Vulnerability of Central Texas Urban Forests to Climate Change

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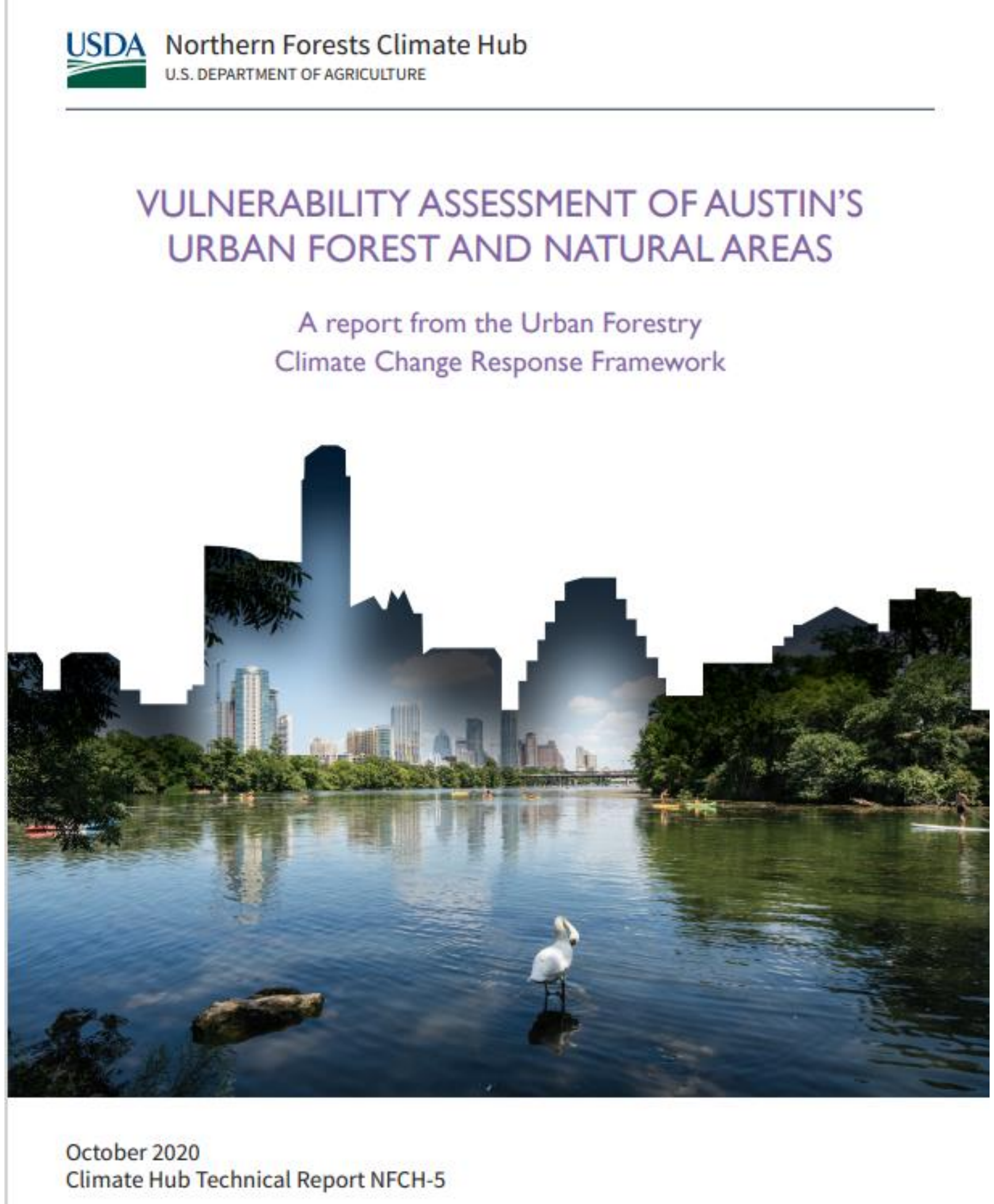
Impacts of Climate Change on Texas

- Physical impacts from changing temperature and precipitation
  - Hotter days, warmer nights, more extreme precipitation, wildfire
- Physiological impacts on fauna and flora
  - Hitting upper tolerances for processes like photosynthesis
- Phenological impacts
  - Longer growing season, mismatches between predator and prey lifecycles
- Range shifts
  - Disrupted bird migration, changing habitat distributions, “new” plant hardiness zones

Today we’re going to talk about a specific project that recently examined the vulnerability of the Central Texas landscape to changing climate


USDA Northern Forests Climate Hub
U.S. DEPARTMENT OF AGRICULTURE

VULNERABILITY ASSESSMENT OF AUSTIN’S URBAN FOREST AND NATURAL AREAS

A report from the Urban Forestry Climate Change Response Framework

October 2020
Climate Hub Technical Report NFCH-5

Goal of the Urban Forestry Climate Change Response Framework

To ensure that urban forests will continue to provide benefits to the people that live in urban communities as the climate changes. We define the urban forest as all publicly and privately-owned trees within an urban area— including individual trees along streets and in backyards, as well as stands of remnant forest.

The trees, developed green spaces, and natural areas within the City of Austin’s 400,882 acres will face direct and indirect impacts from a changing climate over the 21st century. **This assessment evaluates the vulnerability of urban trees and natural and developed landscapes within the City of Austin to a range of future climates.**

The Vulnerability Assessment

Used scientific projections of future changes in climate, such as differences in seasonal temperature and precipitation, to set boundary conditions

Reviewed results from the latest research to determine how urban forests and natural areas around Austin may respond to changes in climate, disturbance, and management

Drew from local expertise - scientists and forest managers - to synthesize results and identify key vulnerabilities within the urban forest and natural ecosystems

Described the implications that future changes will have on a wide variety of ecological, social, and economic factors

Vulnerability is the susceptibility of a system to the adverse effects of climate change. It is a function of potential climate change impacts and the adaptive capacity of the system. A system is vulnerable if it is at risk for no longer being recognizable as that community type, or if the system is anticipated to suffer substantial declines in health or productivity.

To assess vulnerability, a panel of experts on the ecology and management of Austin’s urban forest, including developed and natural areas, met for a two-day workshop. Areas in the Austin region tended to be rated in the moderately vulnerable range.

Key Vulnerability Assessment Findings: Climate Trends & Projections

- Austin has been warming at a rate of about 0.4°F per decade since 1948 and is expected to warm by 5 to 10 degrees by the end of this century compared to the most recent 30-year average.
- Since 2000, all years have been hotter than the 1961-1990 average – a standard baseline for examining climate trends.
- Eight of the top 10 years with the most 100°F days have occurred this century.
- Six of the ten hottest years in Austin have occurred between 2000 and 2019.

