

Resilient Tree Species for Urban Environments in Virginia

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COLLEGE OF NATURAL RESOURCES AND ENVIRONMENT
**FOREST RESOURCES AND
ENVIRONMENTAL CONSERVATION**
VIRGINIA TECH™

VCE Master Gardener College • Blacksburg, VA • June 9, 2023



Source: www.ballarat.vic.gov.au/treesincob

Presentation Outline

Goal: Improve your knowledge of resilience and equip you to make resilience recommendations; not going to tell you what to plant, but how to think about what to plant

- **Defining ecosystem resilience**
- **Threats to urban forests that require resilience**
- **Factors that determine tree species resilience**
- **Selecting resilient tree species**



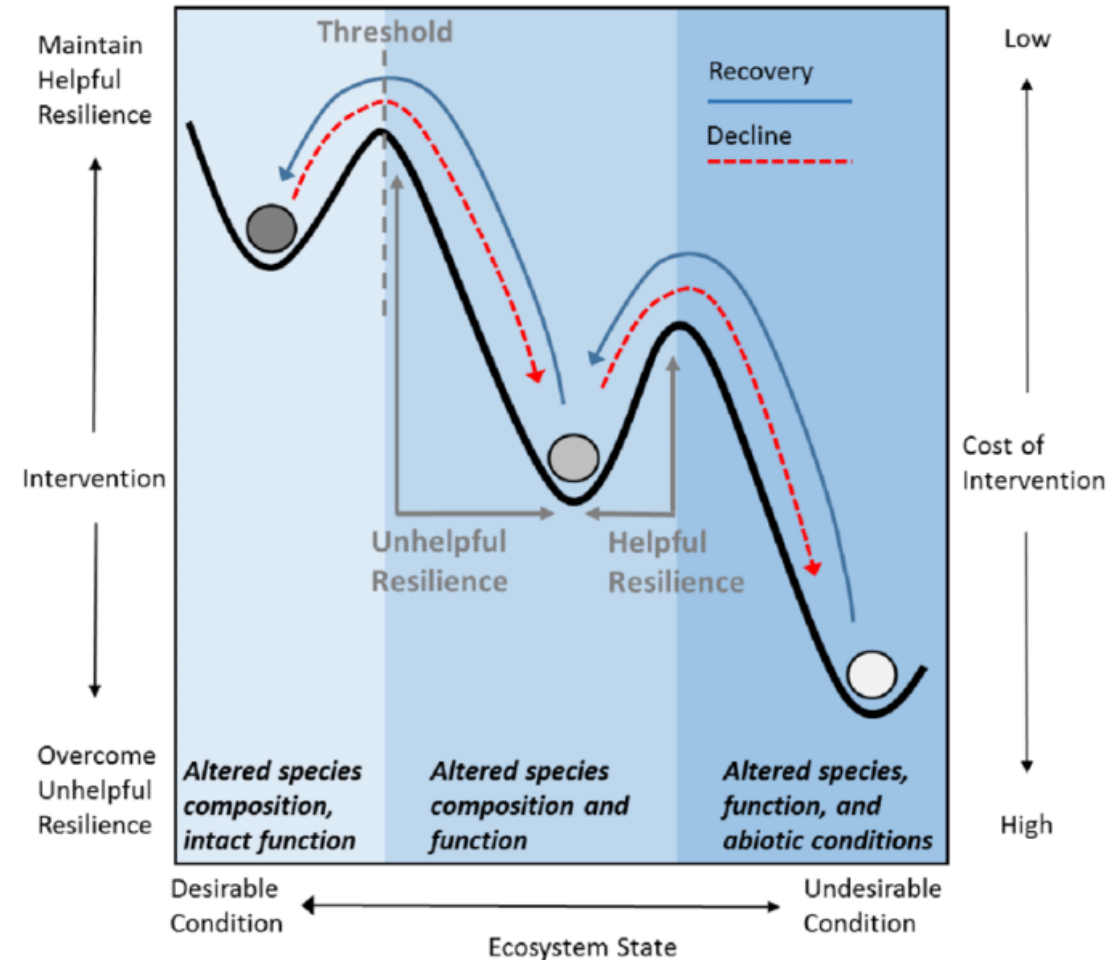
Defining Ecosystem Resilience

The ability of an ecosystem to withstand and recover from disturbances or changes while maintaining its essential structure, function, and ability to provide goods and services.

Source: Standish, Rachel J., et al. "Resilience in ecology: Abstraction, distraction, or where the action is?." *Biological Conservation* 177 (2014): 43-51.

