit understands the positive impact that groups such as Resource Conservation Districts and local Fire Safe Councils have when reaching the public and garnering funds for projects that focus on fuel management, reduction, and education of landowners.

Shaded Fuel Breaks

Shaded fuel breaks are constructed as a means to create a defensible space in which firefighters can conduct relatively safe fire suppression activities. Fuel breaks may also slow a wildfire's progress enough to allow supplemental attack by firefighters. The main idea behind fuel break construction is to break up fuel continuity and prevent a fire from reaching the treetops, thus forcing the fire to stay on the ground, where it can be more easily and safely extinguished. Fuel breaks may also be utilized to replace flammable vegetation with less combustible vegetation that burns less intensely. In addition to fuel reduction, a well-designed shaded fuel break also provides an aesthetic setting for people and a desirable habitat for wildlife. The California Board of Forestry has addressed the requirement to strengthen community fire defense systems, improve forest health, and provide environmental protection.

- Fuel breaks should be easily accessible by fire crews and equipment at several points. Rapid response and the ability to staff a fire line are very important for quick containment of a wildfire.

- The edges of a fuel break are varied to create a mosaic or natural look. Where possible, fuel breaks should compliment natural or man-made barriers such as meadows, rock outcroppings, and roadways.

- The most important component is maintenance. A maintenance plan should be developed before construction of a fuel break. Although a fuel break can be constructed in a few weeks, maintenance must be conducted periodically to keep the fuel break functioning properly.

- The establishment of a shaded fuel break can lead to erosion if not properly constructed. Short ground cover, such as grass, should be maintained throughout the fuel break to protect the soil from erosion.

- A properly treated area should consist of well-spaced vegetation with little or no ground fuels or understory brush. Tree crowns should be approximately 10–15 feet apart. The area should be characterized by an abundance of open space and have a "park like look" after treatment.

Mechanical Treatments

Mechanical methods to remove fuels include, but are not limited to, the utilization of bulldozers with or without brush rakes, excavators, chainsaws, mechanized falling machines, masticators, chippers, and grinders. Mechanical treatments are typically conducted on chaparral landscapes with some type of masticator, which grinds standing brush and reduces it to chips, which are typically left on the ground. Brush may also be mechanically removed and fed into a grinder for biomass production. Mechanical treatments are also utilized on industrial and non-industrial timberlands, where trees are thinned by mechanized tree cutting or falling machines. In most cases stands of trees are thinned from below as a means to eliminate the fuels that allows a fire to shoot higher into the tree canopy (ladder fuels). However, stands of trees may also be thinned from above to eliminate crown continuity.

Due to air quality concerns, the mechanical treatment method is fast becoming the acceptable method of fuel reduction in Urban Interface areas. Compared to prescribed fire, mechanical treatment involves less risk, produces less air pollutants, is more aesthetically pleasing and allows landowners to leave desirable vegetation.

Defensible Fuel Profile Zones (DFPZs) are strategically located lineal fuel reduction and fire protection areas that are generally constructed a quarter mile wide along public and private roads that traverse communities, watersheds, and areas of special concern. These are similar to shaded fuel breaks. The shaded fuel break objective is to reduce fire intensity, while DFPZ fuel management is designed to allow fire fighters quicker and safer access for attacking and suppressing oncoming forest fires. The DFPZ is more of a defensive line fighting area that manages fire behavior through fuels management. The lineal connectivity of the DFPZ network allows various property owners within a watershed the opportunity to connect fuel reduction projects to adjoining properties through local County Fire Safe Councils. The DFPZ network is the starting point for addressing the scale of the existing hazardous fuel problems at the appropriate pace of annual acres treated.

DFPZs are best placed primarily on ridges and upper south and west slopes and, where possible, along existing roads. They also should be located with respect to urban-wildland intermix and other high-value areas (such as old-growth or wildlife habitat areas), areas of high historical fire occurrence, and/or areas of heavy fuel concentration. Thinning from below and treatment of surface fuels can result in fairly open stands, dominated mostly by larger trees of fire-tolerant species. DFPZs need not be uniform, monotonous areas, however, but may encompass considerable diversity in age, size, and distribution of trees. The key feature should be the general openness and discontinuity of crown fuels, both horizontally and vertically, producing a very low probability of sustained crown fire. DFPZs should offer multiple benefits by providing not only local protection to treated areas (as with any fuel-management treatment) but also safe zones, within which firefighters have improved odds of stopping a fire. In addition DFPZs interrupt the continuity of hazardous fuels across a landscape, and provide various benefits not related to fire, including improved forest health, greater landscape diversity, and increased availability of relatively open forest habitats dominated by large trees.

Prescribed Fire

Prescribed fire is the controlled application of fire to the land used to accomplish specific land management goals. These goals can vary from annual burning around residences to clear grass and weeds, agricultural field burning for preparation of crop planting, range improvement burning, burning of brush piles, and landscape burning of forest to remove brush and accumulation of forest fuel. Forestlands can benefit from prescribed fire by attempting to regulate or moderate the frequency and intensity of wildfires. The advantages of using fire and improvement cuttings to restore and maintain seral, fire-resistant species include:

- Resistance to insect and disease epidemics and severe wildfire
- Providing continual forest cover for aesthetics and wildlife habitat
- Frequent harvests for timber products
- Stimulation of forage species
- Moderate site disturbance that allows for tree regeneration

By returning to regular burning, forests can achieve a measure of protection from catastrophic loss, by reducing the amounts and concentration of brush and other forest fuels.

Prescribed fire can also be an effective tool for managing fuels. In most forested areas, however, fuel structures are currently too hazardous to safely attempt prescribed ignitions without pre-treating the stand mechanically. Planned non-suppression fires are fires resulting from unplanned ignitions (caused by either lightning of humans). In areas that prescribed natural fire, plans have been adopted that specify conditions under which planned non-suppression fires are allowed to burn. Following specific fire management activities, prescribed natural fire planning represents an important opportunity to have wildfire help meet watershed management objectives.