Key Vulnerability Assessment Findings: Climate Trends & Projections

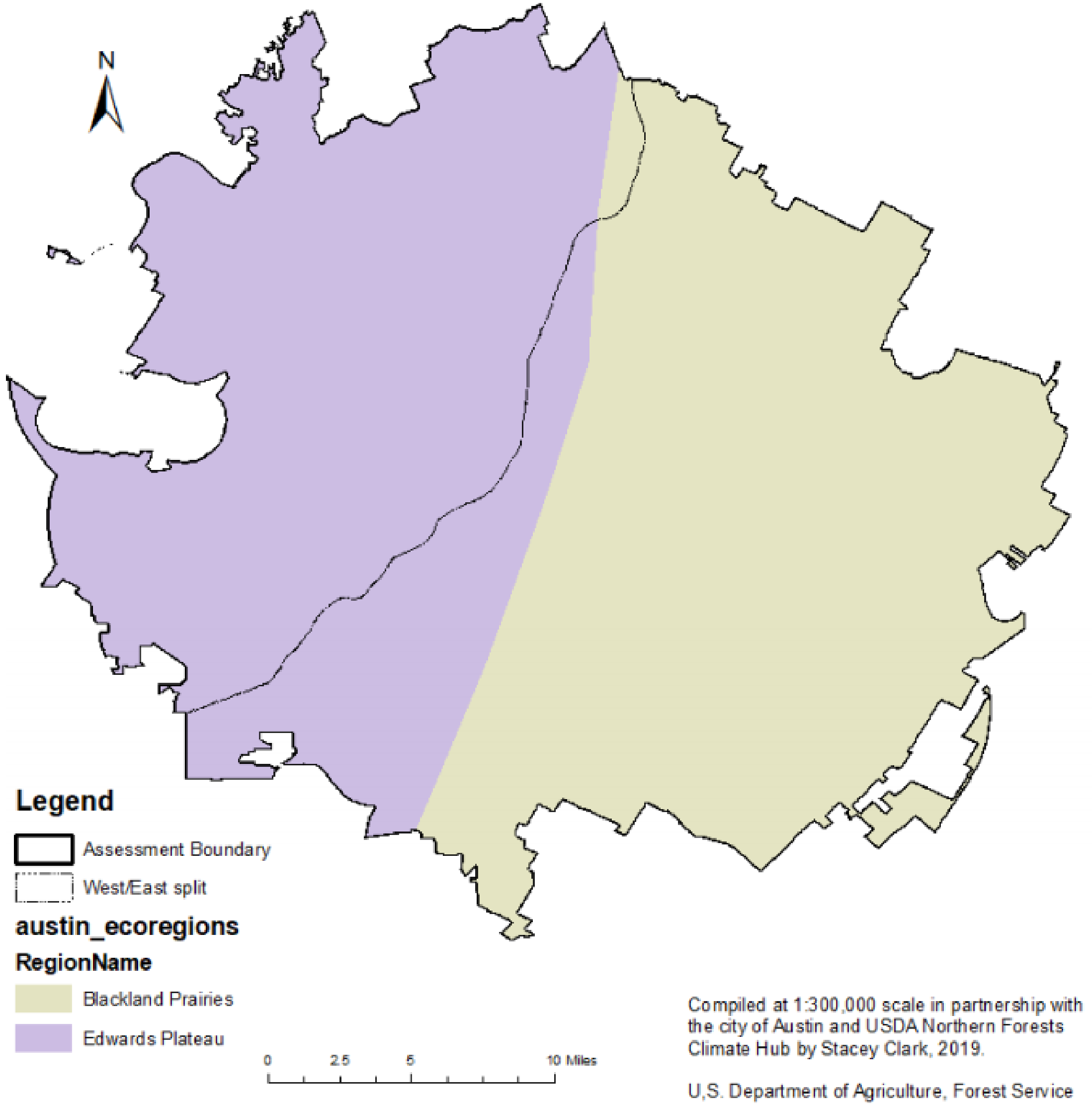
- Austin has been getting slightly wetter on average, but precipitation can vary widely within and between years, and future projections of precipitation are uncertain.
- Overall, the balance of precipitation and temperature may shift Austin's climate to be more similar to the arid Southwest.
- It is highly probable there will be both an increase in heavy rain events and severe droughts in the future decades, which will stress the area's trees.
- Changes in temperature and precipitation may exacerbate current stressors such as non-native invasive plants, insect pests, and pathogens.

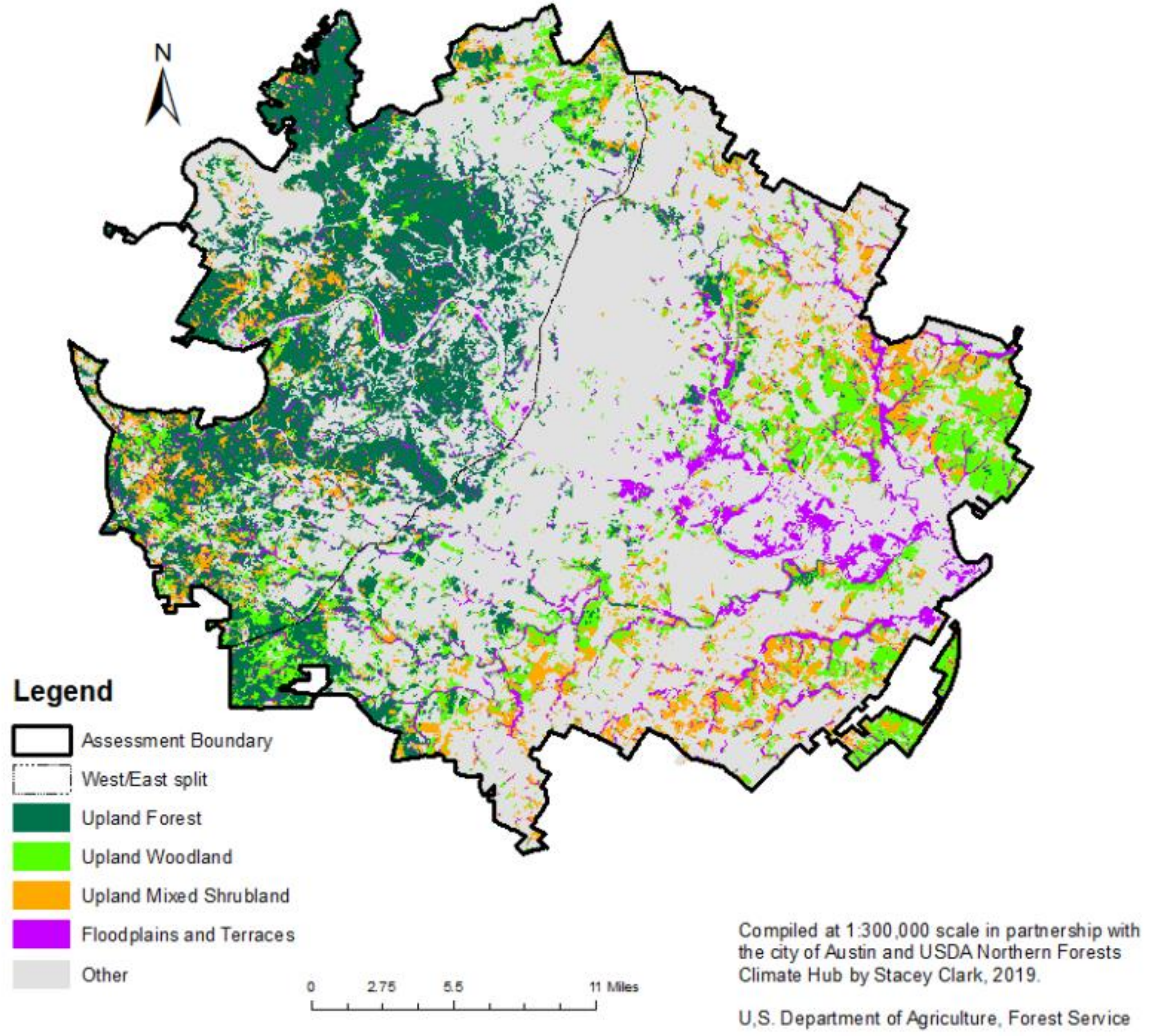
Austin’s Contemporary Landscape: 2014 Urban Forest Inventory and Analysis

- Austin is composed of two ecoregions: Edwards Plateau to the west and Blackland Prairie to the east. These areas support different tree species that are uniquely adapted to each ecoregion.
- Austin’s urban forest is made up of approximately 34 million trees with a tree canopy covering about 31% of the city.
- The majority (92%) of trees are native to Texas, and the 10 most common trees account for 84% of all trees.

Austin’s Contemporary Landscape – Continued

- The most common species are Ashe juniper, cedar elm, live oak, sugarberry, and Texas persimmon.
- Trees with diameters ≤5” account for 62% of the tree population.
- Large-diameter trees ≥15” are only 3% of the total population, but 18% of total leaf area and provide many ecosystem services.