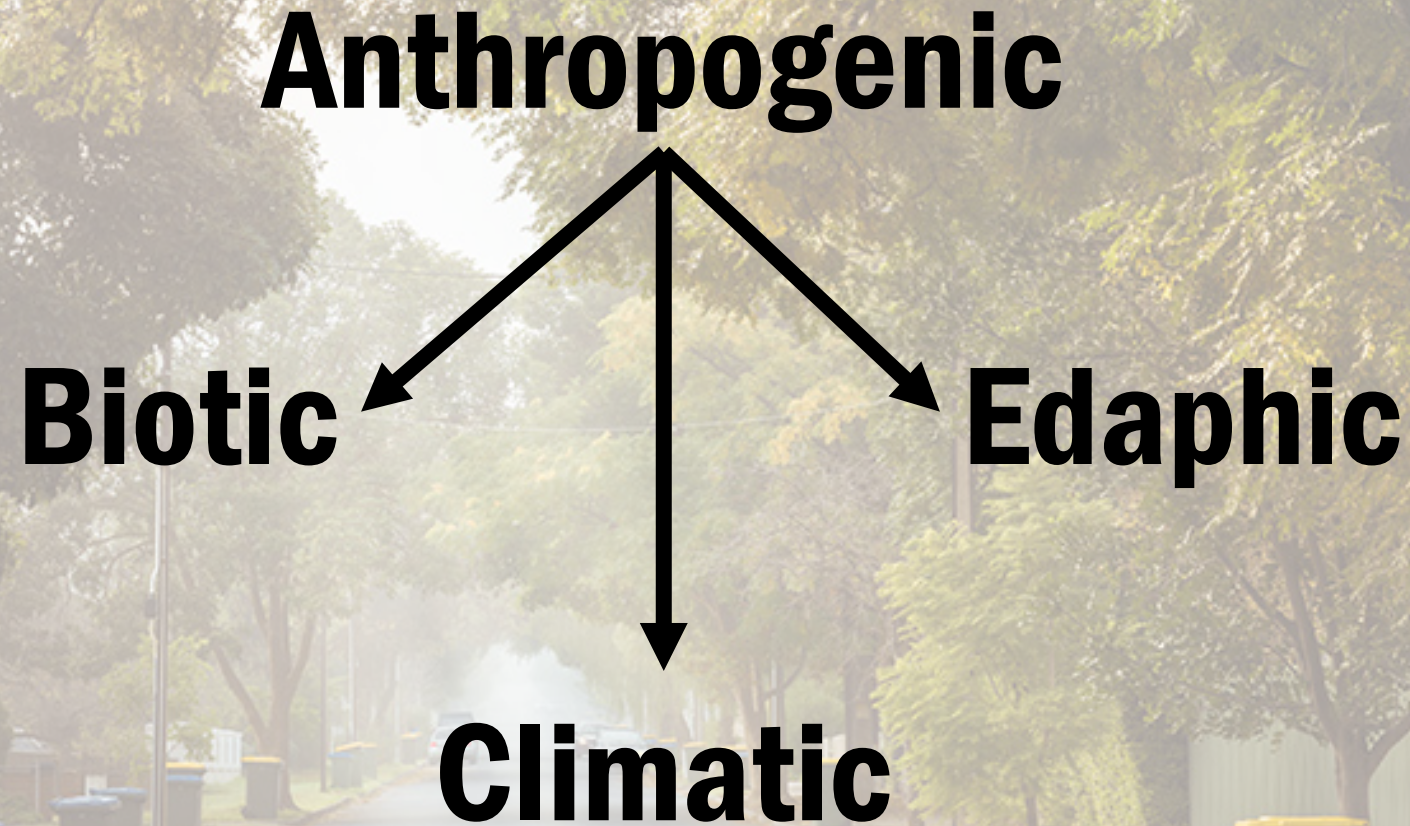
Characteristics of Resilient Ecosystems:

- Diversity
- Connectivity
- Flexibility
- Resistance and recovery



Ball-and-cup figure representing ecological resilience and changes in ecosystem characteristics Modified from Standish and others, 2014.

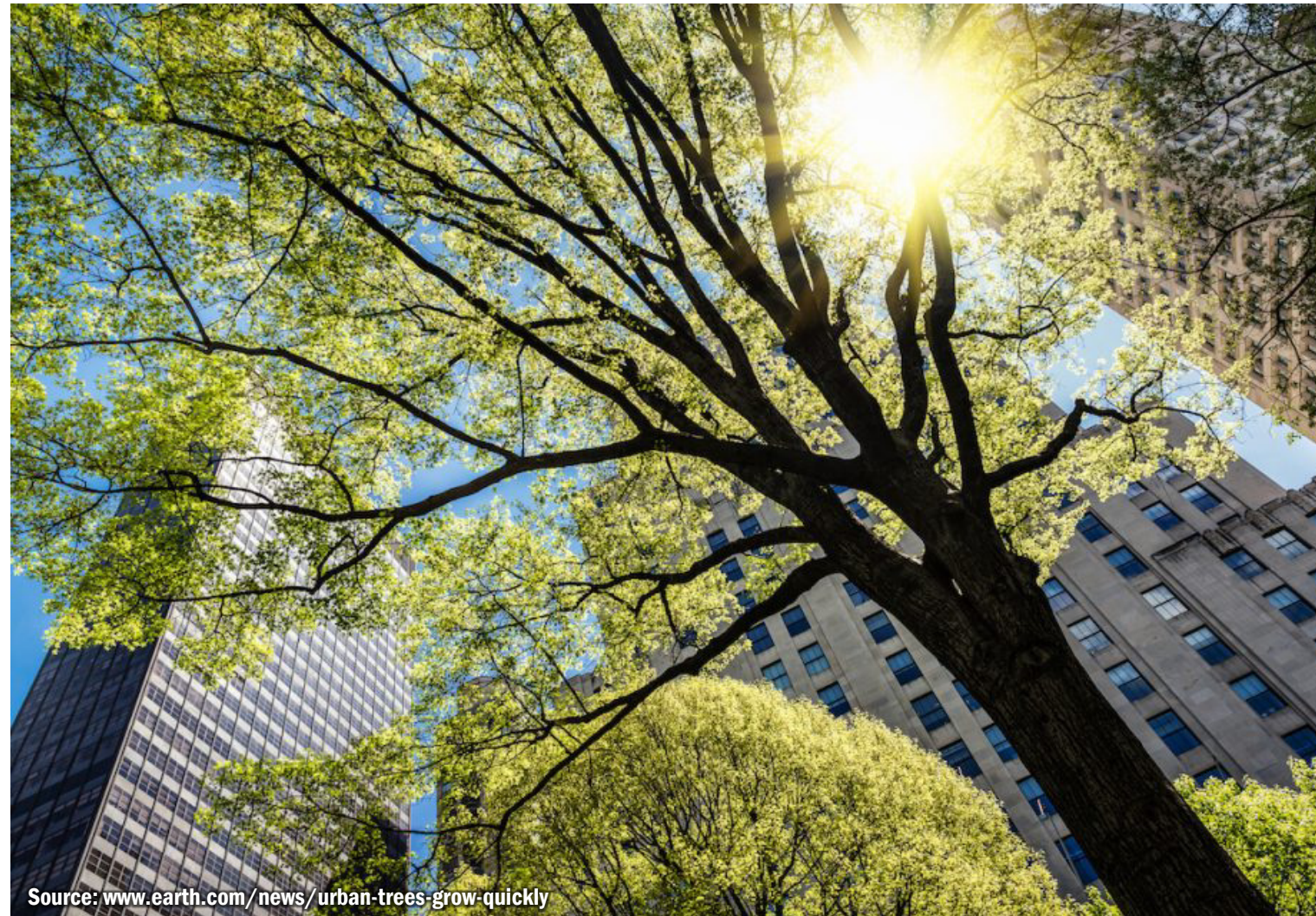
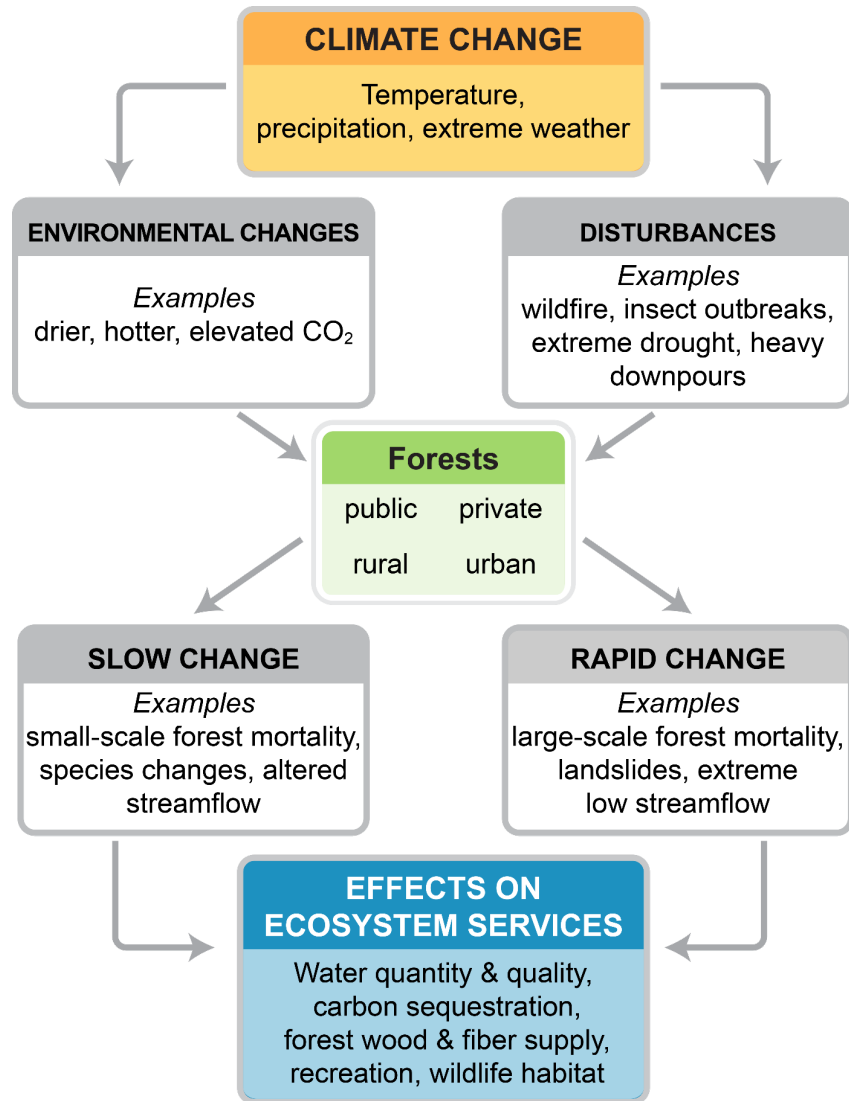
Source: pubs.er.usgs.gov/publication/ofr20171091



