3.0 FIRE ENVIRONMENT

Wildland fires in the U.S. have been increasing in size and severity since regular records have been kept. Understanding central Texas fire ecology, historical and current fire occurrence of central Texas, and the factors that influence fire behavior on the landscape provide a basis for determining a community's wildfire risk and identifying and implementing effective wildfire prevention and mitigation strategies.

3.1 FIRE OCCURRENCE

3.1.1 HISTORICAL FIRE OCCURRENCE

Historical fire occurrences in central Texas prior to European settlement are not well documented. However, evidence of historic fire scars in woody vegetation, the presence of easily ignitable fuels such as grasslands, and written historical accounts indicate that fire has been present on the landscape for perhaps thousands of years (Smeins et al. 2005).

As European settlers started moving into this region in the 1830s, their written accounts indicate they witnessed fires started either accidentally or deliberately. However, as more people moved into the state, loss of resources and property became more of a concern and fire-suppression laws were implemented. A Texas state law passed in 1848 made it illegal to burn the prairies between July 1 and February 15, and in 1884, another state law made setting fire to grass a felony (Taylor 2007).

Since the beginning of twentieth century, wildfires and prescribed fire have been suppressed due to governmental policy and societal bias. In the 1940s, the American public was introduced to Smokey Bear with support from the U.S. Forest Service (USFS), the National Advertising Council, and state forestry agencies. The Smokey Bear program became the most effective advertising campaign in the anti-fire effort (Johnson and Hale 2000). Recently, the Smokey Bear Program has adopted language that emphasizes fire's many beneifts to fire-dependent ecosystems; however, the general public must continue to be responsible when using fire.

Fire suppression policies have allowed fuel loads across the United States to reach excessive proportions that make catastrophic wildfire almost inevitable in many regions. Individual wildfires that burned between 500 and 4,000-plus acres have been identified in 1959, 1961, 1962, 1968, 1989, 1993, 1994, and 2011 and affected all areas of Travis County (Henderson 1961, Henderson 1962, Austin American-Statesman 1963, Obregon et al. 1989, Breaux and Krausse 1989, Lindell 1993, Austin American-Statesman 1993, Burgess and Matustik 1994, Osborn 2011).

3.1.2 CURRENT FIRE OCCURRENCE

3.1.2.1 WILDLAND-URBAN INTERFACE

The wildland-urban interface (WUI) is an important component of the present-day fire environment. It occurs where urban and suburban development abuts wildland vegetation such as forests, shrub, and grasslands. The WUI provides the greatest challenge in wildfire protection and preparedness efforts and is often the source of human-caused fires (Radeloff et al. 2005). The City of Austin population is expected to double in the next 30 years with continued outward expansion into and urbanization of previously rural, undeveloped lands throughout Travis County (City of Austin 2012b). Continued housing development in the WUI puts more people at a greater risk of catastrophic wildfire and puts more pressure on land managers and fire department personnel to mitigate fire risk.

3.1.2.2 INCIDENTS

The Texas State Fire Marshal's Office (SFMO) collects data on fire incidents through the Texas Fire Incident Reporting System (TEXFIRS; SFMO 2013a). TEXFIRS documented 7,885 wildfires in Travis County from 1998 through 2012 (SFMO 2013a), with most occurring in 1999, 2008, 2009, and 2011 (SFMO 2013a). Wildfire data from TEXFIRS were obtained via the NFIRS website (http://www.nfirs.fema.gov/NFIRSWebTools/welcome.do) for Travis County. They included incident types in the categories of 140 natural vegetation fires, other; 141 forest, woods, or wildland fires; 142 brush, or brush- and grass-mixture fuel, and 143 grass fires.

While wildfires can and do occur any month of the year, January, July, and August have the highest occurrence (SFMO 2013a). The greater number of January fires is likely due to high winds associated with dry, gusty cold fronts. July and August fires are likely because of increased fuel loads from high vegetation production during the preceding spring growth period. Low humidity, which contributes to fuel drying, and low precipitation are typical for these high-fire months. Environmental factors associated with fire behavior are discussed in further detail in Section 3.2.