N
Legend
Assessment Boundary
West/East split
austin_ecoregions
RegionName
Blackland Prairies
Edwards Plateau
0
2.5
5
10 Miles
Compiled at 1:300,000 scale in partnership with the city of Austin and USDA Northern Forests Climate Hub by Stacey Clark, 2019.
U,S. Department of Agriculture, Forest Service

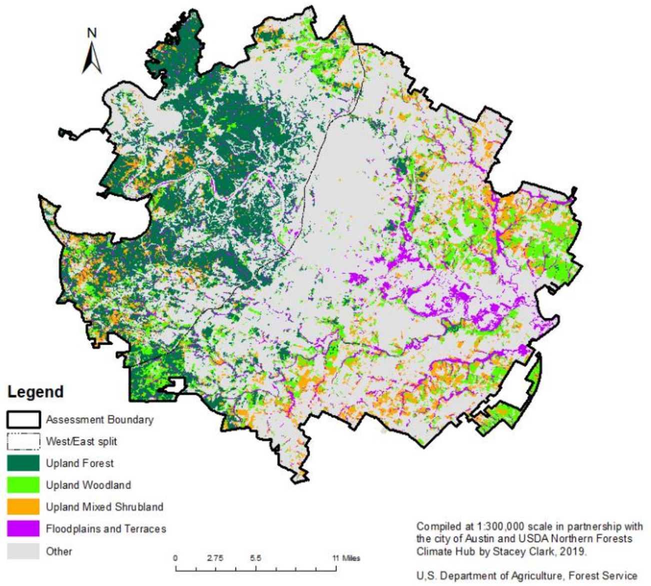

N
Legend
Assessment Boundary
West/East split
Upland Forest
Upland Woodland
Upland Mixed Shrubland
Floodplains and Terraces
Other
0
2.75
5.5
11 Miles
Compiled at 1:300,000 scale in partnership with the city of Austin and USDA Northern Forests Climate Hub by Stacey Clark, 2019.
U,S. Department of Agriculture, Forest Service

Upland Forest

Ashe juniper, Texas red oak, Texas/escarpment live oak, white shin oak, cedar elm, sugarberry, post oak, blackjack oak, Arizona walnut, Escarpment black cherry, Texas ash, gum bumelia, Texas redbud, Carolina buckthorn, rusty blackhaw, red buckeye, Mexican buckeye, Mexican plum, Texas madrone

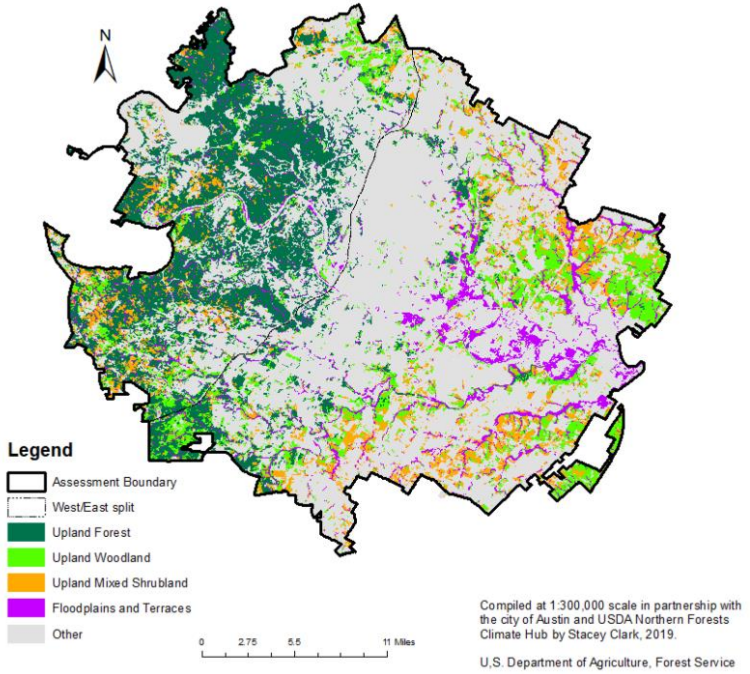
Upland Woodland

Ashe juniper, Texas/escarpment live oak, cedar elm, sugarberry, post oak, white shin oak, blackjack oak, Shumard oak, southern live oak, mesquite, eastern redcedar, gum bumelia



Upland Mixed Shrubland

Texas/escarpment live oak, Ashe juniper



Floodplains and Terraces

Sugarberry, cedar elm, Texas/escarpment live oak, green ash, pecan, American elm, American sycamore, little walnut, western soapberry, Texas oak/Buckley oak, black walnut, eastern cottonwood, Ashe juniper, chinaberry, bald cypress, boxelder, Texas ash, Vitex, Chinese elm, wafer ash, mesquite, black willow, mulberry sp., eastern redcedar, gum bumelia

Large Versus Small Tree Species

- The most common large-diameter (≥15”) trees are Ashe juniper, live oak, cedar elm, pecan, sugarberry, Texas red oak, honey mesquite, chinaberry, and cottonwood.
- The most common small diameter (≤5”) species: Ashe juniper, cedar elm, Texas persimmon, sugarberry, live oak, yaupon holly, Texas mountain laurel, glossy privet (ligustrum), chinaberry, and green ash.
- If current large trees are not replaced by other large trees, this may reduce the future canopy cover of Austin.

East Versus West Austin

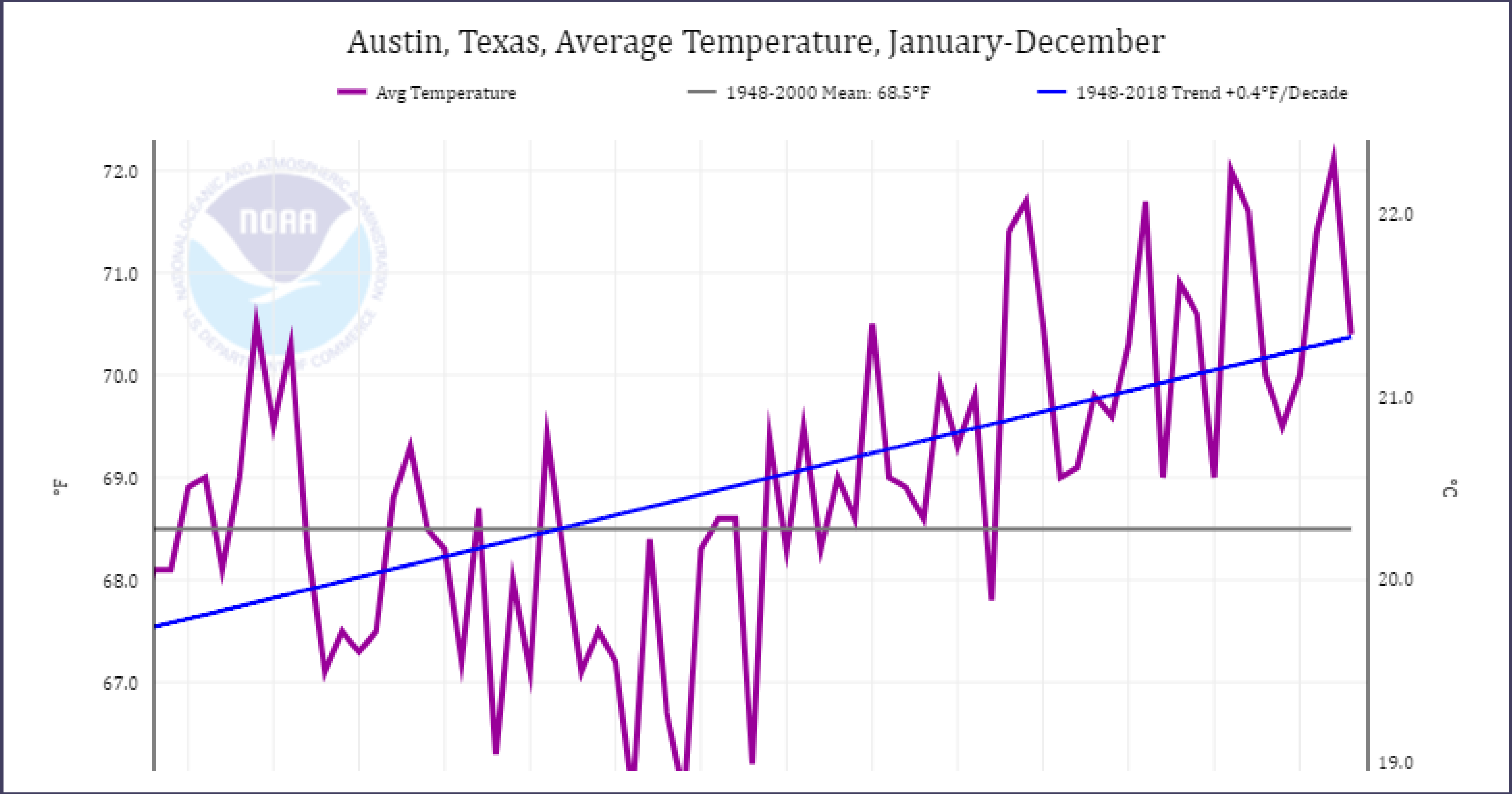
- Ashe juniper and live oak make up 80% of species composition in West Austin versus four species (Ashe juniper, cedar elm, honey mesquite, and live oak) making up 60% of in East Austin.
- In West Austin, Ashe juniper covers 68% of the area compared to 20% in East Austin. Cedar elm is more common in East Austin at 18% compared to just 2% in West Austin. Live oak is similar across the city at 12% to 14%.
- West Austin contains 11 unique species, while East Austin contains a 29 unique species.