On average, ecosystems will need to shift about 0.42 kilometers per year (about a quarter mile per year) to keep pace with changing temperatures across the globe.

Source: Loarie, Scott R., et al. "The velocity of climate change." *Nature* 462.7276 (2009): 1052-1055.

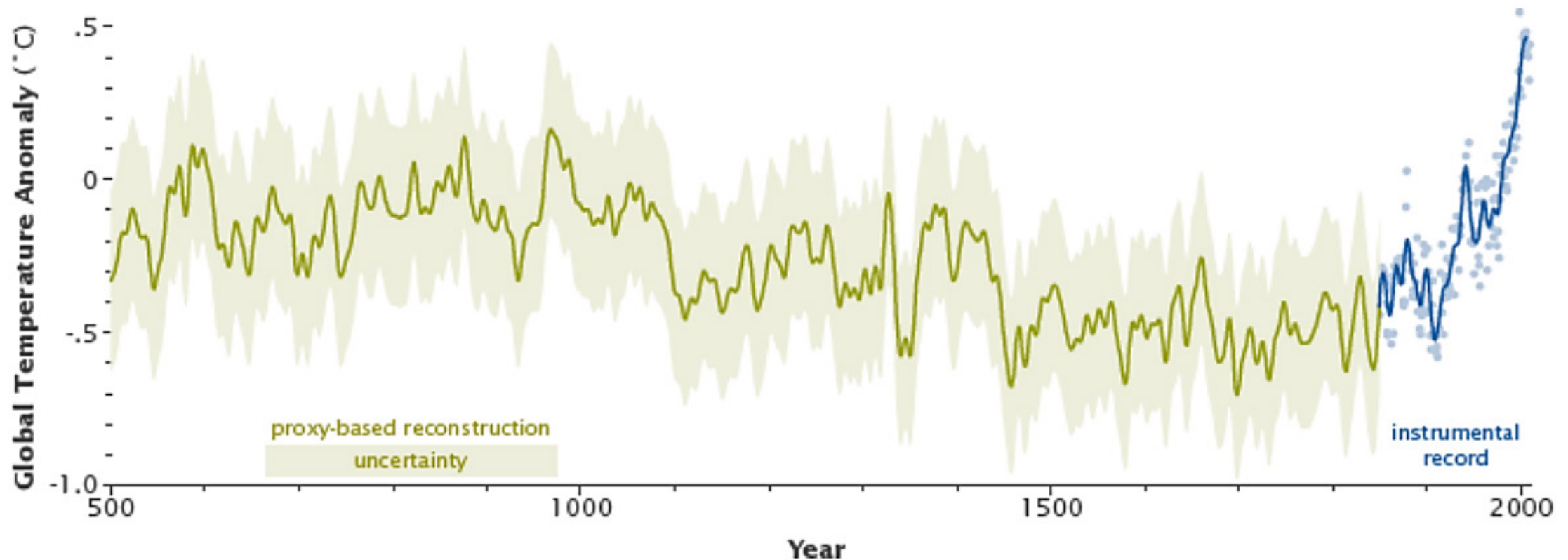
Threats to Urban Forests



Source: www.earth.com/news/urban-trees-grow-quickly

Source: nca2018.globalchange.gov/chapter/6

Threats to Urban Forests



Temperature histories from paleoclimate data (green line) compared to the history based on modern instruments (blue line) suggest that global temperature is warmer now than it has been in the past 1,000 years, and possibly longer. (Graph adapted from [Mann et al., 2008.](#))