A key element to fuel management planning is the initiation of market uses for small trees and biomass removed from wildlands under fuels management programs. The intensity and temperature of most prescribed fire scenarios are significantly less than catastrophic wildfire and produce positive rather than negative ecosystem impacts. Benefits of prescribed fire include:

- Reduction of fuel buildup of dead wood, overcrowded, unhealthy trees and thick layers of pine needles and ground vegetation that can contribute to larger in size, intensity, and more uncontrollable fires

- Thinning of overcrowded forests that have previously been thinned by fire. These forests are generally healthier and more vigorous, recover quicker, and are more resistant to insect and disease attacks

- Preparation of the site for new growth by removing excess vegetation. As the excess vegetation is burned, nitrogen and other nutrients are released, allowing the soil to be receptive for new plants to grow and allowing conifer seeds to germinate. Additionally, some forms of conifers and brush (knob cone pine, lodge pole pine manzanita, deer brush) rely on frequent fire for germination of seeds and new growth development

- Creation of diverse vegetation for wildlife by having varying ages and type of plants available for animals to forage on, and find shelter in. Wildlife that graze (deer, elk) benefit from new growth as young plants provide more nutrients. Fire can create more open stands that allow predators to be seen and down wood for small mammals and insects

- Increase in water and spring yield by removing encroaching chaparral and shade-tolerant species and decreasing evapotranspiration. Increases occur in local springs and groundwater discharge to creeks. Significant increased flows are common after fires; and spring yield may increase as much as 200 percent (Bursy, undated)

- Increase in nutrients such as phosphorus, potassium, calcium, and magnesium in the ash deposits (Ahlegren and Kozlowski 1974)

The California Vegetation Management Plan (CVMP) is a cost-sharing program that focuses on the use of prescribed fire and mechanical means for addressing wildland fire fuel hazards and other resource management issues on State Responsibility Area (SRA) lands. The use of prescribed fire mimics natural processes, restores fire to its historical role in wildland ecosystems, and provides significant fire hazard reduction benefits that enhance public and firefighter safety.

CVMP allows private landowners to enter into a contract with CDF to use prescribed fire to accomplish a combination of management goals on both forestlands and grasslands. Since 1981 approximately 500,000 acres (an average of 31,000 acres per year) have been treated with prescribed fire under CVMP in California. Cost of the prescribed burning averages $25 to $30 per acre but can vary, based on the number of acres and resources necessary for the prescribed fire project. This cost, sharing program includes the landowner paying approximately 25 to 30 percent of the total project costs.

The recent CVMP and other prescribed burns in the watershed are included on Table 11-11.

Wildland Fire Use

Wildland Fire Use is the management of lightning and other naturally caused fires to accomplish resource management objectives. The current and forecasted weather conditions, fuel conditions, availability of fire resources, and resource goals for the specific site are all taken into account before designating a particular fire as fire use. These factors are then continuously monitored as the fire progresses. Furthermore, extremely detailed plans are drafted that outline the conditions required for the fire to continue burning under this designation. The presence of structures in the vicinity of a fire often excludes that area as a fire use zone.

Table 11-11
CDF VEGETATION MANAGEMENT PROGRAM
PROJECT DATA 1979 TO 2005

Year	Project Name	Acres	Agency
1979	Roney	865.51	CDF
1981	Roney	1,397.09	CDF
1983	Brushy	1,098.30	CDF
1983	Partch	1,018.60	CDF
1983	Plum Creek	1,061.43	CDF
1984	A & K (Meyers)	455.05	CDF
1984	Brushy	4,716.72	CDF
1985	Keenan	166.68	CDF
1985	Rancho Rio Frio	115.53	CDF
1986	Burrows	438.34	CDF
1986	Cameron	2,030.52	CDF
1987	Rancho Rio Frio	15.17	CDF
1987	Rio Frio	160.29	CDF
1987	Storer	346.23	CDF
1987	Vantress	126.34	CDF
1988	Brushy Mountain	7,105.64	CDF
1988	Cox	311.56	CDF
1988	Grapevine	1,797.92	CDF
1989	Rancho Rio Frio	265.59	CDF
1989	Roseburg	267.57	CDF
1989	Vantress	125.17	CDF
1990	Bald	3,939.87	CDF
1990	Cohasset	1,300.25	CDF
1990	Giovanetti	321.94	CDF
1990	Round Valley	323.13	CDF
1990	Sunflower	275.11	CDF
1991	Giovanetti	209.40	CDF
1991	Nature Conservancy	805.82	CDF
1991	Roseburg 91	1,004.42	CDF
1992	PG&E	227.43	CDF
2003	Grindstone Type Conversion	216.21	USFS
2003	SPI VMP BURN	48.79	CDF
2004	Grindstone Brush (GS)	1,946.67	USFS
2004	Valentine Ridge	98.38	USFS
2005	Little Wildcat	854.75	CDF
2005	Little Wildcat 2	854.45	CDF

DATA GAPS

No major data gaps were identified during the watershed analysis process. The upcoming Tehama West Fire and Fuels Management Plan will be a detailed document presenting significant planning and implementation projects.

CONCLUSIONS AND RECOMMENDATIONS

The following recommendations apply to fire and fuel related activities in the watershed.

- Implement Tehama West Fire and Fuels Management Plan
- Identify projects that result in the protection of residents and firefighters, and public and private properties, such as projects that:
    - Provide immediate and direct impacts on the threat and intensity of wildfires such as fuel breaks and fuel reduction projects
    - Result in improvements to firefighting and fire protection infrastructure including access for firefighting forces, egress of residents along with water storage, and water delivery system upgrades
    - Involve regulatory matters such as changes in laws, ordinances, and codes that relate to fire safety and fire management
    - Formally classify a number of small communities as officially recognized communities at risk and identify these communities' Wildland Urban Interface areas
    - Improve water storage handling and delivery systems to be used for fire suppression in the county
    - Provide incentives to property owners that provide access to water storage structures during fire events
    - Review the Tehama County building and land development standards and zoning
        - Fire hydrants and fire sprinklers
        - Ingress and egress provisions
        - Densities
        - Evaluate wood shake roofs and clearance standards
        - Fire safe landscaping
    - Public outreach
    - Tehama County-wide adjoining county fire plan

