

## CHAPTER 4: VULNERABILITY OF AUSTIN'S URBAN FOREST

This chapter focuses on the vulnerability of the urban forest in Austin's developed and natural areas to climate change. Vulnerability is the susceptibility of a system to the adverse effects of climate change (Parry, et al., 2007). It is a function of potential climate change impacts and the adaptive capacity of the system. We consider both developed and natural urban forests to be vulnerable if they are anticipated to suffer substantial declines in health or productivity. In urban forests with a more natural composition of native species, systems are also vulnerable if climate change would fundamentally alter their composition or character (Brandt, et al., 2016). For this assessment, we defined developed urban forests as trees occurring in any areas (e.g., parks, street trees, residential yards, campuses) that are classified as "developed" using the national landcover database within the city of Austin's extraterritorial boundary. We defined natural areas as those areas that are classified as forest or shrubland by the national landcover database within the city of Austin's extraterritorial boundary. Natural and developed urban forests were evaluated for their vulnerability using the same methods used for assessing natural ecosystems in rural areas (Brandt, et al., 2016), but considerations of social, economic, and organizational factors were weighed more heavily for developed areas due to the greater influence of and on humans (Brandt, et al., 2016, Ordonez and Duinker, 2014).

We evaluated vulnerability using two key components: impacts and adaptive capacity (Swanston, et al., 2016). Climate change impacts are the direct and indirect effects of climate change on the system in question. To assess impacts, we evaluated how climate change would affect the key characteristics, dominant species, and current stressors of a system (Brandt, et al., 2016). Adaptive capacity is the ability of a species or ecosystem to accommodate or cope with potential climate change impacts with minimal disruption. For natural areas, we focused on the ecological adaptive capacity of the systems, including factors such as species and topographic diversity and connectivity. For developed areas, we also included social, economic, and organizational factors that could affect the capacity to adapt the management of the urban forest.

To assess vulnerability, we assembled a panel of experts on the ecology and management of Austin's urban forest, including developed and natural areas, for a two-day workshop. Twenty-five people attended the workshop, which included representatives from the US Department of Agriculture, City of Austin, Regenerative Environmental Design, The Nature Conservancy, Travis County, UT-Austin, Texas A&M Forest Service, and the municipalities of San Marcos, New Braunfels, and Sunset Valley. Participants were presented information on current trends and projected changes in climate and preliminary results from the tree species assessment. We then used a facilitated process to identify key impacts and adaptive capacity factors for three developed areas and four natural areas based on the presented climate information and expert knowledge of the ecology and management of Austin's urban trees.

Areas for evaluation were pre-determined by a workshop planning team as being distinctive enough to have different ecology, management, composition, stressors, and/or climate change impacts that may make them differ in their vulnerability to climate change. The key characteristics, dominant species, and current stressors were then described by workshop participants and summarized. The group then discussed how climate change may affect key characteristics, dominant species, and stressors and what key adaptive capacity factors each area had. Each participant was given time to deliberate on what they perceived as the key factors contributing to that area's impacts and adaptive capacity, and asked to rate the overall vulnerability and the amount of evidence and agreement among that evidence contributing to their rating. Ratings from each individual were then discussed to determine an overall vulnerability and confidence rating for each area. See Brandt et al. (2016) for a more detailed description of the assessment process.

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The areas in the Austin region tended to be rated in the moderate vulnerability range, indicating that there wasn’t one specific area type that was more vulnerable than others (Table 4.1). However, the underlying factors that contributed to their vulnerability varied greatly. These contributing factors are summarized for each area evaluated in this chapter.

Table 4.1 – Summary of impacts, adaptive capacity, and vulnerability for areas evaluated in the Austin Region.