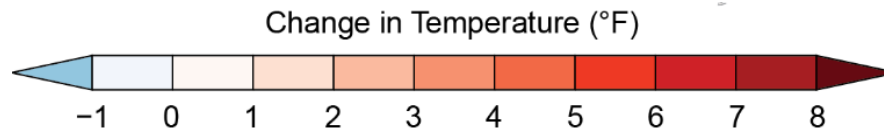
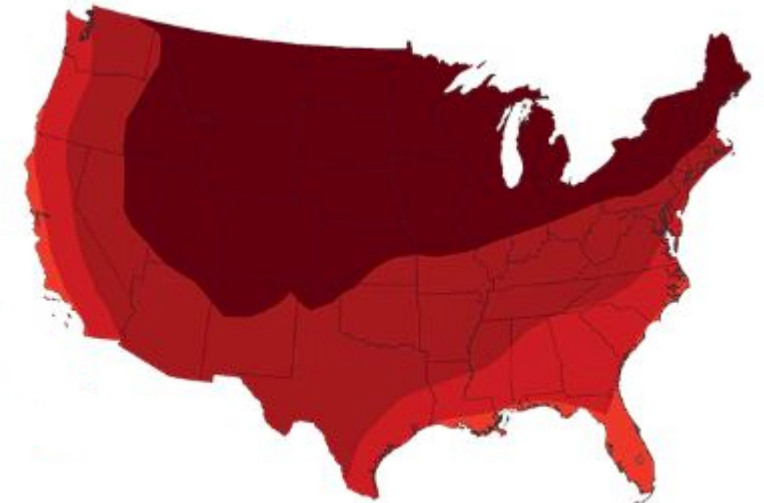
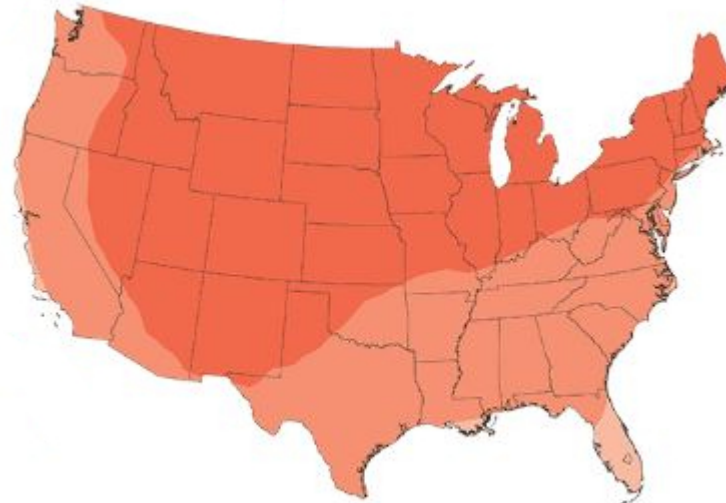
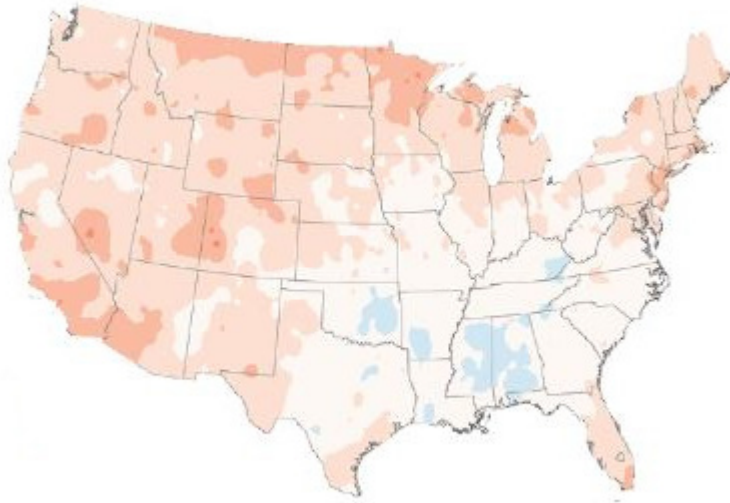
Source: earthobservatory.nasa.gov/features/GlobalWarming/page3.php?itid=1k_inline_enhanced-template

Threats to Urban Forests

Observed

Mid-21st Century
Higher Scenario (RCP8.5)

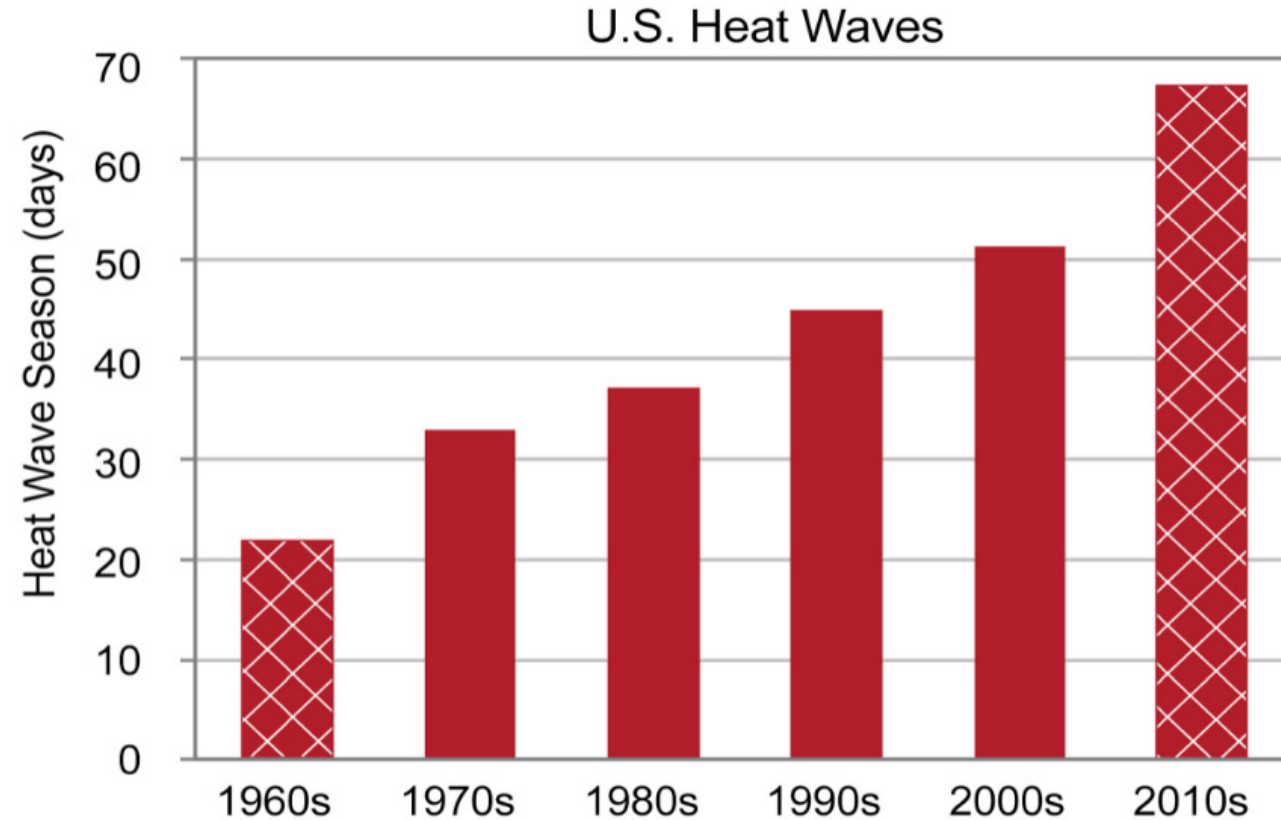
Late 21st Century
Higher Scenario (RCP8.5)