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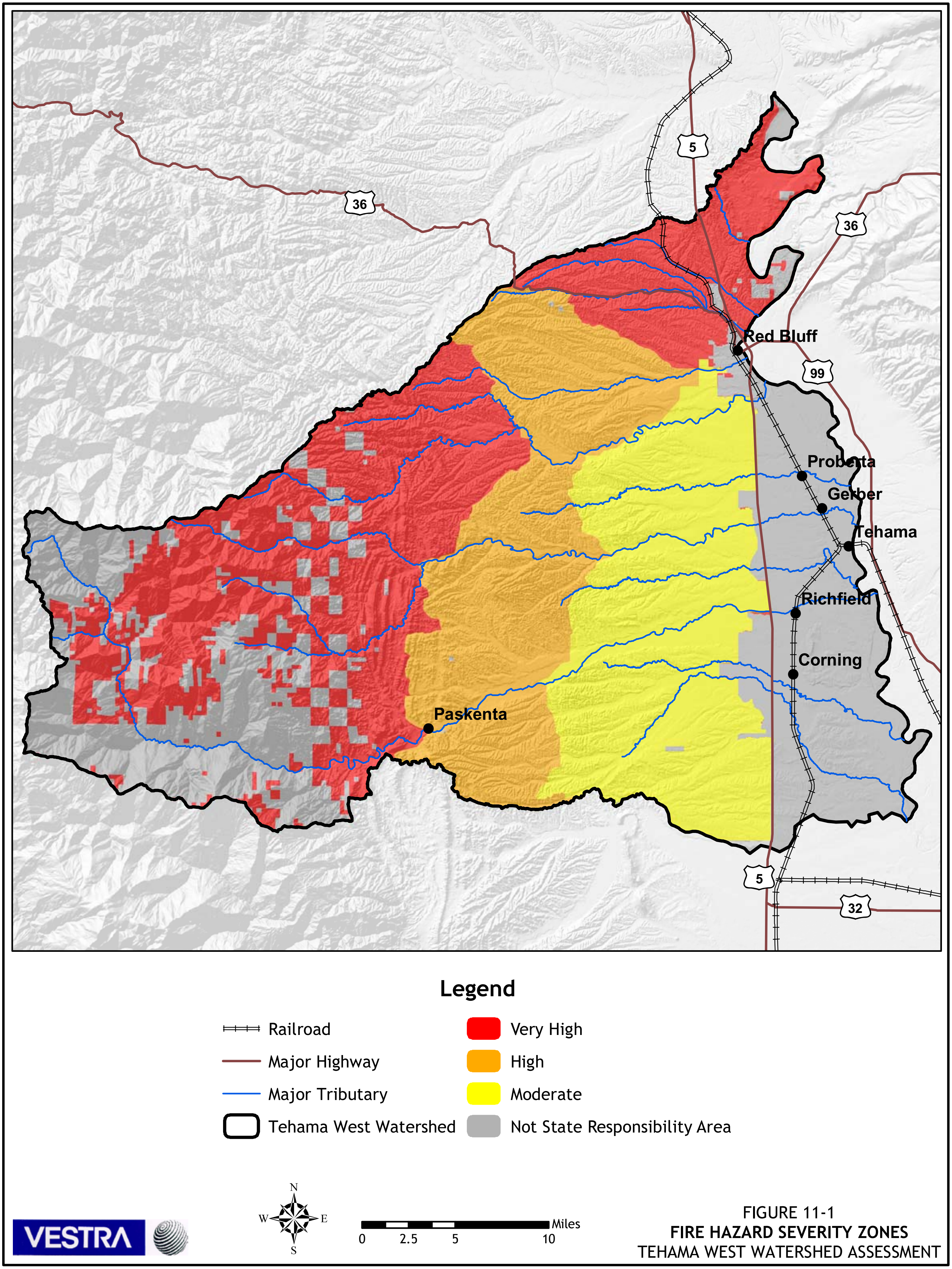
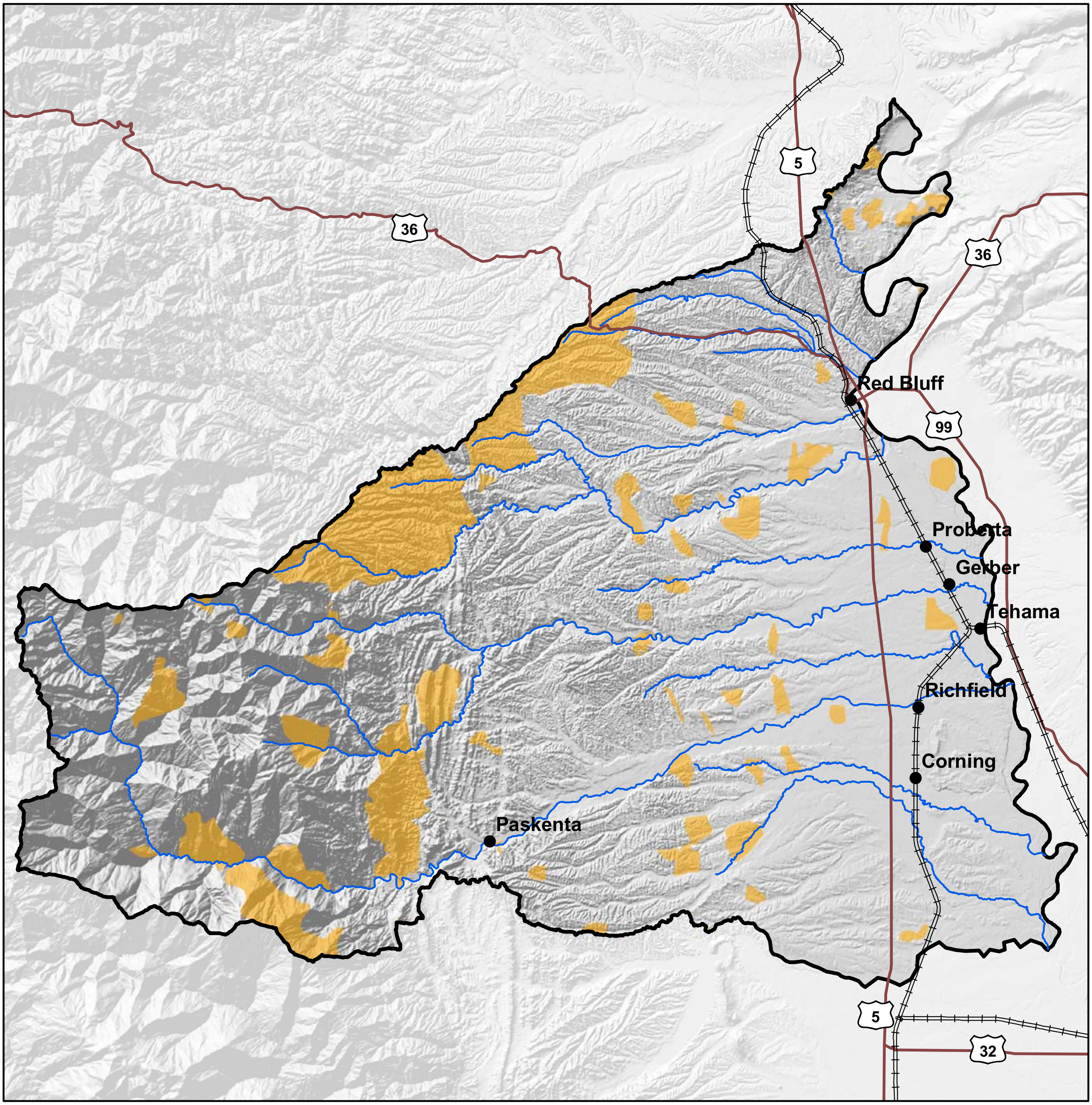