<b>Developed or Natural Area</b>	<b>Impacts</b>	<b>Adaptive Capacity</b>	<b>Vulnerability</b>	<b>Evidence</b>	<b>Agreement</b>
<b>Urban Core</b>	Moderately disruptive	Moderate	Moderate-High	Medium	Medium
<b>West Austin</b>	Moderate	Moderate	Moderate	Medium	Medium
<b>East Austin</b>	Moderate	Moderate-High	Moderate	Medium	Medium
<b>Floodplains and Terraces</b>	Moderately disruptive	Moderate-High	Moderate	Medium	Medium-High
<b>Upland Mixed Shrubland</b>	Moderately disruptive	Low-moderate	Moderate-High	Medium	Low
<b>Upland Woodland and Savanna</b>	Moderate	Moderate	Moderate	Limited-Medium	Low-Medium
<b>Upland Forest</b>	Moderately disruptive	Moderate	Moderate-High	Medium	Low

## URBAN CORE

*Moderate - High Vulnerability; Medium Agreement, Medium Evidence*

### **Potential Impacts: Moderately Disruptive**

#### **Key Characteristics**

The urban core has a lower canopy cover (less than 30 percent) and higher impervious surface cover compared to the rest of the City of Austin. Both of these factors, along with waste heat from buildings and vehicles, contribute to a more pronounced urban heat island effect in the area. Thus, the urban core is thought to be the most vulnerable to increases in temperature, especially nighttime temperatures. This area also has highly altered soils and hydrology, which can make trees both more susceptible to reduced soil moisture and fertility as well as localized flooding, both of which are expected to become more pronounced under future climate conditions.

#### **Dominant Species**

Species commonly found in the urban cores that may be particularly vulnerable include pecan, eastern cottonwood, post oak, American sycamore, Texas red (Buckley) oak, cedar elm, and green ash. Species that are considered the least vulnerable are Texas mountain laurel and Mexican white oak.

#### **Stressors and Threats**

Damage from development and construction that is typical in the urban core can make trees more susceptible to pests and disease and other stressors including extreme heat and fluctuating precipitation expected under a changing climate. Typical pests and pathogens observed in the urban core include hypoxylon, bacterial leaf scorch, oak wilt, emerald ash borer, and root decay fungi such as Armillaria. There is no current evidence that changes in temperature and precipitation projected for Austin will worsen these biological stressors. Trees in the urban core that have not been planted at the correct depth or with insufficient rooting space may also be susceptible to anticipated climate changes.

### **Adaptive Capacity: Moderate**

Trees in the urban core tend to be short-lived, and thus there are more small, young trees with less established root systems that may be more vulnerable to precipitation extremes. Because only a few species are tolerant of the harsh urban conditions, species and genetic diversity tends to be lower than in other parts of Austin. However, the trees that are planted tend to be relatively resilient to a variety of stressors including heat and drought. The urban core tends to have a high level of investment of resources per tree and high visibility, which enables early detection, treatment, and replacement of trees when problems arise.



Downtown Austin

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## WEST AUSTIN

*Moderate vulnerability; Medium agreement, medium evidence*

### **Impacts: Moderate**

#### **Key Characteristics**

West Austin tends to have higher canopy cover (exceeding 50 percent on average) than other developed parts of the Austin area. This higher canopy cover can help keep the area cooler and protected from wind. This area was developed on upland, thin limestone soils over karst that can make the area susceptible to erosion and can sometimes make the establishment of new trees difficult. Much of this area is in the wildland urban interface (WUI). Although fire has been suppressed in the area, increases in tree mortality, heat, and drought could make the area more susceptible to wildfire in the future.

#### **Dominant species**

Ashe juniper is the most dominant species in West Austin, making up 68% of the trees there, and is considered to be moderately vulnerable. Other moderately to highly vulnerable species common in West Austin include pecan, cedar elm, and velvet ash. Species common to West Austin that are considered most adaptable include yaupon, Eve's necklace, and Texas mountain laurel.