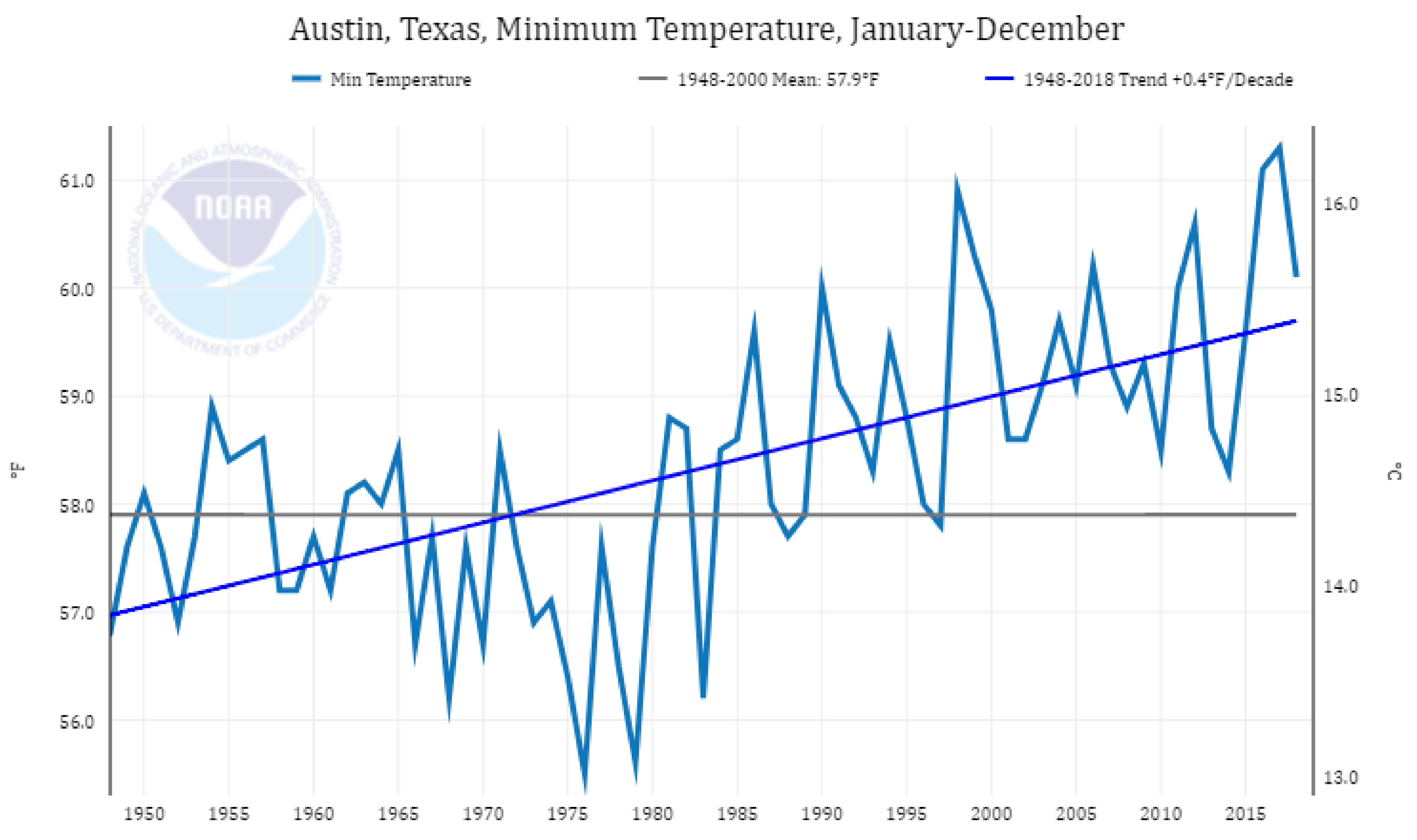
Climate Projections

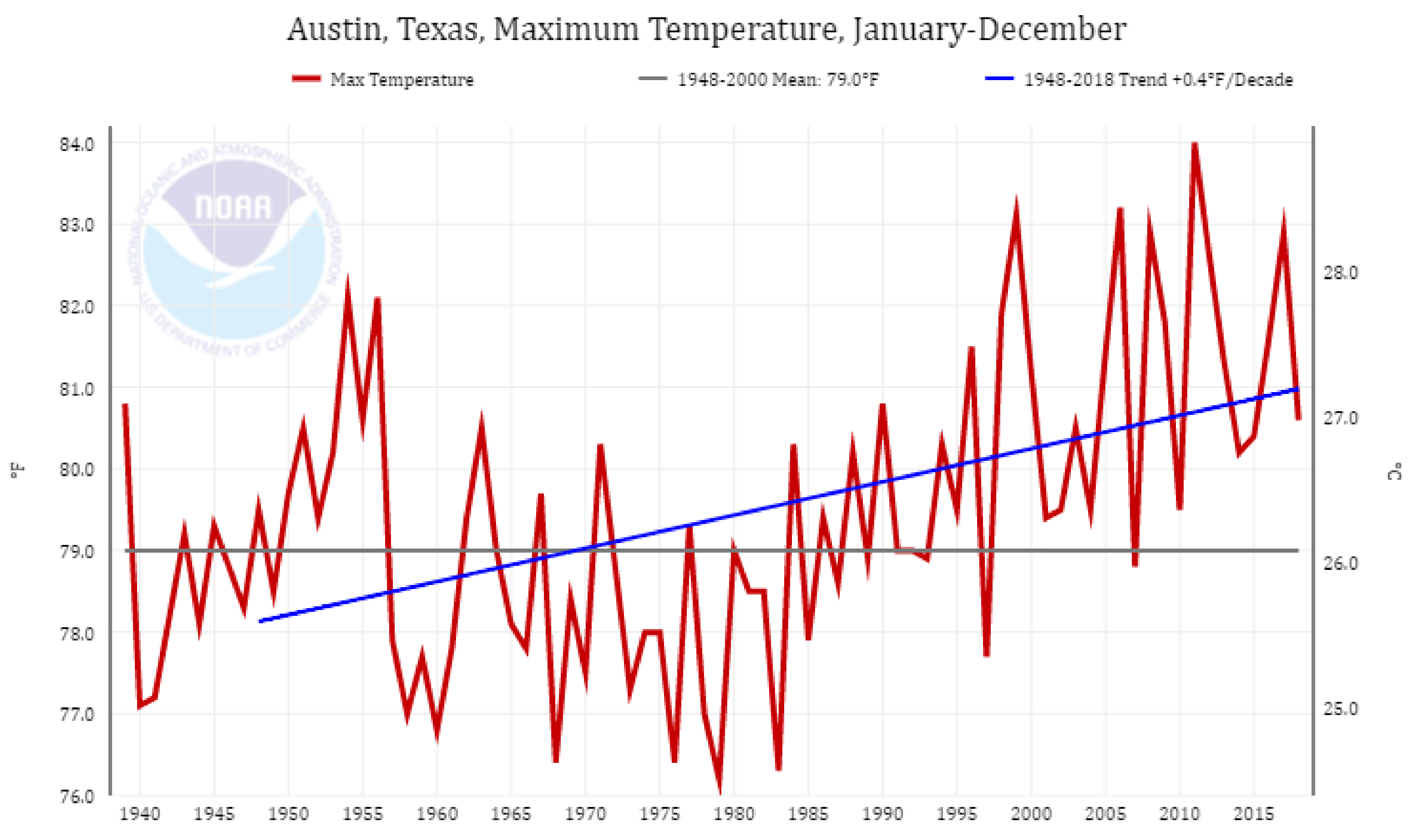
- Climate projections were retrieved from Climate Mapper using 2 emissions scenarios and 20 climate models (averaged) downscaled to 4km.