The 2011 fire season was the most significant fire year in the history of Texas, with the greatest number of incidents overall. **Figure 7** shows where the Combined Transportation, Emergency & Communications Center (CTECC) dispatched fire responders for WUI, brush, and grass incidents. Although many of the reported incidents may have been minor, most were concentrated in areas with a high human population.

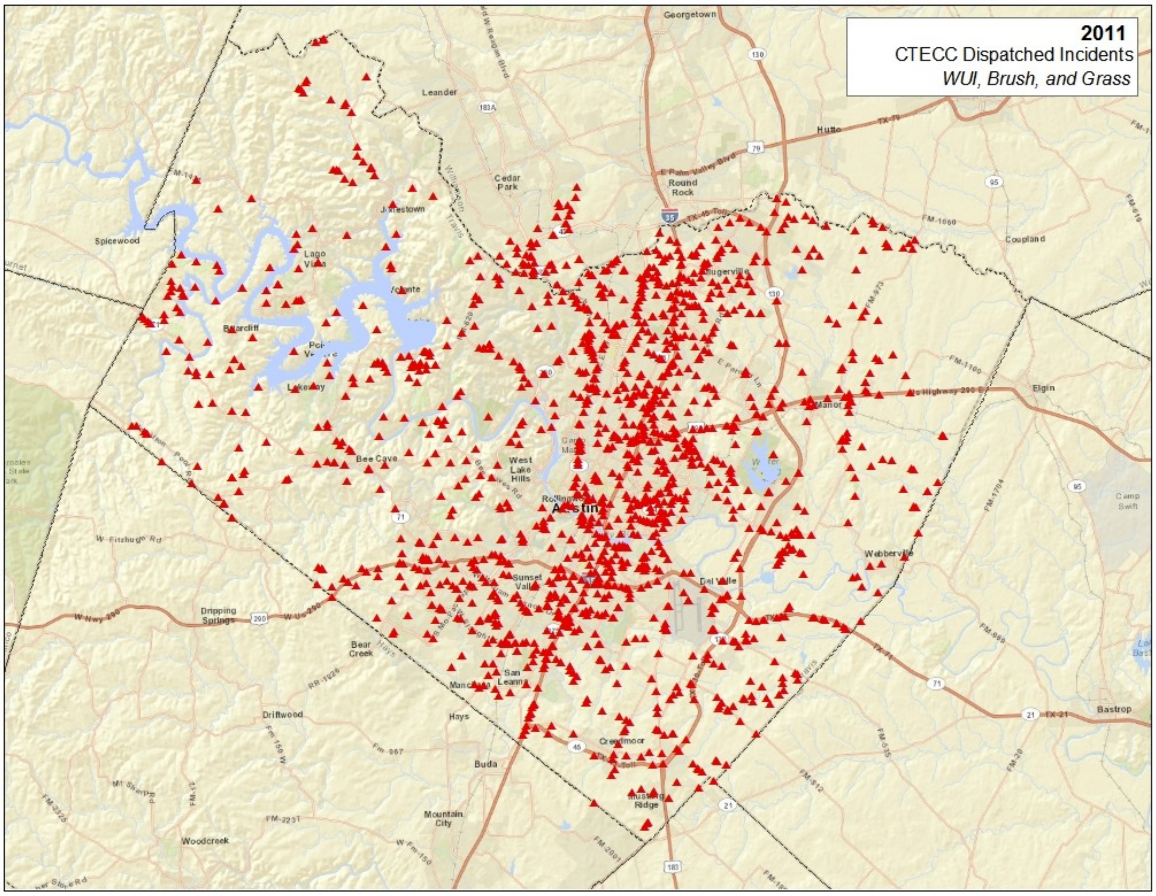

Figure 7. Dispatched Incidents in Travis County, 2011 (Thies 2013).