#### **Current Stressors**

The position of West Austin in the wildland-urban interface makes the area exposed to both stressors that are human and ecological in nature. Development and landscaping practices such as overuse of fertilizer or improper irrigation practices can stress trees and make them more vulnerable to the direct and indirect effects of climate change. Feral hogs, deer, and other wildlife can also disrupt vegetation through activities such as rooting and browsing. It is unclear how these wildlife species may be affected by changes in temperature and precipitation, but the stress they place on vegetation and soil can make the area more susceptible to mortality and erosion. In addition, concerns about wildfire risk can lead people to clear vegetation around their properties, reducing tree cover.

### **Adaptive Capacity: Moderate**

Although Ashe juniper dominates in this area, there is a considerable richness of other species (both planted and naturally-occurring). There also tends to be moderate genetic diversity and a high amount of diversity of tree sizes and ages. West Austin is dominated by higher-income owner-occupied households. Thus, there is a relatively high capacity for people to care for and replace stressed trees if they are informed of best practices. There are also some restrictions on development in this area, which could help the area maintain its tree canopy. Because this area is already heavily forested, there may be reduced opportunities to enhance canopy or biodiversity from where it currently is.

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## EAST AUSTIN

*Moderate Vulnerability; Medium Evidence, Medium Agreement*

### **Impacts: Moderate**

#### **Key Characteristics**

East Austin was developed on an area that was historically prairie, and thus tree canopy tends to be much lower than West Austin (25 percent or less). Impervious cover is higher than West Austin but less than the Urban Core. This area is flatter and dominated by soils with higher clay content that tends to make them susceptible to shrink-swell from changes in moisture, a phenomenon that is expected to become more pronounced as precipitation becomes more variable. However, the position in a floodplain and on former prairie contribute to a deep layer of soil rich in organic matter which could help reduce drought vulnerability. Parts of this area are in a floodplain and are vulnerable to increased flashiness and severity of flooding associated with increased heavy rain events. This area interfaces with agricultural and rangelands, which could make it susceptible to grass fires during hot, dry periods and agriculture runoff during periods of heavy rain.

#### **Dominant Species**

East Austin has a wide variety of species, although Ashe juniper is still the most common species. Species considered particularly vulnerable in the area are pecan, black walnut, eastern cottonwood, post oak, and black willow. Species that are considered less vulnerable include live oak, yaupon, Mexican white oak, Texas mountain laurel, Jerusalem thorn (retama), Texas persimmon, honey mesquite, and Mexican sycamore.

#### **Stressors and Threats**

This area is experiencing rapid development, which could reduce canopy cover and increase the urban heat island effect and interact with current and projected temperature increases from climate change to increase temperatures at a more rapid rate. Concerns about gentrification can reduce support for planting and caring for trees.

### **Adaptive Capacity: Moderate**

Because this was formerly prairie, there is a greater amount of tree species that were not historically present in the area. The range of species that was planted in East Austin tends to be diverse, with a greater amount of species adapted to hot, dry conditions than what is found in West Austin. Trees common in floodplains are also widely present which may be more able to withstand increases in flooding. Housing lots tend to be smaller and average income is lower than West Austin, limiting the amount of resources that can be allocated to tree care and planting but also reducing the number of trees each resident needs to care for. There is currently more opportunity to increase tree canopy and open space conservation, but also risks associated with increased development and gentrification.

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Source: [https://commons.wikimedia.org/wiki/File:East\\_Austin\\_Gentrification\\_Holly\\_St\\_2018.jpg](https://commons.wikimedia.org/wiki/File:East_Austin_Gentrification_Holly_St_2018.jpg)

## FLOODPLAINS AND TERRACES

*Moderate Vulnerability; Medium evidence, Medium-High Agreement*

### Impacts: Moderately Disruptive

#### Key Characteristics

These systems include forests in large alluvial floodplains along the Colorado River and other large rivers with bottomland soils influenced by outwash from the surrounding landscape. They also riparian forests along smaller streams that tend to have more gravely erosional soils along steep slopes. In both areas, flood regime tends to be the dominant driver of species composition and structure. These areas could be extremely vulnerable to increased flashiness from periods of extremely high rain followed by periods of drought.