This figure compares **observed change for 1986–2016** (relative to 1901–1960) with projected differences in annual average temperature for **mid-century (2036–2065)** and **end-of-century (2070–2099)** relative to the near-present (1986–2016).

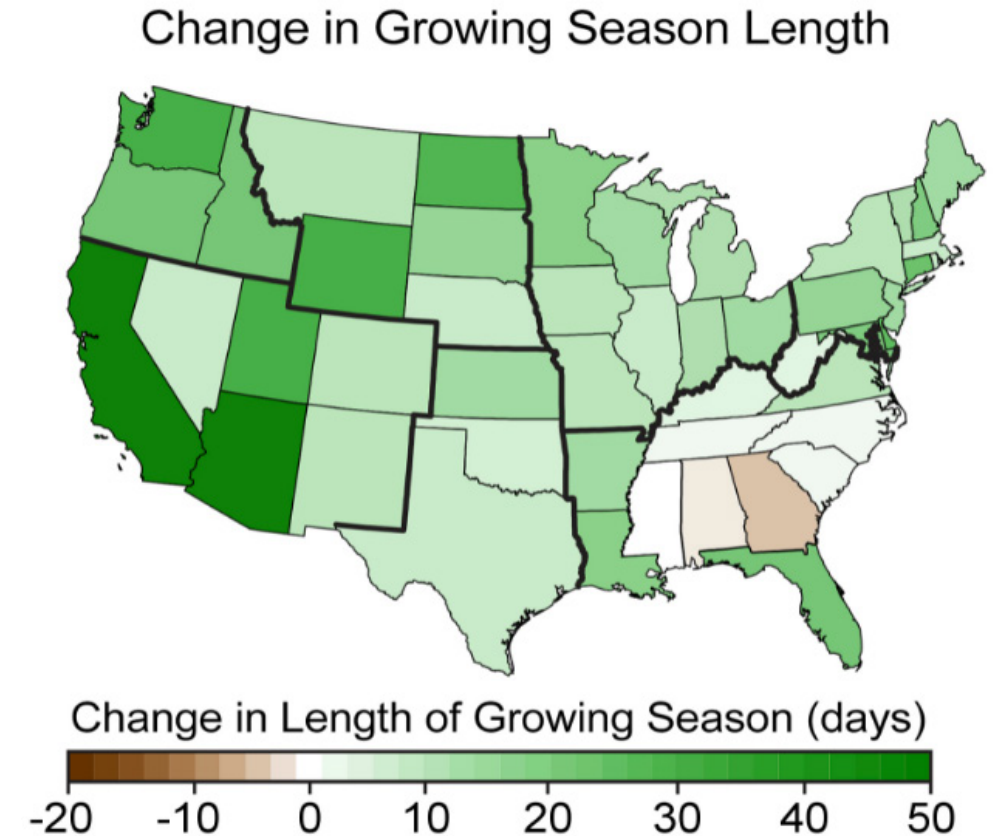
Source: nca2018.globalchange.gov/chapter/2/

Threats to Urban Forests



The **season length of heat waves** in many U.S. cities has increased by over 40 days since the 1960s. Hatched bars indicate partially complete decadal data.

Source: nca2018.globalchange.gov/chapter/1/#fig-1-2



The average **length of the growing season** has increased across the contiguous United States since the early 20th century, meaning that, on average, the **last spring frost** occurs earlier and the **first fall frost** arrives later; this map shows changes in growing season length at the state level from 1895 to 2016.