3.1.2.3 IGNITION SOURCES

Accidents or deliberate human actions cause the majority of wildfires, with only a few from natural causes (NFIRS 2013). Nationally, on average, local fire departments reported 915 brush, grass, or forest fires per day from 2007 to 2011. Leading cause of, or factors contributing to, these wildfires included:

- Intentional (20 percent);
- Hot embers or ashes (16 percent);

- Outside fires for debris or waste disposal (14 percent);
- High wind (14 percent);
- Smoking materials (11 percent);
- Playing with heat source (five percent);
- Fireworks (four percent);
- Lightning (four percent),
- Spark, ember, or flame from operating equipment, and electrical power or utility lines (four percent) (Ahrens 2013).

The 2011 fire season caused the most home losses in Texas history (TFS 2011). Labor Day September 4th, the Bastrop Complex Fire occurred due to the interaction of high winds caused by Tropical Storm Lee that made landfall in Louisiana. The record drought, low humidity, fallen electrical power lines and intervening fuels caused the high winds to whip the slack power lines together sending hot molten material to drought-impacted fuels below. These same factors were responsible for the loss of 24 homes in the Steiner Ranch community, 45 homes in the Spicewood community which was Travis County's largest fire burning 6400 acres, and 3 separate fires one of which was named the Hodde Lane fire that burned 300-500 acres destroying 2 homes in the City of Pflugerville.

For Travis County, **Table 9** summarizes the ignition causes for known wildfires from 1998 through 2012. The most common human-caused wildfire was from careless burning of brush piles and household trash (TFS 2013a). Other frequent causes included sparks from welding/grinding equipment, discarded smoking materials, and hot vehicle pollution control equipment (TFS 2013a).

Among natural wildfire causes, only lightning was notable in Travis County and it was thought to have caused only about two percent of all wildfires in recent decades (NFIRS 2013). Because lightning occurs with higher humidity associated with thunderstorms, conditions are often unfavorable for the spread of wildfire. Wildfires that are thought to have been caused by lightning on the Balcones Canyonlands Preserve have only burned the tree struck by lightning and did not spread to other trees (W. Conrad, pers. comm. 2013).

Table 9. Ignition causes for wildfire in Travis County, 1998 through 2012.

Cause of Ignition	Number	Percent
Cause under investigation	80	1
Act of nature	159	3
Failure of equipment or heat source	242	4
Cause, other (conversion and exposure 1 only)	404	6
Intentional	696	11
Cause undetermined after investigation	2,053	30
Unintentional	2,991	45
Total	6,625	100

Source: National Fire Incident Reporting System (NFIRS) 2013. Summary output report for incident types in categories of 140 natural vegetation fires, other; 141 forest, woods or wildland fires; 142 brush, or brush and grass mixture fuel; and 143 grass fires.

Figure 8 shows the density of wildfire ignition in Travis County for 2005 – 2009 and the likelihood of wildfire starting based on historical ignition patterns. The wildfire ignition density data were provided by TxWRAP, which used historic wildfire ignitions to create an average ignition rate map that showed the number of fires per year per 1,000 acres. The ignition density is lowest in areas with low human population, and there is a strong correlation with ignition fire density and the wildfire risk modeling (as discussed further in Section 4.0). Considering that humans cause most wildfires, effective measures for prevention, education, and awareness would significantly reduce wildfire danger in Travis County.