FIGURE 11-1
FIRE HAZARD SEVERITY ZONES
TEHAMA WEST WATERSHED ASSESSMENT

SOURCE: CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION



Legend

Railroad

Major Highway

Major Tributary

Tehama West Watershed

Historical Fire Area

N W E S

0 2.5 5 10 Miles

VESTRA

FIGURE 11-2
HISTORICAL FIRE BOUNDARIES
TEHAMA WEST WATERSHED ASSESSMENT

SOURCE: CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

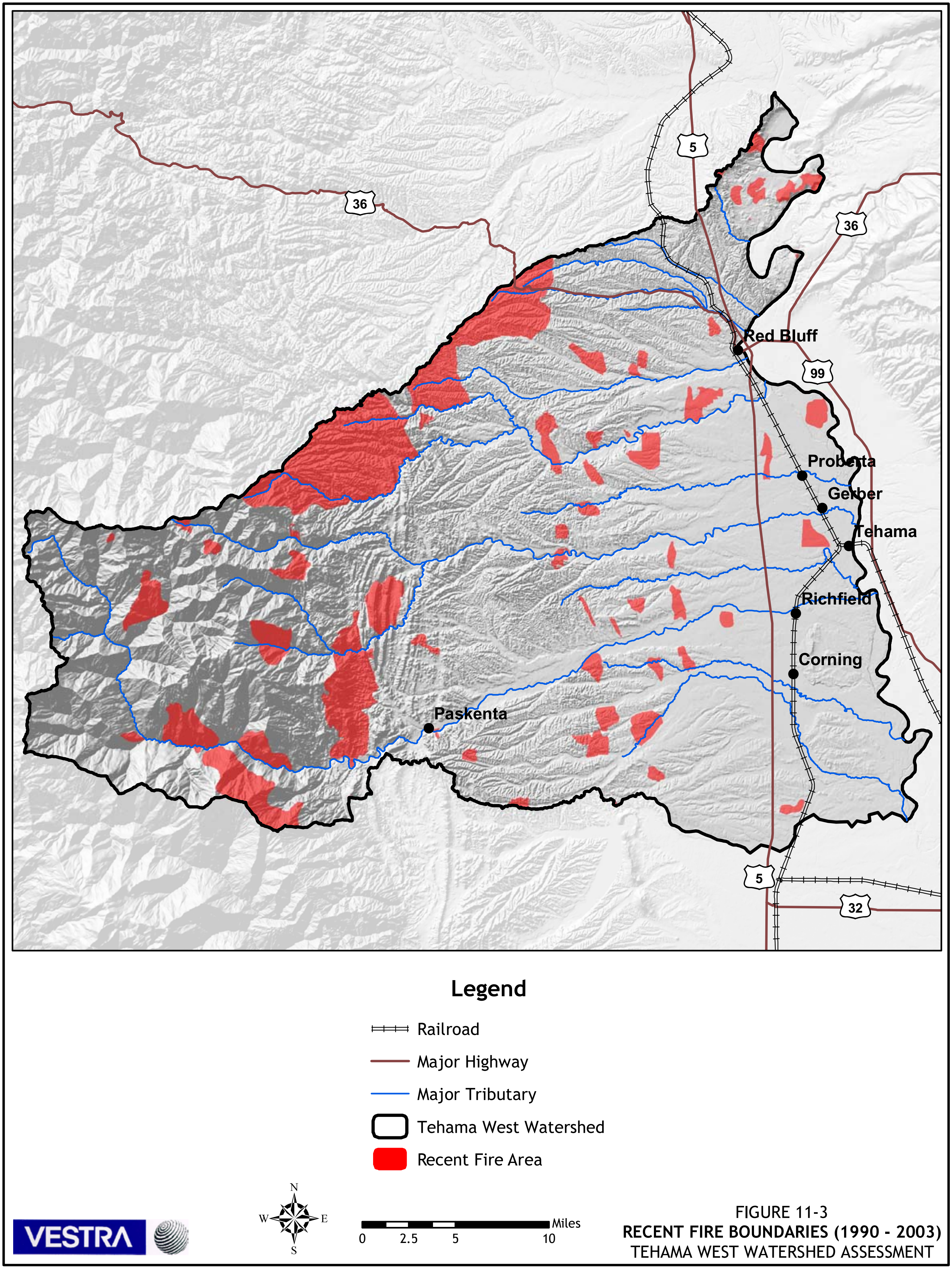


FIGURE 11-3