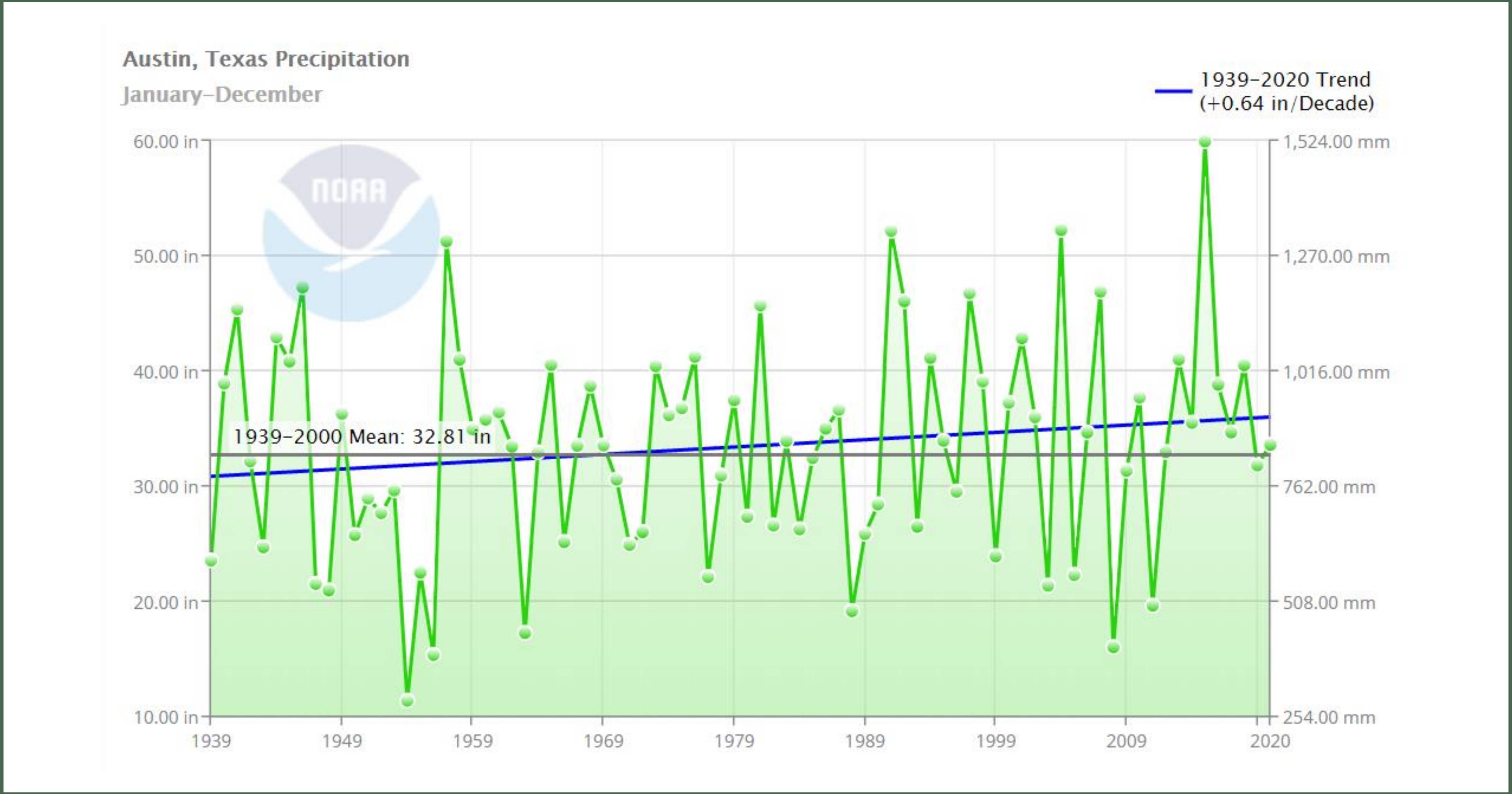
  Scenario 1: greenhouse gas emission rates are dramatically reduced.

  Scenario 2: “business as usual” in which emissions keep growing at the current rate.
- At 4km resolution we can look at climate trends across the Austin area, but cannot identify microclimates that could be hotter or cooler, such as urban heat islands and north-facing slopes.
- The project bounded results by pairing a model that tends to be cooler and wetter than average projections with the reduced emissions scenario and using a model that tends to be hotter and drier than average with the high emissions scenario.


Austin, Texas, Average Temperature, January-December
Avg Temperature
1948-2000 Mean: 68.5°F
1948-2018 Trend +0.4°F/Decade
72.0
71.0
70.0
69.0
68.0
67.0
°F
22.0
21.0
20.0
19.0
°C


Austin, Texas, Minimum Temperature, January-December
Min Temperature
1948-2000 Mean: 57.9°F
1948-2018 Trend +0.4°F/Decade
°F
°C
61.0
60.0
59.0
58.0
57.0
56.0
16.0
15.0
14.0
13.0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015


Austin, Texas, Maximum Temperature, January-December
Max Temperature
1948-2000 Mean: 79.0°F
1948-2018 Trend +0.4°F/Decade
84.0
83.0
82.0
81.0
80.0
79.0
78.0
77.0
76.0
°F
28.0
27.0
26.0
25.0
°C
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015



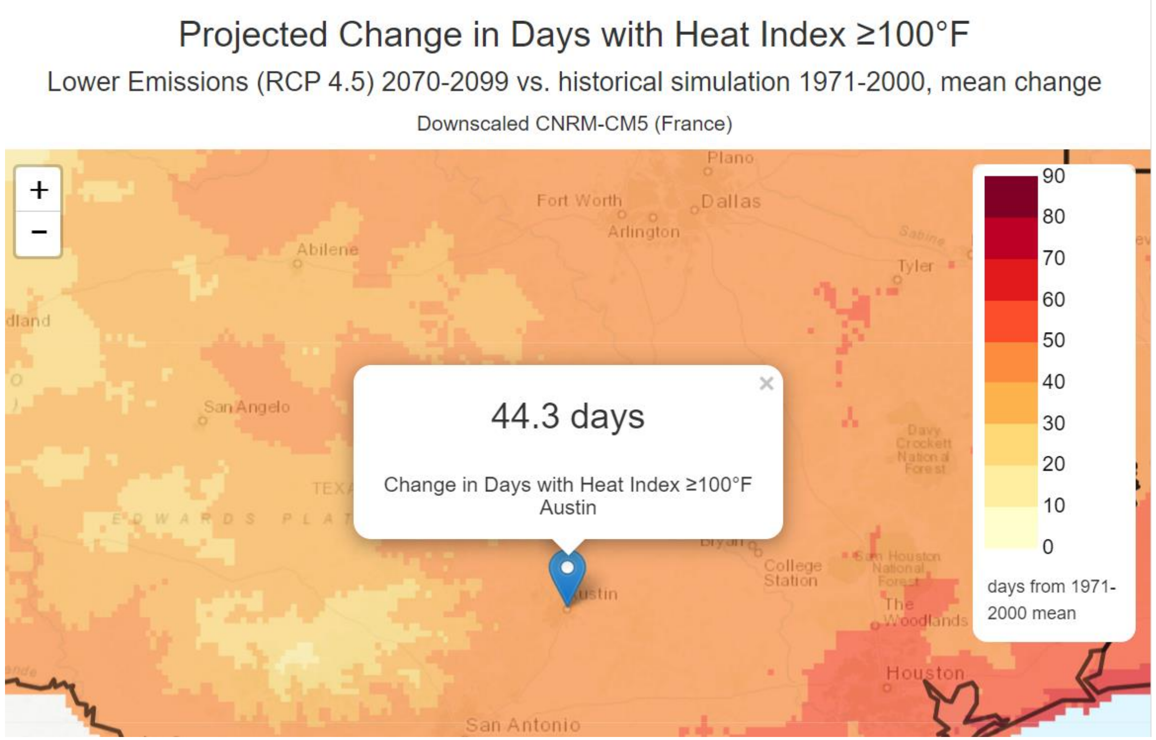
Austin, Texas Precipitation
January–December
1939–2020 Trend
(+0.64 in/Decade)
1939–2000 Mean: 32.81 in
60.00 in
50.00 in
40.00 in
30.00 in
20.00 in
10.00 in
1,524.00 mm
1,270.00 mm
1,016.00 mm
762.00 mm
508.00 mm
254.00 mm
1939
1949
1959
1969
1979
1989
1999
2009
2020