#### Dominant Species

Because these areas receive frequent flooding, common species intolerant of flooding may be particularly vulnerable in these areas, such as roughleaf dogwood, Texas red (Buckley) oak, escarpment live oak, and Ashe juniper. In addition, there are some flood-adapted species that may not be able to withstand higher temperatures, such as sugarberry, possumhaw, Chinese tallowtree, boxelder, American elm, black willow, green ash, American sycamore, eastern cottonwood, and western soapberry. Species that may be most adaptable to both increased temperature and flooding that are common in floodplains and low terraces are desert willow, yaupon, and the invasive Chinaberry.

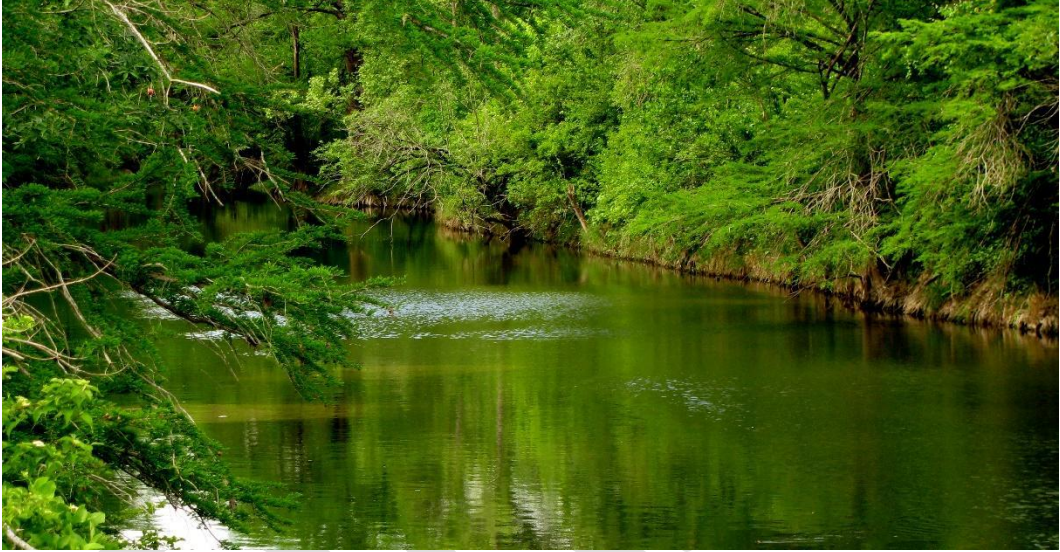
#### Stressors and Threats

This area is susceptible to invasion by non-native woody species (Chinaberry, Chinese Tallow, Glossy Privet) and grasses (bermudagrass, King Ranch bluestem, Johnsongrass, Arrundo). These invasive species may be able to take advantage of increased disturbed area from flash floods and erosion and colonize new areas. Hydrology of many of these areas has been altered through structures such as dams and reservoirs, making the systems less adapted to natural flood regimes. In some areas, a lack of tree seed sources, among other factors, has converted some riparian and floodplain forests to herbaceous plant community types. This type of conversion could become more common if tree seedling recruitment and survival is reduced with higher temperatures and altered flood regimes.

### Adaptive Capacity: Moderate-High

Riparian and floodplain forests tend to have a high species diversity and connectivity to enable gene flow and species migration. In the alluvial floodplains, soils tend to be deep and more resilient to changes in moisture. Erosional, rocky areas may be more susceptible to soil moisture extremes. The species present in these areas tend to be well-adapted to flooding. There is also a high amount of community support for restoration of riparian and floodplain forests.

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## UPLAND MIXED SHRUBLAND

*Moderate-High Vulnerability; Medium Evidence, Low Agreement*

### **Impacts: Moderately disruptive**

#### **Key Characteristics**

Shrublands tend to occur on more xeric sites with shallow soils, and trees do not dominate the canopy and tend to be stunted. This is a historically fire-driven system, but it is now typically maintained through prescribed fire or other management. Although climate change could increase conditions for wildfire, there may be fewer opportunities for prescribed fire, which could have negative impacts to shrublands. Grazing and browsing also shapes this system. As herbivores prefer deciduous trees, they are selectively removed, leading to the dominance of evergreens such as Ashe juniper, which is one species that is relatively vulnerable to climate change.