Threats to Urban Forests

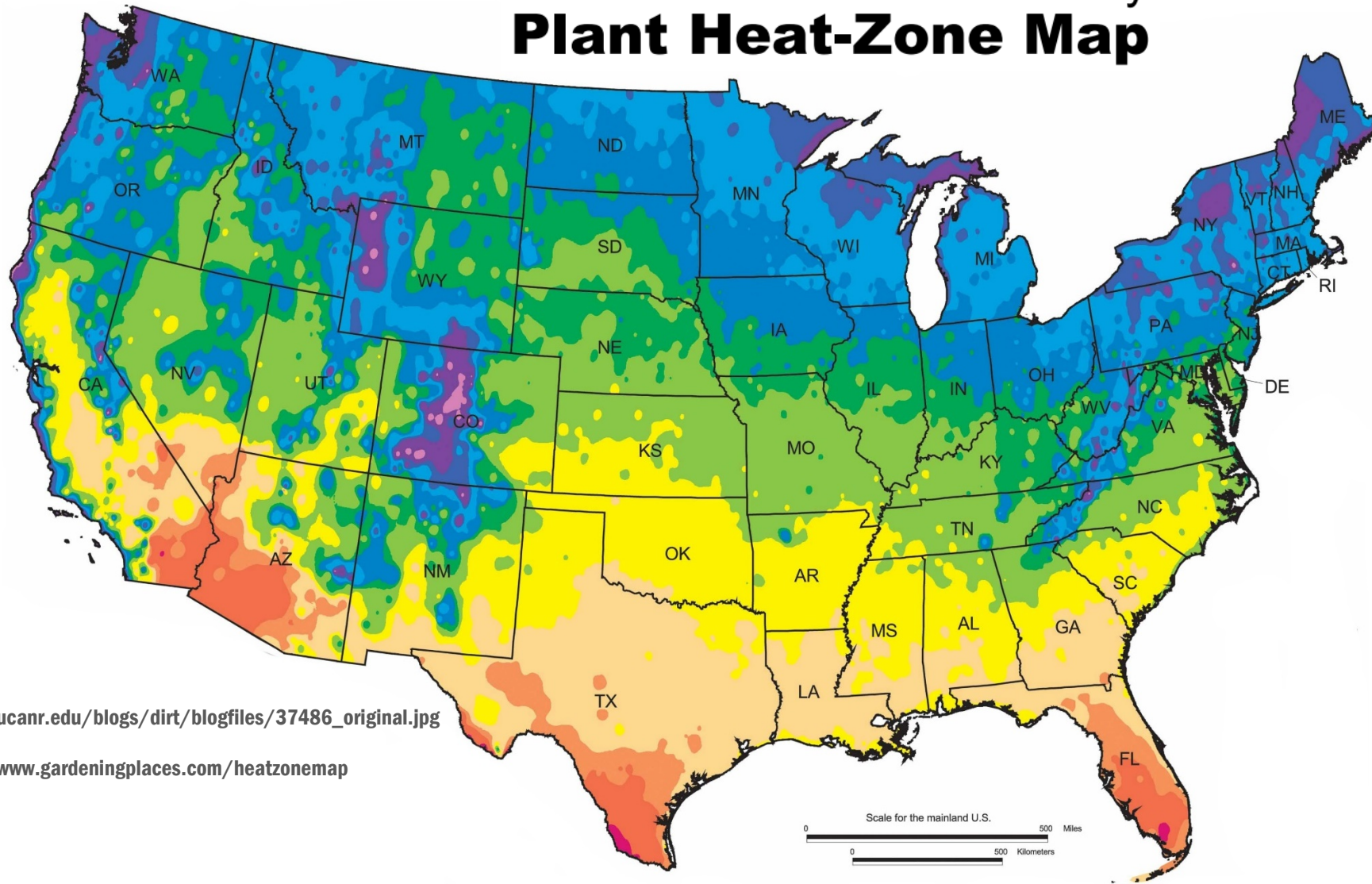


Source: www.washingtonpost.com/environment/interactive/2013/05/20/



Threats to Urban Forests

American Horticultural Society Plant Heat-Zone Map



Average Number
of Days per Year
Above 86° F (30°C)

- < 1
- 1 to 7
- > 7 to 14
- > 14 to 30
- > 30 to 45
- > 45 to 60
- > 60 to 90
- > 90 to 120
- > 120 to 150
- > 150 to 180
- > 180 to 210
- > 210