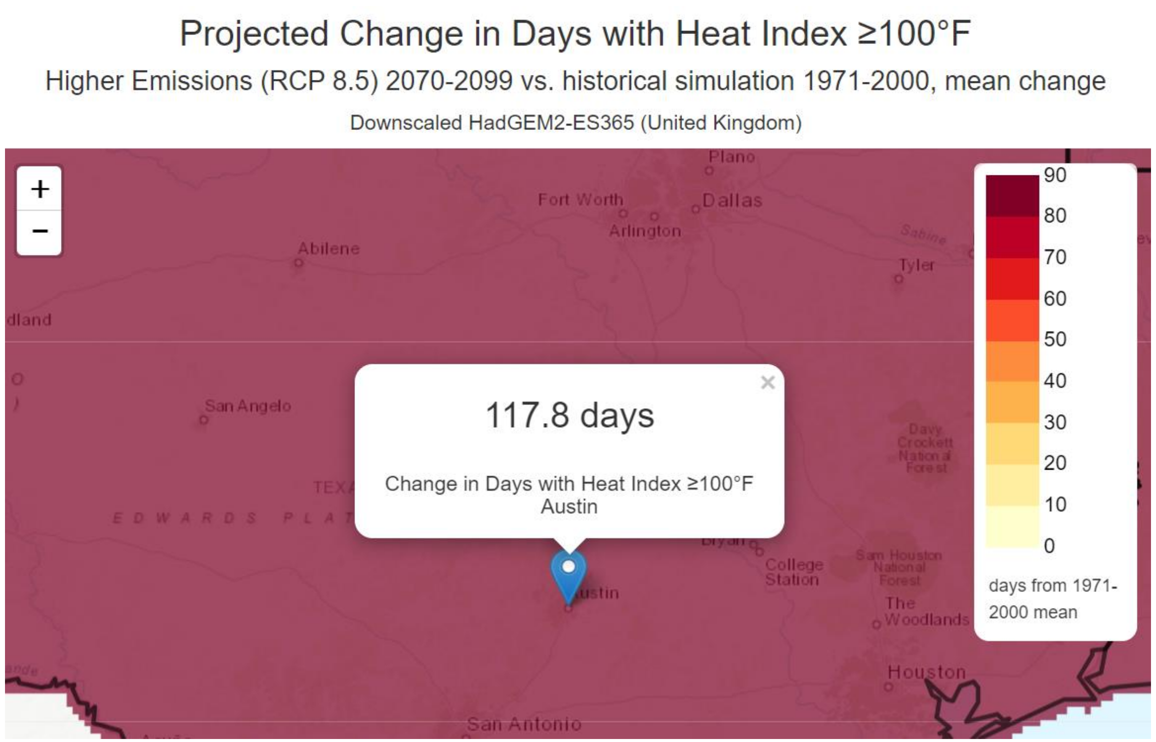
Climate Projections

- Hotter on the order of 5-10˚F by the end of the century with the “business as usual” scenario generating larger increases
- Mixed message on precipitation; regardless, increasing heat will drive increased soil evaporation and drying. Evidence of storms becoming more intense (e.g., Atlas14).

Note: Forecasting precipitation in Central Texas is notoriously challenging to meteorologists using present-day weather models due to the atmospheric dynamics of this region. Those same challenges hamper climate modeling of this region.

End of Century Climate Modeling Envelope





Modeling Projections of Species Distributions

Scientists can project future habitat suitability using *species distribution models* (SDMs). SDMs establish a statistical relationship between the current distribution of a species or ecosystem and key attributes of its habitat. This relationship is used to make projections about how the range of the species will shift as climate change affects those attributes.

Species Distribution Modeling Results - Decline

Of 31 existing species examined for the Austin region, suitable habitat for 14 of them was projected to **decline** under both high and low scenarios.

More common ones are **American sycamore, black walnut, burr oak, eastern red cedar, post oak, and mulberry.**

Species Distribution Modeling Results - Stable

Suitable habitat for 10 species was projected to remain relatively **stable** under both scenarios.

More common ones include **American elm, Ashe juniper, boxelder, green ash, northern hackberry, southern live oak (Q. virginiana), and winged elm**.