RECENT FIRE BOUNDARIES (1990 - 2003)
TEHAMA WEST WATERSHED ASSESSMENT

SOURCE: CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

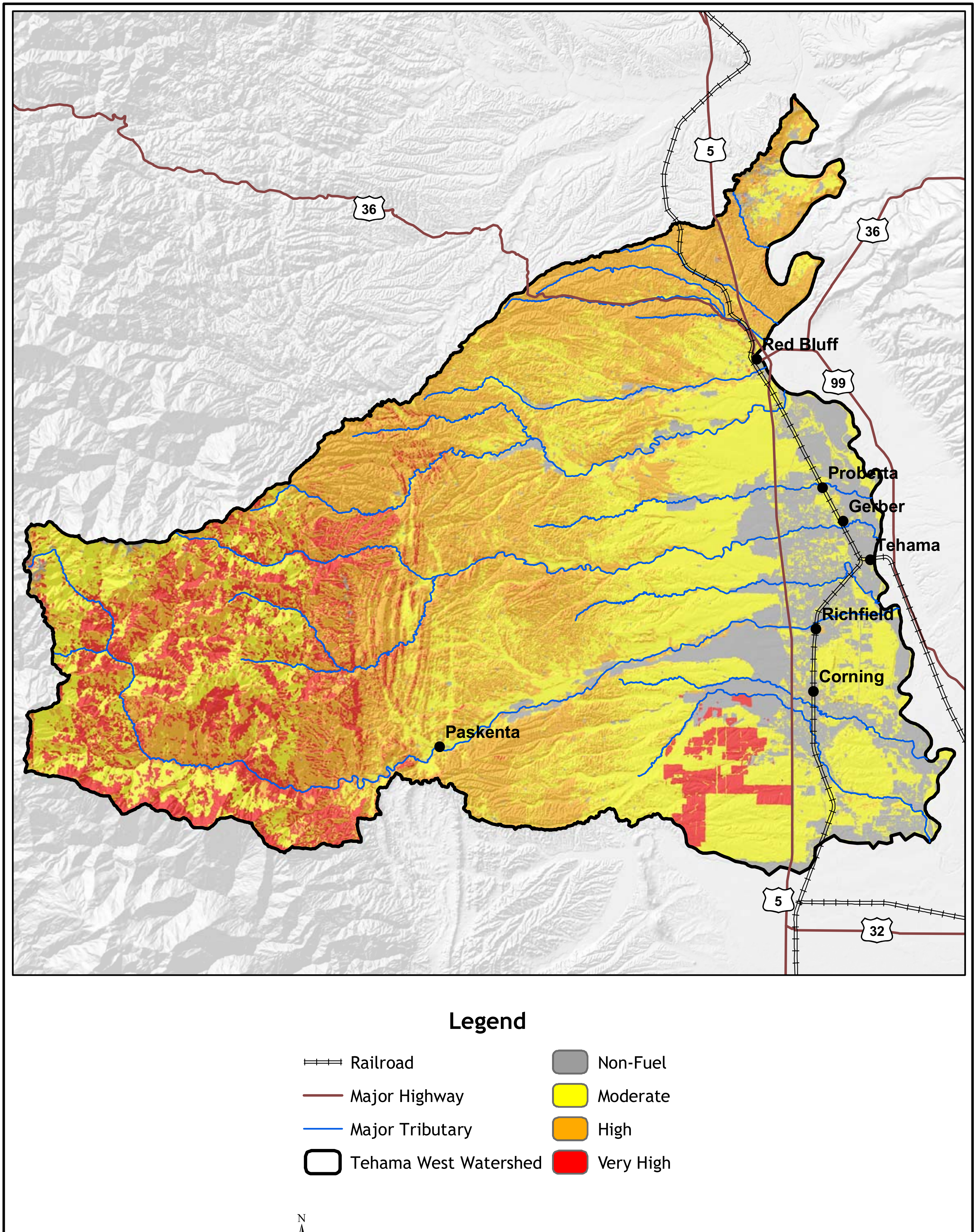


FIGURE 11-4
FUEL RANKS
TEHAMA WEST WATERSHED ASSESSMENT

SOURCE: CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

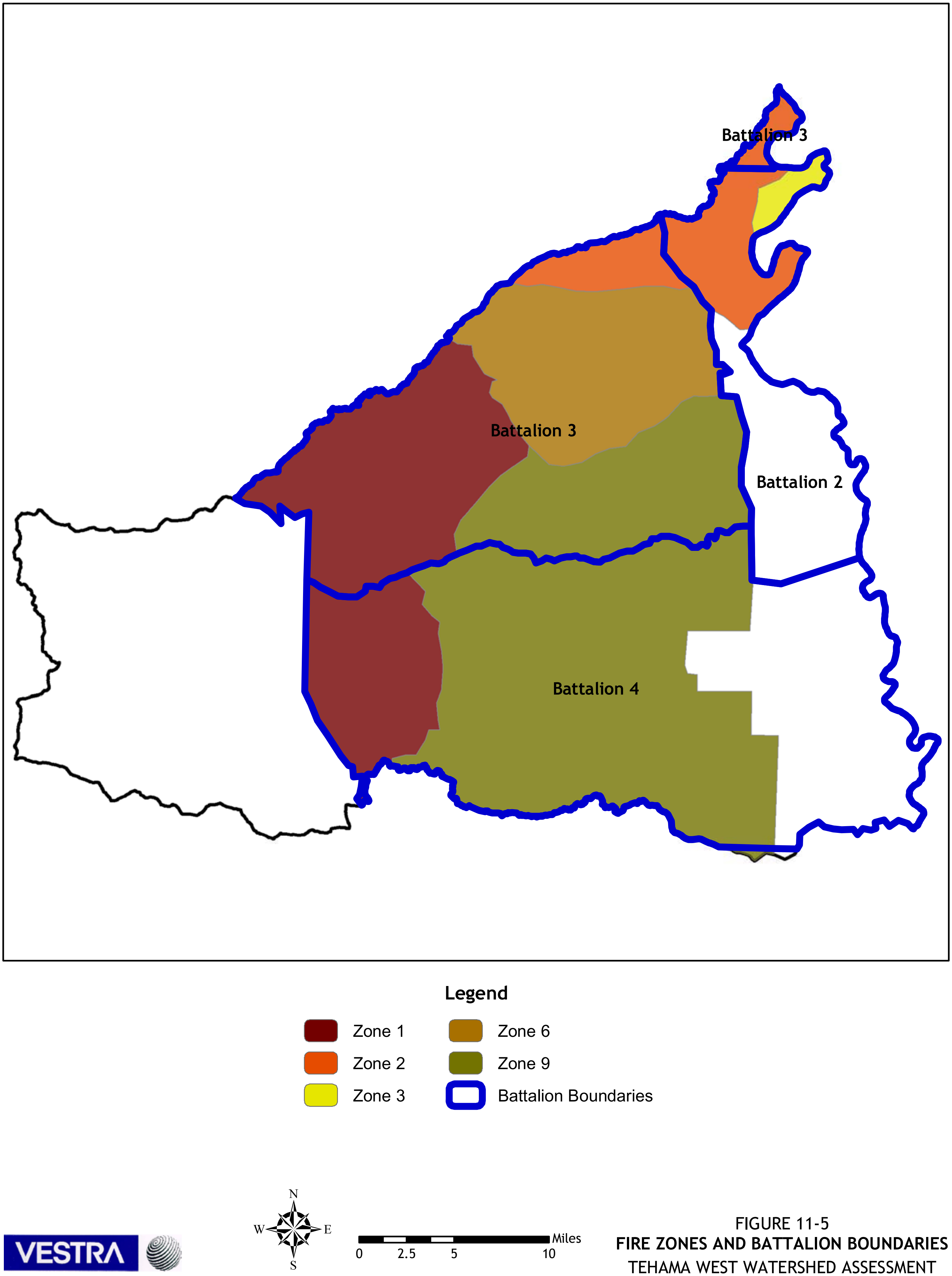


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FIGURE 11-5
FIRE ZONES AND BATTALION BOUNDARIES
TEHAMA WEST WATERSHED ASSESSMENT