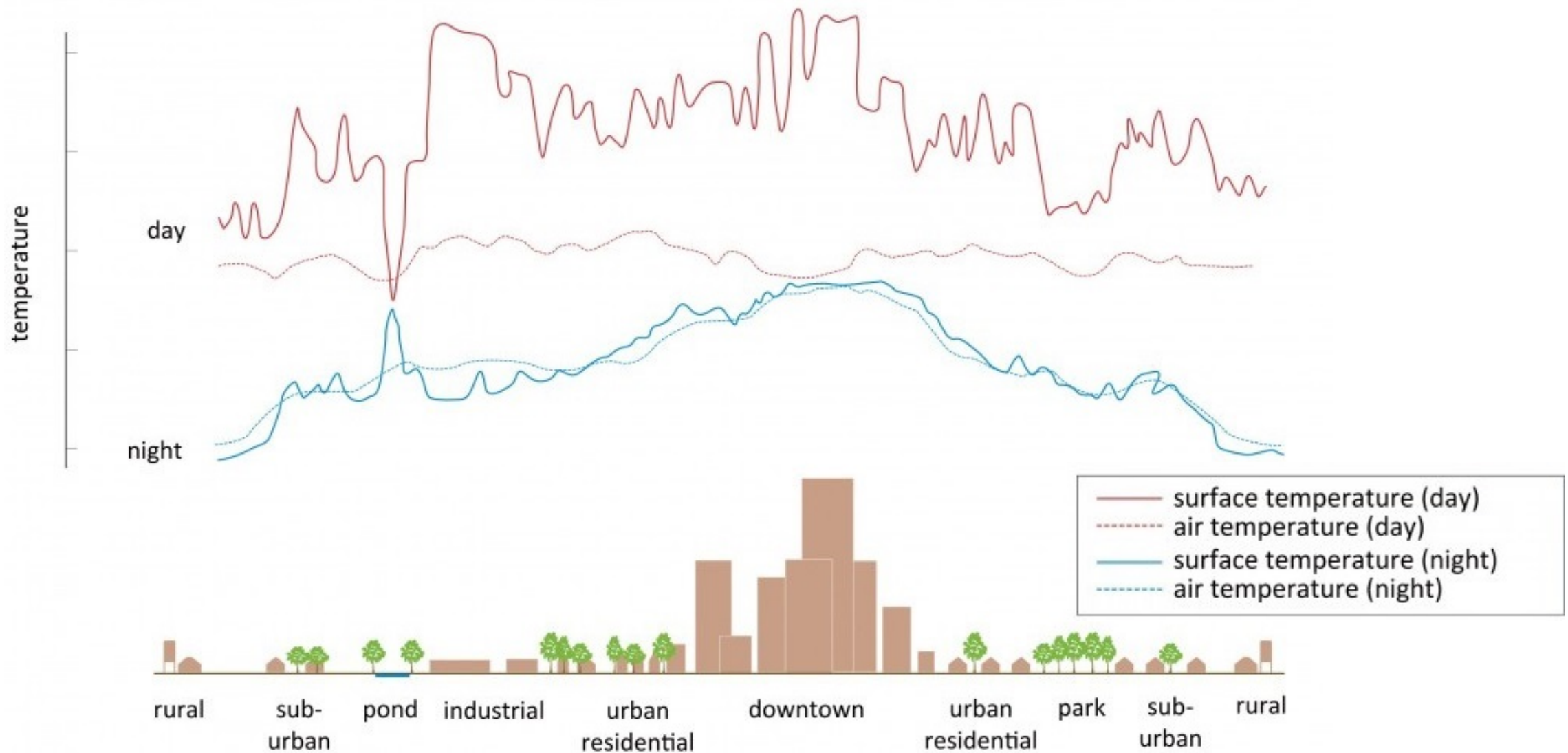
Zone



Source: ucanr.edu/blogs/dirt/blogfiles/37486_original.jpg

Source: www.gardeningplaces.com/heatzonemap

Threats to Urban Forests

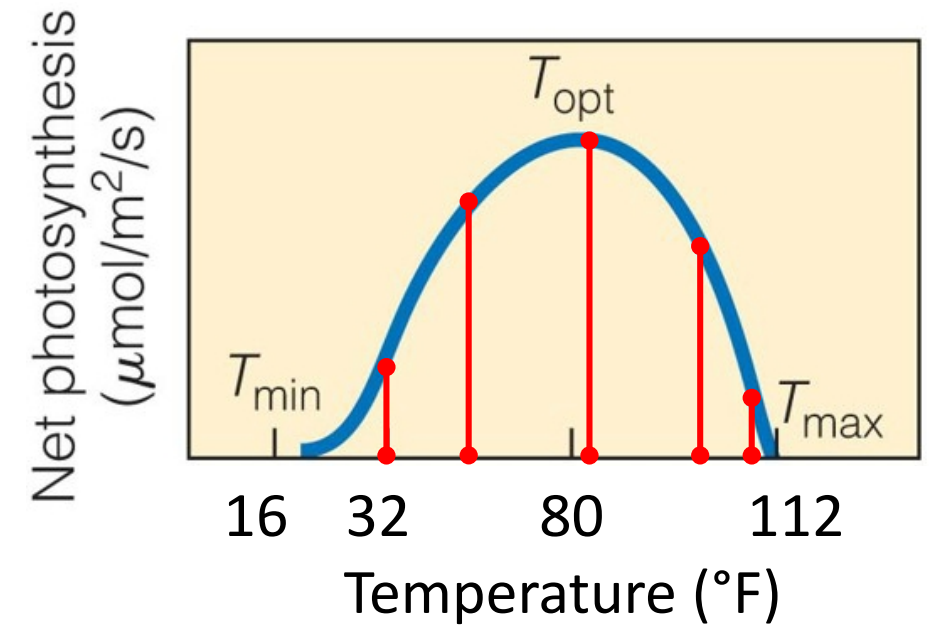
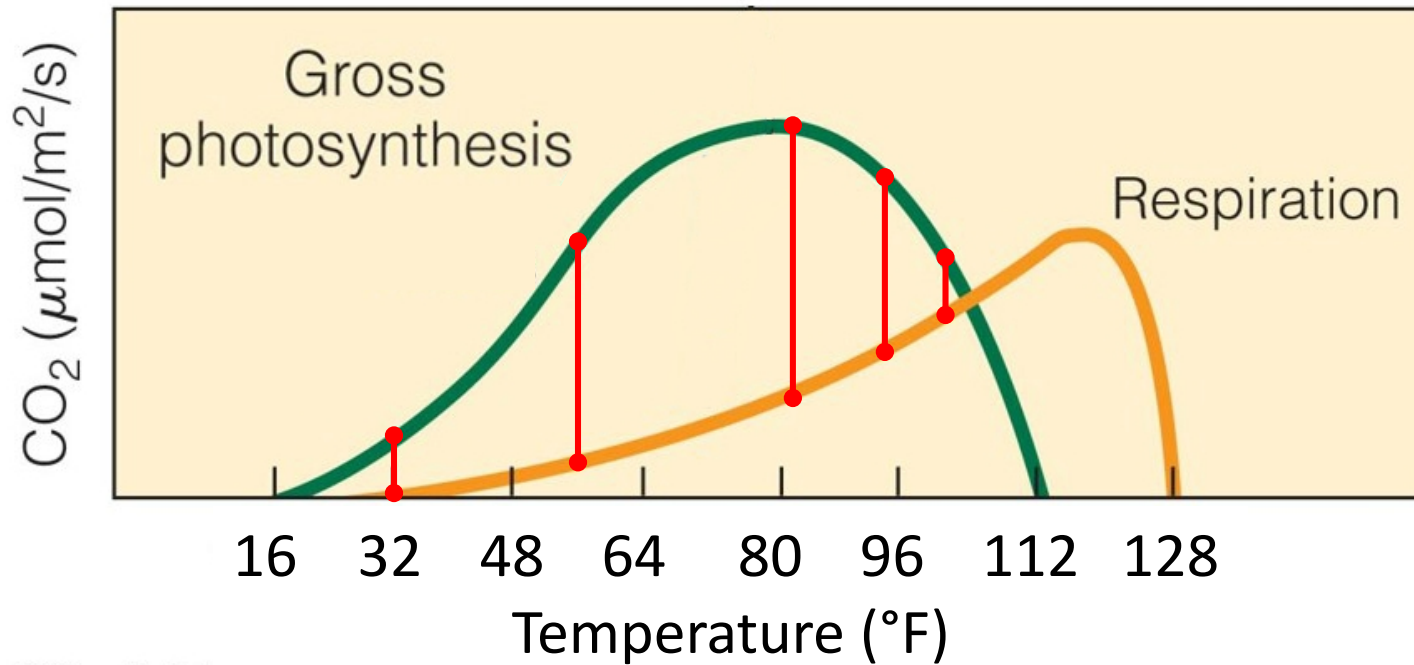


Source: www.urbangreenbluegrids.com/heat

Threats to Urban Forests

When it gets too hot...