Additional Results from Species Distribution Modeling

Gain

blackjack oak

pecan

sugarberry

water oak

Uncertain Change

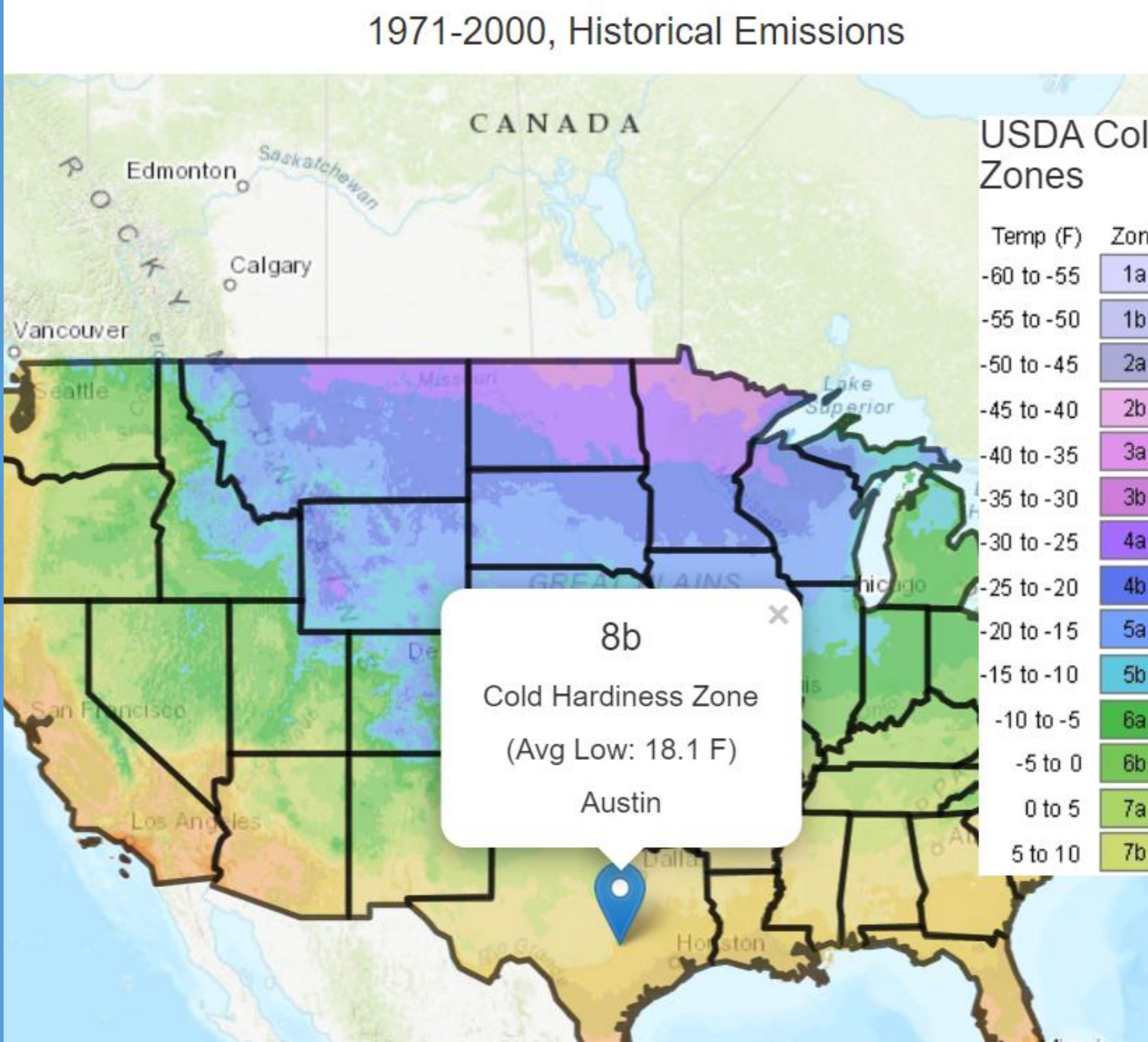
cedar elm

gum bumelia

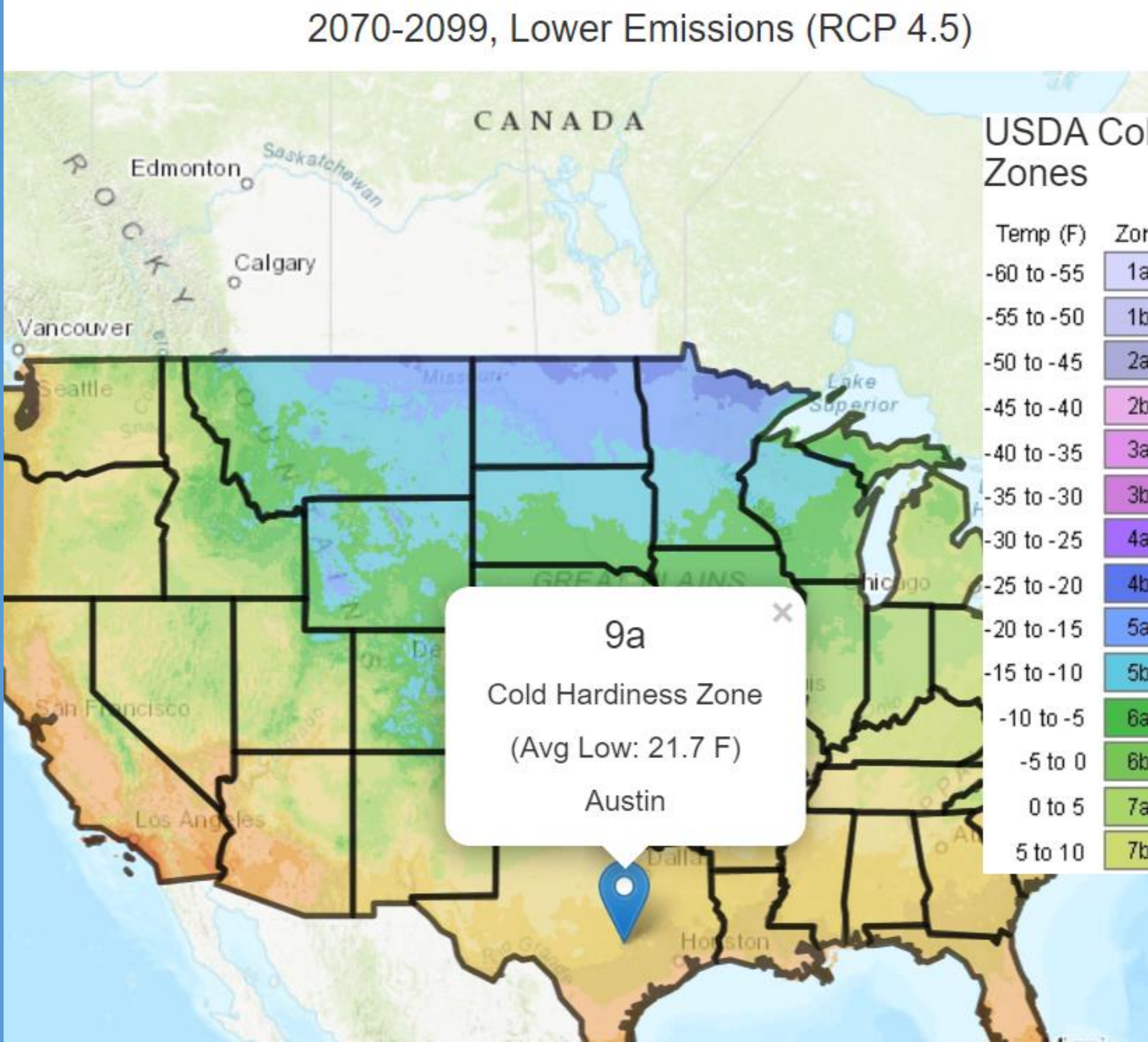
honey locust

Alternatively, we projected changes to species distributions from heat and hardiness zone shifts.

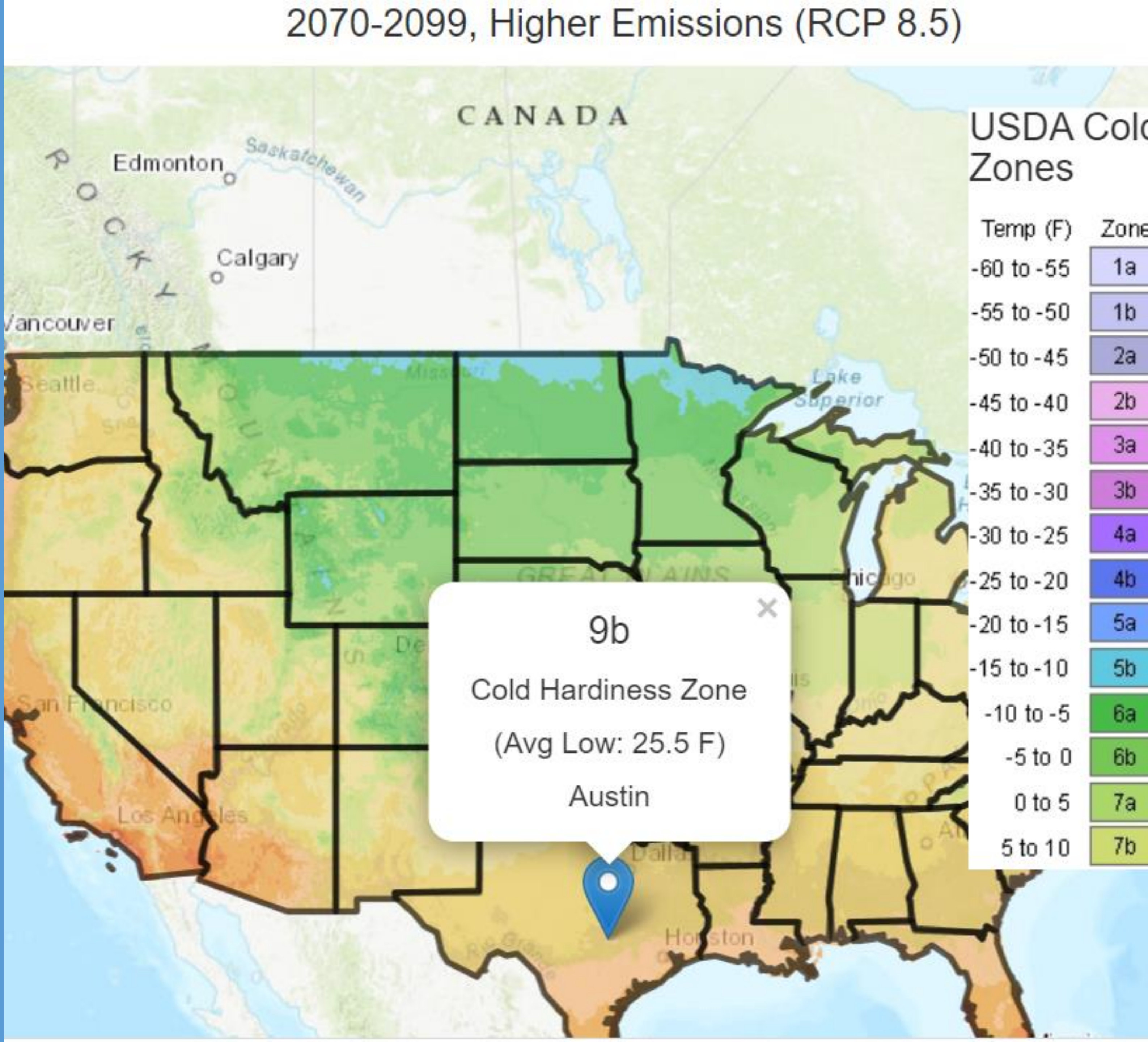
Cold Hardiness Zones



Cold Hardiness Zone – Scenario 1



Cold Hardiness Zone – Business As Usual



Heat Tolerance, Cold Hardiness, and Growing Season Length in the Austin Area through 2099

	Average	RCP 4.5			RCP 8.5		
	1971–2000	2010–2039	2040–2069	2070–2099	2010–2039	2040–2069	2070–2099
Plant Heat-Tolerance Zone	9	10	11	11	10	11	12
Cold Hardiness Zone	8b	8b	9a	9a	8b	9a	9b
Growing Season Length (Days)	278	276	286	300	299	319	359

We examined species' current ranges by county using the Biota of North America (Kartesz, 2015). **The climate of Austin is projected to become similar to areas south and west over the coming decades. Species presently found south and west of Austin may be best suited to future climate conditions.**

A species currently at the northern and/or eastern extent of its range in Travis County (more common to the southwest), is likely to be positively affected by climate change. A species at the southern and/or western extent of its range (more common to the northeast), is likely to be negatively affected.