SOURCE: CDF, 2005

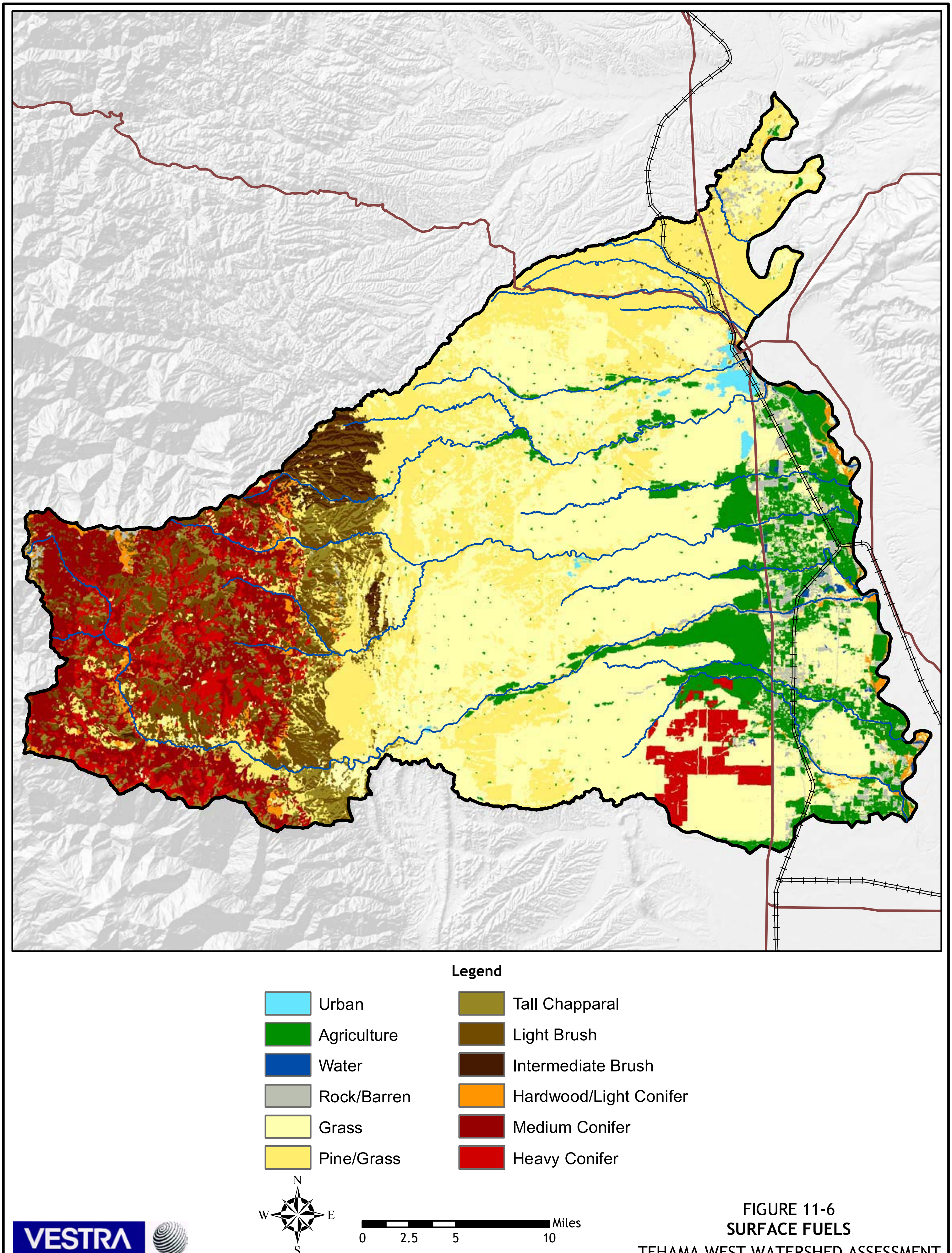
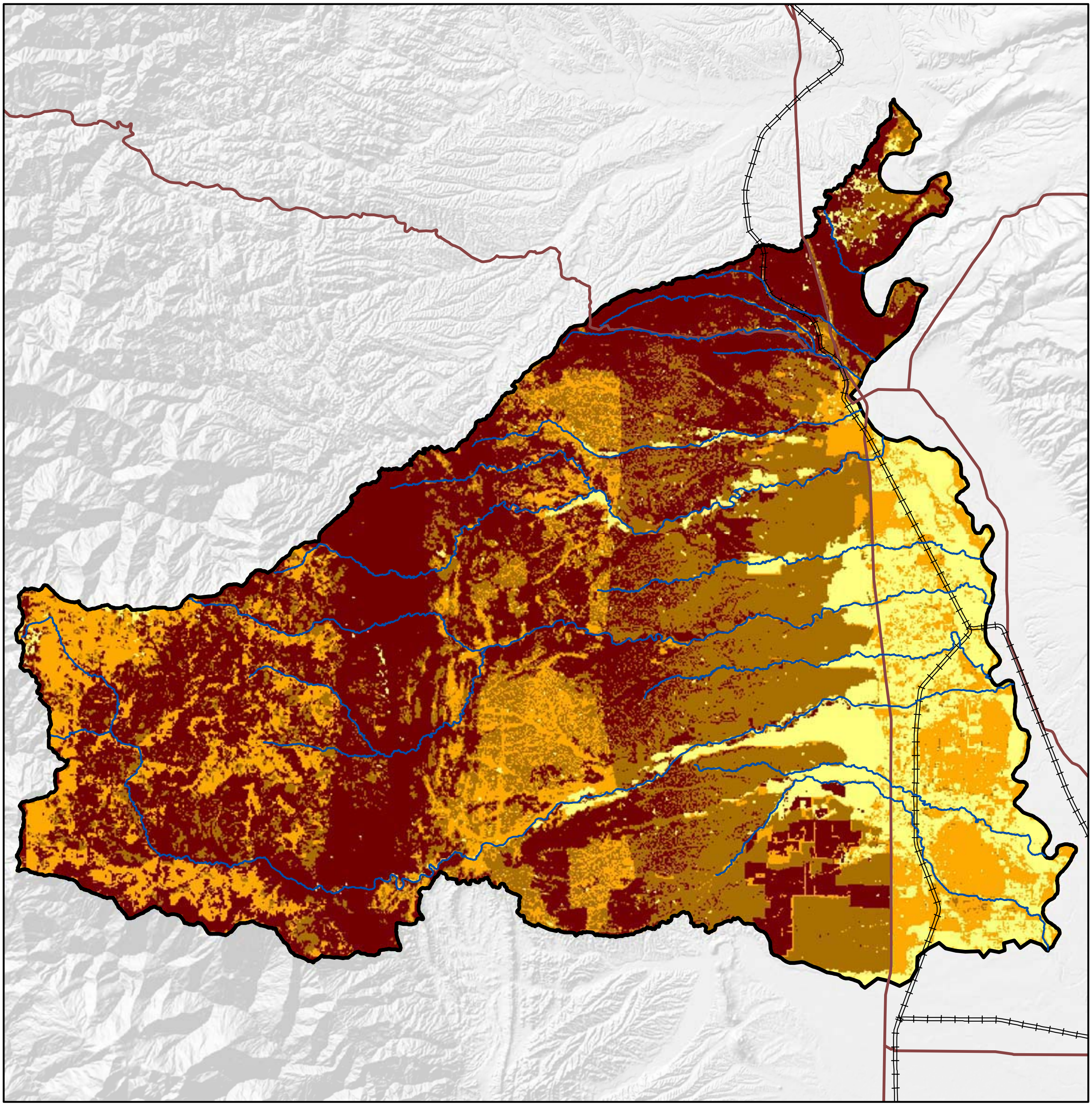