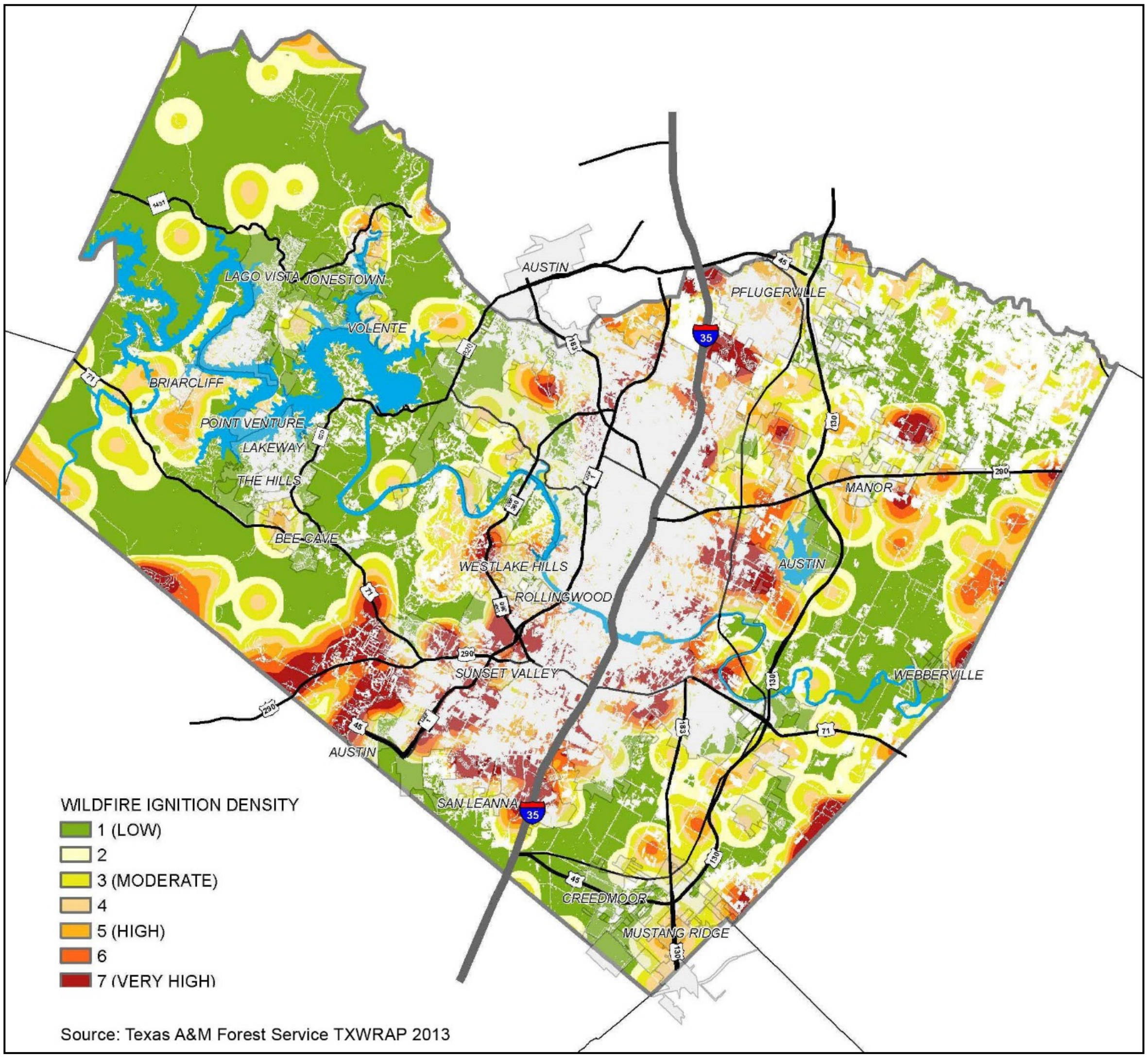

Figure 8. Wildfire ignition density, Travis County, 2005 – 2009.

3.2 FIRE BEHAVIOR

Understanding how wildfires behave is critical in determining potential risk, setting priorities, and identifying appropriate mitigation treatments. Wildfires can occur when all three of the following conditions are met: the presence of fuel (such as vegetation and homes), suitable weather conditions (such as low humidity), and an ignition source (such as a cigarette or lightning). These conditions are interrelated and affect each other. For example, it is very difficult to light damp firewood with a match. However, a different ignition source, such as a lighter, or a different fuel such as fine, dry grass, can produce very different results. Fires may be classified as crown, spot, or surface fires.