Based on this method, **23** species may **benefit from milder winters** (indicated by a shift in hardiness zone) over the next century including **southern live oak** (Q. virginiana), **Texas mountain laurel,** loquat, Mexican (Berlandier) ash, Jerusalem thorn (retama), Mexican white oak, and sweet acacia (huisache).

60 species had either hardiness zone, heat zone, or range limits (or a combination thereof) that suggests a **negative impact from an increase in temperature**. Many of Austin's most common species are included in this category including **Ashe juniper, cedar elm, sugarberry/ hackberry, yaupon, green ash, Texas red oak (Q. buckleyi), boxelder, bastard/white shin oak (Q. sinuata), pecan, western soapberry, crapemyrtle, winged elm, American sycamore, and Texas live oak (Q. fusiformis).**

21 species are **not anticipated to be affected** by temperature. Species include **Texas persimmon, honey mesquite, and Texas ash**.

Sample Results from Species Distribution Models

Common Name	Scientific Name	Model Reliability	Change Class-Low Emissions (RCP 4.5)	Change Class-High Emissions (RCP 8.5)
DECREASE UNDER BOTH SCENARIOS				
American sycamore	*Platanus occidentalis*	Low	Small decrease	Small decrease
bitternut hickory	*Carya cordiformis*	Low	Large decrease	Large decrease
Black cherry	*Prunus serotina*	Medium	Small decrease	Small decrease
black oak	*Quercus velutina*	High	Small decrease	Small decrease
black walnut	*Juglans nigra*	Low	Small decrease	Small decrease
bur oak	*Quercus macrocarpa*	Medium	Small decrease	Large decrease
eastern redcedar	*Juniperus virginiana*	Medium	Small decrease	Small decrease
flowering dogwood	*Cornus florida*	Medium	Large decrease	Large decrease
loblolly pine	*Pinus taeda*	High	Small decrease	Small decrease
post oak	*Quercus stellata*	High	Small decrease	Small decrease
red mulberry	*Morus rubra*	Low	Small decrease	Small decrease
Shumard oak	*Quercus shumardii*	Low	Small decrease	Small decrease
slippery elm	*Ulmus rubra*	Low	Small decrease	Small decrease
white ash	*Fraxinus americana*	Medium	Small decrease	Small decrease

Sample Results from Hardiness & Heat Zone Shift Evaluation

Common Name	Scientific Name	Native?	Estimated Trees in Austin	Hardiness Zone	Heat Zone	Position in Range	Climate Change Effect
American elm	*Ulmus americana*	Yes	72,039	3 to 9	9 to 1	West	Negative
American smoketree	*Cotinus obovatus*	Yes		4 to 8	N/A	South	Negative
American sycamore	*Platanus occidentalis*	Yes	132,468	5 to 9	9 to 3	Southwest	Negative
anacacho orchid tree	*Bauhinia lunarioides*	No		9 to 11	N/A	North (rare)	Positive
Arizona walnut	*Juglans major*	Yes		N/A	N/A	East	Negative
Arroyo sweetwood	*Myrospermum sousanum*	No		8 to 10	N/A	N/A	Positive
Ashe juniper	*Juniperus ashei*	Yes	13,315,759	6 to 9	10 to 7	South	Negative
Asian persimmon	*Diospyros kaki*	No		7 to 10	N/A	Center	No effect
baldcypress	*Taxodium distichum*	Yes	12,725	5 to 11	12 to 5	West	Negative
bastard/white shin oak (scalybark oak)	*Quercus sinuata*	Yes	243,656	7 to 9	N/A	South	Negative
black hickory	*Carya texana*	Yes		5 to 9	N/A	Southwest	Negative
black walnut	*Juglans nigra*	Yes	105,106	4 to 9	9 to 3	South	Negative
black willow	*Salix nigra*	Yes		4 to 9	N/A	Southwest	Negative
blackjack oak	*Quercus marilandica*	Yes		6 to 9	N/A	Southwest	Negative
boxelder	*Acer negundo*	Yes	367,930	2 to 8	8 to 3	South	Negative

Evaluating Adaptive Capacity of Species

- Species were scored according to *modification factors* to reflect their adaptive capacity.
- Modification factors include fire or drought tolerance, dispersal ability, shade tolerance, site specificity, and susceptibility to insect pests and diseases.
- A species with a large number of positive modification factors = high adaptive capacity.
- 104 species and varieties were ranked as having high, medium, and low adaptive capacity based on modification factor scores.

Highly Adaptable Species

Many of the most adaptable species are non-native invasive species, such as Chinese tallow, Chinese elm, glossy privet, chinaberry, paper and white mulberry, mimosa/silktree, Chinese pistache, and goldenrain tree.

Native species with high adaptability scores include bald cypress, cedar elm, eastern redbud, gum bumelia, sumac species, yaupon, Texas persimmon, live oak species, possumhaw, and sugarberry.

Native species with low adaptability scores include black and little walnut, black hickory, Escarpment black cherry, pecan, and lacey oak.

Vulnerability = Susceptibility to Climate Change x Adaptability

Climate Change Effect	Adapt Class: Low	Medium	High
Negative	High Vulnerability	Moderate-high Vulnerability	Moderate Vulnerability
No Effect	Moderate-high Vulnerability	Moderate Vulnerability	Low-moderate Vulnerability
Positive	Moderate Vulnerability	Low-moderate Vulnerability	Low Vulnerability

Common Name	Scientific Name	Estimated Trees Present in Austin	Vulnerability in Natural Areas	Vulnerability in Developed Areas
American elm	*Ulmus americana*	72,039	Moderate	Moderate-High
American smoketree	*Cotinus obovatus*		High	High
American sycamore	*Platanus occidentalis*	132,468	Moderate-High	Moderate-High
Anacacho orchid tree	*Bauhinia lunarioides*		Moderate	Low-Moderate
Arizona walnut	*Juglans major*		Moderate-High	Moderate-High
Arroyo sweetwood	*Myrospermum sousanum*		Low-Moderate	Low-Moderate
Ashe juniper	*Juniperus ashei*	13,315,759	Moderate	Moderate-High

Summary of Impacts, Adaptive Capacity, and Vulnerability for Evaluated Areas

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

Key Findings

Both natural and developed areas in the Austin region are vulnerable to changes in climate.

Natural and developed upland areas in West Austin are also vulnerable to drought, erosion, and wildfire and have less tree diversity than East Austin.

Natural and developed areas in East Austin are more vulnerable to precipitation extremes due to shrink-swell soils and low elevation but have a greater potential for a diverse tree canopy than West Austin.

The urban core and other highly developed areas will experience stress not only from changes in climate but also from compounding effects of drought, heat, and localized runoff-induced flooding.

Summary

- Species distribution modeling of native trees suggests that suitable habitat may decrease for 14 primarily northern species. Suitable habitat was expected to increase for 4 species. Habitat was stable for 10.

- Adaptive capacity of 104 species was evaluated using scoring systems for planted and natural environments, with many non-native invasive species among those with the highest capacity to adapt to a range of stressors.

Management Considerations

Maintaining species diversity and selecting appropriate species for the projected changes in habitat suitability will become more of a challenge for everyone, from land managers to the nursery industry.

Given the uncertainties around the effects of climate change it will be important for land managers to continue to observe and document impacts on tree species and refine models and management strategies.

So how do you decide what to plant next?

Are you planting for 2025, 2055 or 2095?

Resources

Climateactiontexas.org

- https://www.climatehubs.usda.gov/index.php/hubs/northern-forests/topic/vulnerability-assessment-austins-urban-forest-and-natural-areas