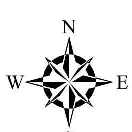
FIGURE 11-6
SURFACE FUELS
TEHAMA WEST WATERSHED ASSESSMENT

SOURCE: CDF, 2005



Legend

- Little or No Threat
- Moderate
- High
- Very High



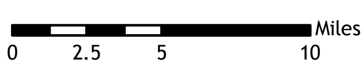


FIGURE 11-7
CDF FIRE THREAT
TEHAMA WEST WATERSHED ASSESSMENT

SOURCE: CDF, 2005

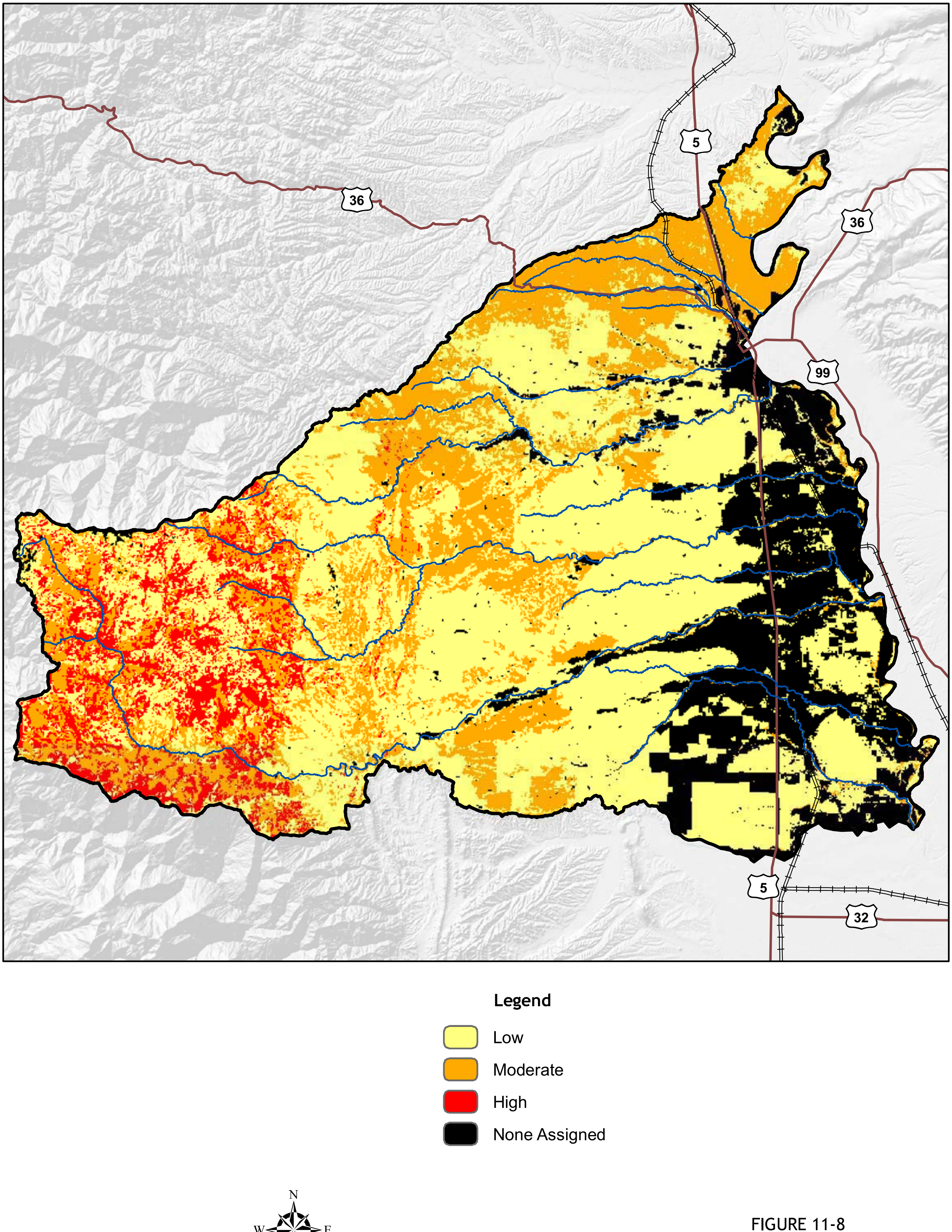


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FIGURE 11-8