Crown fire – A large, wind-driven fire that travels from treetop (crown) to treetop in dense stands of trees.

Spot fire – A fire caused by embers blown downwind from the main fire to receptive fuels. This type of fire creates many challenges for fire fighters including safety, undermining fire suppression efforts, and increasing the demands on fire suppression resources.

Surface fire – A fire that burns along the ground through a horizontally continuous and unbroken layer of fuels.

Understanding fire behavior is central to protecting structures from wildfire. The following sections introduce the important types and characteristics of fuels, weather conditions, ignition sources, and other factors.

3.2.1 FUEL TYPES

The most commonly used fire behavior fuel models assume that central Texas vegetation is best described by fuel model variables representative of a shrub group that includes southern California chaparral. However, recent research indicates that while Texas juniper woodlands may look similar to California chaparral communities, fuel loads and fire behavior are distinctly different (White et al. 2009, White et al. 2010).

Specifically, Ashe juniper and certain chaparral species may appear to have similar growth forms and vegetative characteristics, but chaparral species are highly flammable and cold and drought intolerant, which can lead to lots of dead fuel. In contrast, central Texas vegetation has higher live-fuel moistures and less dead-fuel loads than are usually associated with chaparral vegetation (White et al. 2009, White et al. 2010). Fires originating in juniper woodlands have slower rates of spread than fires in chaparral vegetation communities because the juniper canopy has a higher proportion of live, moist foliage. Also, juniper woodlands often include hardwoods, such as oaks, that reduce the potential for canopy fire spread with their relatively sparse arrangement of leaves and branches in the canopy.

Due to these attributes, active canopy fires are rare in mature juniper/hardwood forest. However, when active canopy fire does occur (i.e., during extreme drought and high temperatures) in central Texas woodlands, specifically closed juniper and aggraded juniper woodlands (see below for further descriptions), the fire intensity causes stand-replacing fires which is very similar to how fire behaves in lodgepole pine in western North America. For these reasons, and for the purposes of this document and the model described in **Section 4.0**, regionally specific fuel type data were developed for the Balcones Canyonlands Preserve by White et al. (2009) to more accurately model fire behavior in central Texas. The following photos and captions briefly describe the regionally specific fuel types (in bold) found in Travis County.

Figure 9. Sparse, dry-climate grass (Photo courtesy of Spatial Ecology Laboratory at Baylor University)

Sparse, dry-climate grass, or grassland, is dominated by generally short grasses that may be sparse or discontinuous (Scott and Burgan 2005). Pastures are also considered grasslands (**Figure 9**).

Aggrading juniper shrub fuel type is dominated by live oak-juniper and juniper savanna. It's present throughout the county and includes both Ashe juniper (*Juniperus ashei*), predominantly in western Travis County, and eastern redcedar (*Juniperus virginiana*), predominately in eastern Travis County. Juniper scorch and mortality values by size class are nearly identical between these two *Juniperus* species (**Figure 10**) (Engle and Stritzke 1995).

Figure 10. Aggrading juniper shrub (Photo courtesy of Spatial Ecology Laboratory at Baylor University)

Closed juniper woodland has sufficient canopy closure to limit growth of tall grass (18 inches or more tall) to less than 50 percent of the ground cover. Juniper, including Ashe juniper and/or eastern redcedar, and deciduous trees are the dominant vegetation types. (**Figure 11**).

Mixed juniper hardwood forest fuel type is 25-percent juniper, 75-percent deciduous class. (**Figure 12**).