#### **Dominant Species**

Many of the dominant species are adapted to hot, dry conditions including prairie flameleaf and evergreen sumac, lotebush, honey mesquite, Texas persimmon, Texas mountain-laurel, Lindheimer's silktassel, and catclaw acacia. However, Ashe juniper, escarpment live oak and white shin oak are all expected to be somewhat vulnerable to increases in temperature. Texas kidneywood, Texas redbud, and Mexican buckeye are considered less drought-tolerant. It is also important to note that even some drought-tolerant species like Texas persimmon suffered negative effects during the most recent 2010-2011 drought, and thus even seemingly drought-tolerant species may be vulnerable to extreme and exceptional droughts.

#### **Stressors and Threats**

Shrublands are threatened primarily from loss of habitat and fragmentation as well as altered disturbance regimes (lack of fire, overgrazing/browsing). Fragmentation may decrease the ability of shrubland species to colonize newly suitable habitat. Altered disturbance regimes have led to a reduction in species diversity and loss of dominance of some species that may be better adapted to warmer conditions. Feral hogs are also highly disruptive to these systems, and their rooting activities could increase the vulnerability of soil to erosion and loss with increased heavy rain events.

### **Adaptive capacity: Low-moderate**

Shrublands are typically adapted to hot, dry conditions that may be more common in the coming decades. However, biodiversity is relatively low compared to other habitat types. These tend to be located on very dry, rocky sites so conditions may become so severe that few species may be able to tolerate them, potentially shifting the structure to a grassland or desert. Shrublands are maintained as black-capped vireo habitat (a federally listed species), and thus there will continue to be investment from the management community in maintaining and/or creating shrublands to provide habitat, increasing the likelihood that shrublands will be maintained.



Source: [https://commons.wikimedia.org/wiki/File:Wild\\_Basin\\_Overlook\\_Austin\\_Texas.jpg](https://commons.wikimedia.org/wiki/File:Wild_Basin_Overlook_Austin_Texas.jpg)

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## UPLAND WOODLAND AND SAVANNA

*Moderate Vulnerability; Limited-Medium Evidence, Low-Medium Agreement*

### **Impacts: Moderate**

#### **Key Characteristics**

Woodlands and savannas are characterized as having low-moderate tree canopy cover but still retain large canopy trees as part of their structure. Soil types and topography can vary between woodlands and savannas in East Austin (Blackland Prairie), and West Austin on the Edwards Plateau. In the Blackland Prairie, soils tend to be deeper while soils are more shallow and susceptible to drought on the Edwards Plateau. These systems are historically adapted to fire, but are now maintained through management using tools such as prescribed fire. Conditions for wildfire may increase, but opportunities for prescribed fire may decrease, limiting the opportunity to maintain this community type. Because these areas have less canopy cover, they are more vulnerable to heat and drought stress which could exceed the tolerance of some of the species currently located there.

#### **Dominant Species**

Most species dominant in woodlands and savannas are considered to be drought-tolerant. Oak species like blackjack, Shumard, white shin, escarpment, and post oak, are considered to be drought tolerant, but are vulnerable to increases in temperature whereas coast live oak may be able to withstand temperature increases but is not drought-tolerant. Species that may be more vulnerable to both drought and temperature increases in these areas include cedar elm and sugarberry. Adaptable species include yaupon, fragrant and evergreen sumac, Texas persimmon, honey mesquite, catclaw mimosa, and Texas mountain laurel.