CDF CONDITION CLASS
TEHAMA WEST WATERSHED ASSESSMENT

SOURCE: CDF, 2005

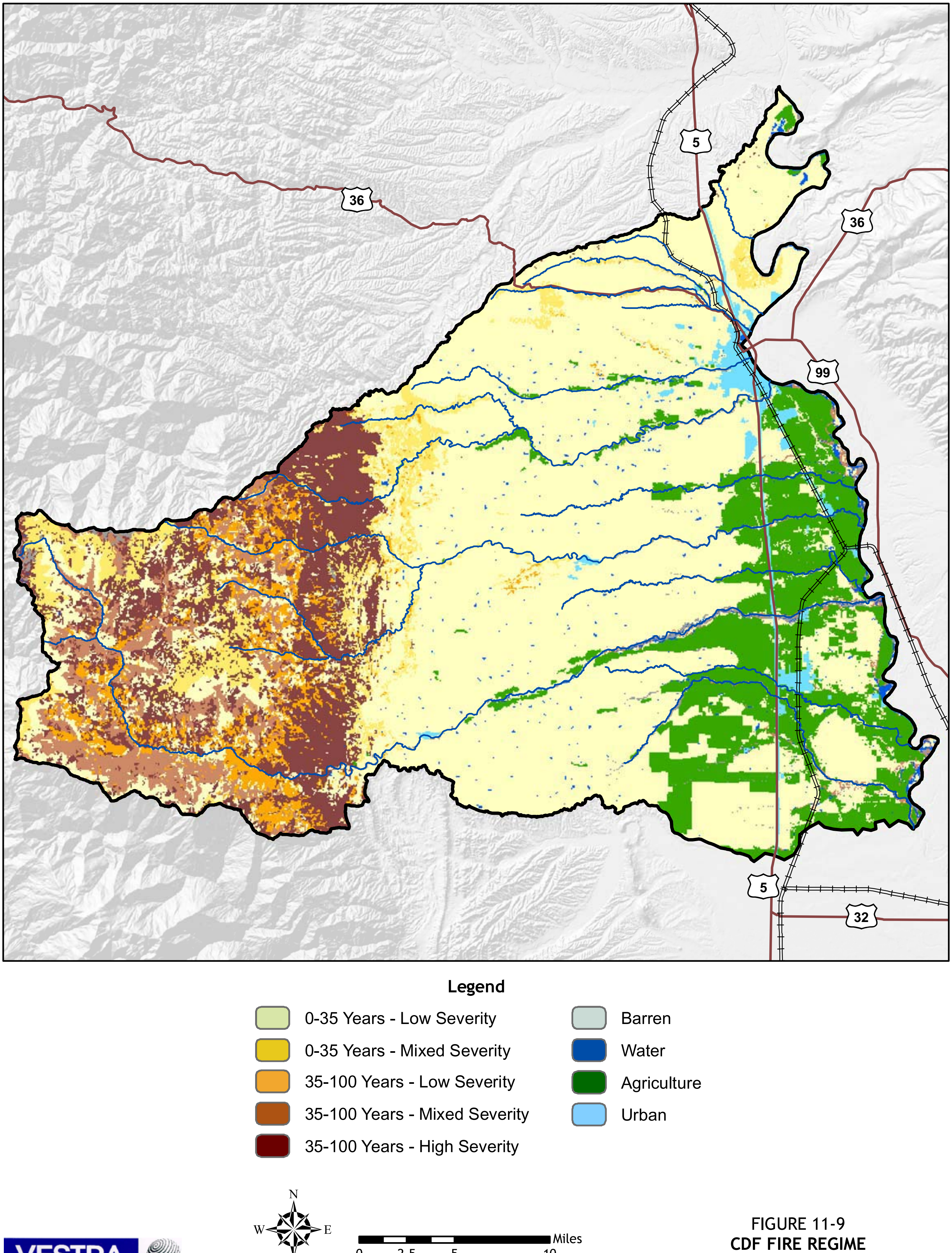

FIGURE 11-9
CDF FIRE REGIME
TEHAMA WEST WATERSHED ASSESSMENT

SOURCE: CDF, 2005

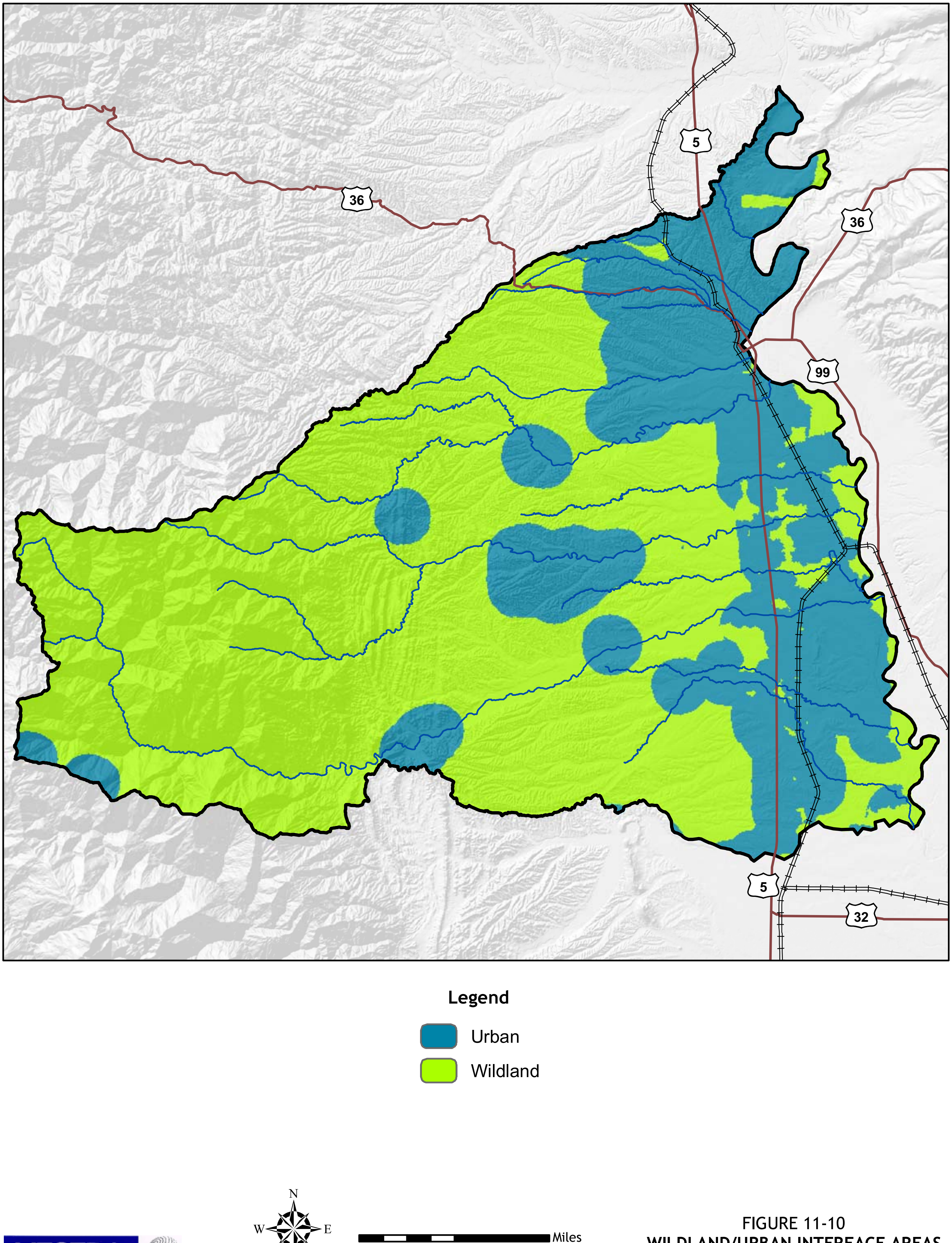

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FIGURE 11-10

WILDLAND/URBAN INTERFACE AREAS

TEHAMA WEST WATERSHED ASSESSMENT

SOURCE: CDF, 2005