Figure 11. Closed juniper woodland (Photo courtesy of Spatial Ecology Laboratory at Baylor University)

Figure 12. Mixed juniper hardwood forest. (Photo courtesy of Spatial Ecology Laboratory at Baylor University)

3.2.2 FUEL CHARACTERISTICS

Fuels are characterized by several physical and chemical properties that influence potential fire behavior. Changing any one of these characteristics will change the fire's behavior and/or its ignition potential. A brief discussion of each of these fuel characteristics is provided below (adapted from Van Wagtendonk 2006, Florida Division of Forestry 2010).

Fuel load – Fuel load is the total amount of fuel available to burn by weight. The heavier the fuel load the more heat will be released.

Size and shape of fuel – Small or fine fuels are less than a quarter-inch in diameter and include grasses, leaves, and twigs. Large fuels include trees and logs. Fine fuels can ignite easily and burn rapidly because they have more surface area available for contact with oxygen. Large fuels require more heat to ignite, and they burn more slowly than finer fuels but generate more heat overall. Large fuels are harder to extinguish than fine ones.

Fuel moisture – The amount of moisture within a fuel is key in determining how much of a fuel, if any, will burn. Temperature, wind, relative humidity, precipitation levels, and the size of the fuel affect fuel moisture. Fine-sized fuels lose and gain moisture rapidly and have the greatest day-to-day variation. Moisture levels in large fuels fluctuate more slowly.

Compactness of fuel – Compactness refers to the spacing between fuels. Tightly compacted fuels do not burn as well as lightly compacted ones due to the reduced amount of oxygen between the fuels.

Horizontal continuity of fuels – A horizontally continuous and unbroken layer of fuel is generally necessary for fire to spread across the landscape. Breaks in horizontal continuity, such as rivers and roads, can act as barriers and help slow and even prevent the spread of wildfire. A wooden privacy fence, common around homes in the WUI, is a fuel and provides wildfires both horizontal and vertical continuity as discussed below.

Vertical continuity of fuels – A vertically continuous and unbroken layer of fuels is necessary for a surface fire to spread into the tree canopy or up the side of a house. Often referred to as ladder fuels, they include vines, low-hanging branches, or a tall understory layer of shrubs and small trees. Wooden privacy fences, sheds, and other combustible structures can also act as ladder fuels, transporting fire up to overhanging tree canopies and roof eaves. As with horizontal breaks, vertical continuity breaks, like removal of ladder fuels, can slow or prevent the spread of fire into the tree canopy.

3.2.3 WEATHER

Humidity, temperature, rainfall, and wind speed are the most important weather conditions associated with wildfire ignition and spread in Travis County. These factors all affect fuel moisture, which determines how much, if any, of the living plant or dead material will burn. Low humidity and lack of rainfall, as well as high temperatures and wind speeds, all serve to dry vegetation and increase the amount of available fuel.

Mistakenly, central Texas weather is often compared with the Mediterranean-type climate of southern California. On average, the relative abundance of precipitation and humidity is greater in central Texas than southern California, and southern California also has strong, extremely dry Santa Ana winds that can exacerbate the drying of fuels and fan regional wildfires. On average, the central Texas climate precludes extreme fires commonly associated with southern California. Central Texas vegetation has higher live-fuel moistures and less dead-fuel loads than are usually associated with chaparral vegetation (White et al. 2009, White et al. 2010).

As shown in **Figure 13**, the prevailing winds in the Austin area on an annual basis are from the north and south (Iowa Environmental Mesonet (IEM) 2013). Local winds vary seasonally; during the summer (April through August), prevailing winds are from the south and south-southeast. Winter winds (November through February) blow primarily from the north, and are often dry and gusty. High winds at any time of year can sustain a wildfire, especially if humidity is low.