#### **Stressors and Threats**

Like shrublands, these systems are threatened by altered fire regimes, overgrazing and loss of habitat. In the East, these systems may be particularly vulnerable to development. Oaks dominate these systems. Oak wilt has led to declines in oaks in the area. Although there is no clear link between changes in climate and oak wilt, the pathogen coupled with heat and drought stress could lead to increased oak mortality. Woodlands and savannas in lower lying areas may also be susceptible to increased flood risk.

### **Adaptive Capacity: Moderate**

These systems tend to have low taxonomic diversity as they are typically dominated by just a few oak species in the canopy. However, the understory tends to be more diverse due to the larger amount of light. These systems are adapted to fire and drought, which both could become more common with projected changes in climate. However, lack of opportunities for prescribed fire and extreme drought or wet conditions could be detrimental to these systems. In addition, severe fires could exceed the tolerance of many of the dominant species.



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## UPLAND FOREST

*Moderate-High Vulnerability; Medium Evidence, Medium Agreement*

### Impacts: Moderately Disruptive

#### Key Characteristics

Upland forests in Austin are concentrated on steep slopes and plateaus on the Edwards Plateau. South-facing slopes and areas with more shallow soil may be more vulnerable to drought stress and mortality as temperatures increase, whereas north-facing slopes and areas with deeper soils may be more protected. The structure and composition of these forests has made them historically resistant to fire. However, fire risk could increase in these areas if future climate conditions lead to tree mortality (from drought, pests and disease, or storms) and a subsequent increase in fuels. By definition, canopy cover in forests is high, which may help buffer some climate change effects. For example, higher canopy cover can help create cooler microclimates, and vegetation can intercept rainfall and help facilitate aquifer recharge. Upland forests are composed of a mix of evergreen and deciduous species, and sites that are completely deciduous tend to be more mesic and less vulnerable to drought.

#### Dominant species

Many of the dominant upland forest species are susceptible to drought and/or heat-based mortality. Species that are considered the most vulnerable include Texas red (Buckley) oak, white shin oak, Arizona walnut, cedar elm, and Mexican plum. Moderately vulnerable species include Carolina buckthorn, Ashe juniper, escarpment live oak, post oak, gum bumelia, escarpment black cherry, and red buckeye. Species that may be the most adaptable are evergreen and fragrant sumac, Texas persimmon, Texas madrone, and Texas mountain laurel.

#### Stressors and Threats

Upland forests in Austin are located in the wildland-urban interface, which makes them vulnerable to non-native species invasion and human-ignited fires as well as development pressure. Non-native woody species like Chinaberry and Glossy Privet could benefit from newly created habitat post-disturbance. Human-ignited fires could become more problematic as warmer, and possibly drier, conditions that are favorable for the spread of wildfire become more common. Development, when it occurs, can lead to increased soil erosion and a lowered water table due to the loss of vegetation.

### Adaptive Capacity: Medium

Upland forests tend to have a higher level of native species diversity, topographic diversity, and larger patch sizes than other natural areas in Austin, all of which could help enhance their adaptive capacity. Thick organic soil layers in some locations can help capture large quantities of rainfall and help reduce vulnerability to drought and fire. Mycorrhizal networks tend to be abundant, which could potentially facilitate nutrient uptake and sharing of resources, but could also enhance the spread of pathogens. A large seedbank of native species in the soil could help these systems resist non-native species invasion and ensure that some native species are able to continue to grow and regenerate. Despite these factors that enhance capacity, these systems are also located at the wildland-urban interface, which could increase future fragmentation and wildfire risk and reduce capacity for expansion to newly suitable areas.



## KEY POINTS

- Both natural and developed areas in the Austin region show some degree of vulnerability to changes in climate.
- Natural and developed upland areas in west Austin are vulnerable to drought, erosion, and wildfire and have less tree canopy diversity.
- Natural and developed areas in east Austin are vulnerable to shrink-swell from precipitation changes and flooding due to their presence at lower elevations, but have a greater potential for a diverse tree canopy.
- The urban core and other highly developed areas will experience stress not only from changes in climate but from compounding effects drought, heat, and local flooding from restricted soil conditions and impervious surfaces.

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