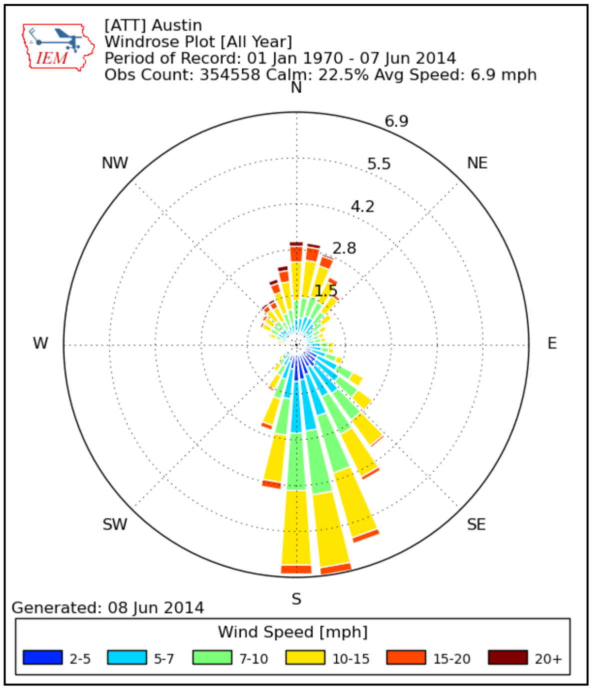

Figure 13. Windrose Plot, Austin, Texas (Iowa Environmental Mesonet 2013)

3.2.4 ADDITIONAL FACTORS

Once a wildfire begins, additional factors influence where and how quickly a fire will spread. These include, but are not limited to, topographic features (slope and aspect), wind direction and speed, and the size and type of fuel breaks (rivers and roads) that may be in the area.

Slope – Wildfires typically burn up-slope. The steeper the slope, the faster the fire will burn due to the convective columns above fires that increase combustion.

Aspect – Aspect is the direction a slope faces: north, south, east, or west. In Travis County, south-facing slopes receive more heat from the sun, which lowers humidity. Lower humidity and increased temperature dry fuels quicker and increase wildfire risk.

Fuel break – A natural, temporary, or permanent manmade feature that isolates an area from a fire hazard. Breaks may limit the flame length of a wildfire, which allows firefighters to offensively situate themselves. They create a temporary refuge for firefighters, and provide access for fire apparatus and firefighters to remote areas during suppression activities.

Drought – Central Texas has experienced extreme and exceptional drought the last few years. Drought has killed trees in much of the planning area, including evergreens (juniper) and broadleaf evergreens (plateau live oak). Live fuels respond differently to drought than dead fuels; however, during prolonged drought, fuel moisture decreases in all fuel types, creating a uniformly dry fuel load and increasing the chances of catastrophic wildfire.

3.3 FIRE ECOLOGY

As illustrated in the preceding sections, fire requires three basic elements -- fuel, oxygen, and heat -- in order to be created and sustained. The simplistic nature of these requirements belies the intricate role and relationship fire has in shaping many aspects of ecosystem function, dynamics, and health. Fire is one piece of a complex system and often works in concert with other disturbances and ecological processes to shape ecosystems.

The discipline of fire ecology focuses on investigating the role and relationship of fire on the natural and human environment. Fire ecologists and scientists study the direct and indirect impacts and effects of fire on many components of those environments, such as soil, hydrology, vegetation, wildlife, air, and climate. By analyzing wildland and prescribed fire effects, land managers and researchers can apply findings to developing robust management plans and strategies that contribute to wildfire preparedness and protection and support ecosystem restoration efforts.

Fire's role is well documented in shaping the structure, composition, and dynamics of certain regions of the U.S. historically and during contemporary time (Pyne 1984, Wright and Bailey 1982, DeBano et al. 1998). However, the outcome of fire on a particular ecosystem is rarely repeatable due to the complex interaction of fire behavior, fuel types, and fire occurrence (Pyne 1984). Unlike ecosystems such as ponderosa pine forests and chaparral shrubs in southern California, the fire regime of central Texas, particularly on the Edwards Plateau, is debated and not fully documented in historic records (Jordan 1973, Smeins 1982, DeBano et al. 1998, Diamond and True 2008). A fire regime is defined as the pattern, frequency, and intensity of fire that creates and maintains a specific plant community.

It is generally accepted that the prairies of the Great Plains, which includes the tallgrass prairie of the Texas Blackland Prairie ecoregion in eastern Travis County, were shaped by fire, as well as by climatic conditions like drought and large herbivore grazing (Wright and Bailey 1982, Diamond and Smeins 1985, Anderson 1990, Griffith 2011). Restoration and maintenance of this ecoregion and vegetation type usually include prescribed fire (Wright and Bailey 1982, Anderson 1990, DeBano et al. 1998).

It's estimated that that less than one-tenth of a percent of the Texas tallgrass prairie remains ecologically intact due to suppression of fire, introduction of intensive grazing by domestic livestock, invasion of woody and non-native species, and conversion to agricultural and urban uses (Briggs et al. 2005, Simmons et al. 2007, TPWD 2012). Unlike areas with extensive woody cover that can utilize fire scars to determine the frequency and intensity of fire, much of what is known about fire occurrence in prairie systems is dependent on historic accounts of anthropogenic uses of fire and the understanding of how grasses respond to disturbance or the lack thereof (Anderson 1990, Collins and Gibson 1990, Smeins et al. 2005).

The fire regime for grassland ecosystems can have widely varying effects on ecological characteristics depending on the historic and current land use, current vegetation composition, fuel continuity and arrangement, and associated interaction with fire behavior (Pyne 1984, Anderson 1990, Taylor et al. 2005). To effectively manage wildfire risk and increase ecological health of this ecoregion, more research is needed to understand the current fire regime in this intensely altered vegetation community.

The Balcones Escarpment divides the Balcones Canyonlands region of the Edwards Plateau ecoregion in the western portion of Travis County from the Texas Blackland Prairie ecoregion to the east. The Balcones Canyonlands have been described as the transition zone between the western arid and the eastern mesic regions. It includes steep canyons, flat uplands, and a unique assemblage of vegetation types and wildlife, particularly along its southeastern border (Griffith 2011, TPWD 2012).

Historic evidence of fire and vegetation characteristics on the Edwards Plateau is mainly based on conflicting and anecdotal records. Lack of direct evidence has created divergent opinions on the importance of fire in creating and maintaining vegetation communities and the range extent for Ashe juniper (Smeins 1982, Diamond 1997, Smeins and Fuhlendorf 1997). Currently, the vegetation on the eastern Edwards Plateau can be described as including a mosaic of juniper-oak woodlands and savannas that are being shaped by fire suppression, intensive grazing by native and non-native wildlife and domestic livestock, and other human-induced impacts. Similarly to the Texas Blackland Prairie ecoregion, woody vegetation, mainly Ashe juniper, has encroached on the savannas of the Edwards Plateau because of fire suppression, overgrazing, and climatic factors (Wink and Wright 1973, Van Auken et al. 2004, Ansley and Rasmussen 2005, Noel and Fowler 2007).

Most research regarding the role of fire has focused on controlling juniper encroachment in savannas and grasslands from a rangeland management perspective (see the following: Wink and Wright 1973, Rasmussen et al. 1986, Rasmussen and Wright 1989, Ansley and Rusmussen 2005). More recently, fire ecologists are focusing on understanding the role of fire as it relates to endangered species habitat management and conservation (Reemts and Hansen 2008, White et al. 2010, Yao et al. 2012, Reemts and Hansen 2013), which has significant implications in Travis County due to the large tracts of land in the county's western portion set aside as mitigation for a number of federally protected species, such as the golden-cheeked warbler and black-capped vireo. Overall, continued efforts in fire effects and ecology research are needed to understand the fire regime and importance of fire on the Edwards Plateau. Further work will continue to bolster countywide wildfire mitigation efforts, particularly within the wildland-urban interface.