- Photorespiration
- Chloroplast instability

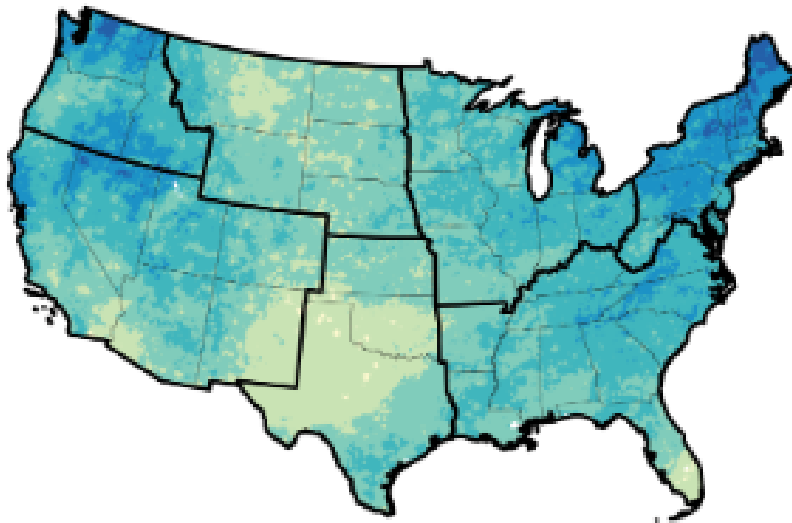


© 2012 Pearson Education, Inc.

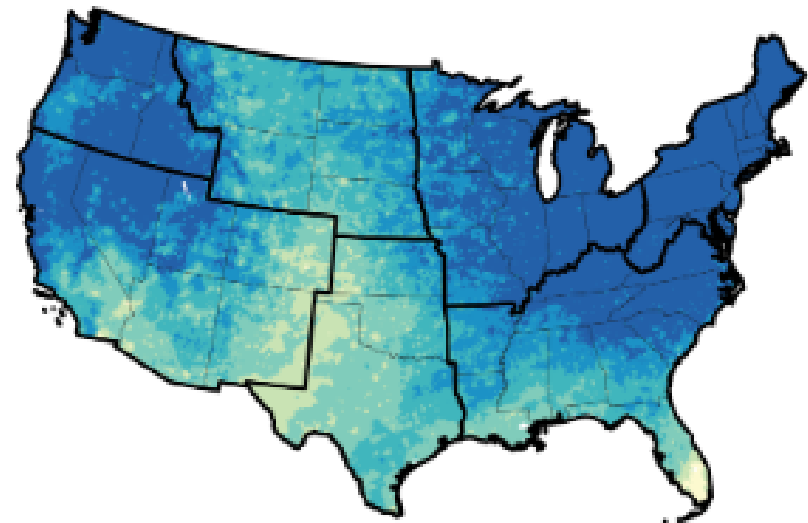
Threats to Urban Forests

Projected Change in Total Annual Precipitation
Falling in the Heaviest 1% of Events by Late 21st Century

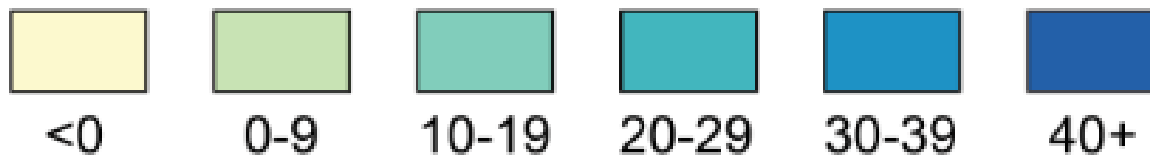
Lower Scenario (RCP4.5)



Higher Scenario (RCP8.5)

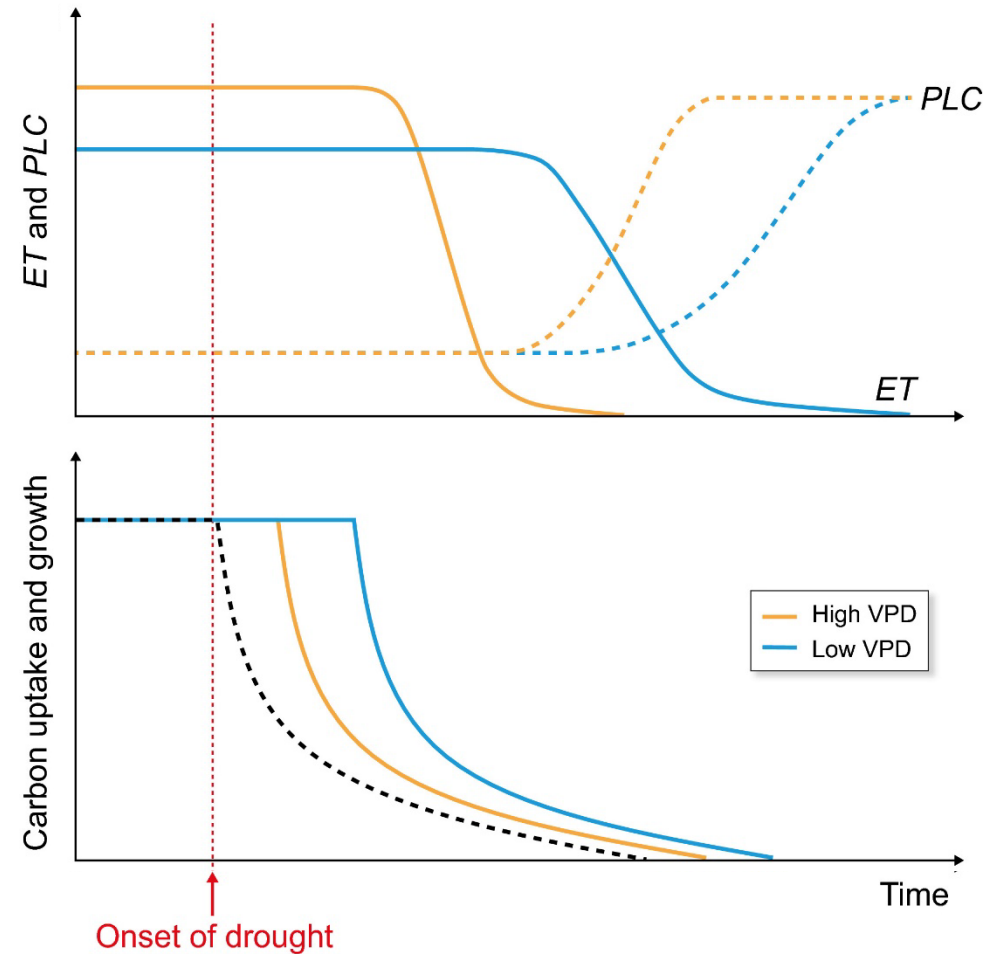
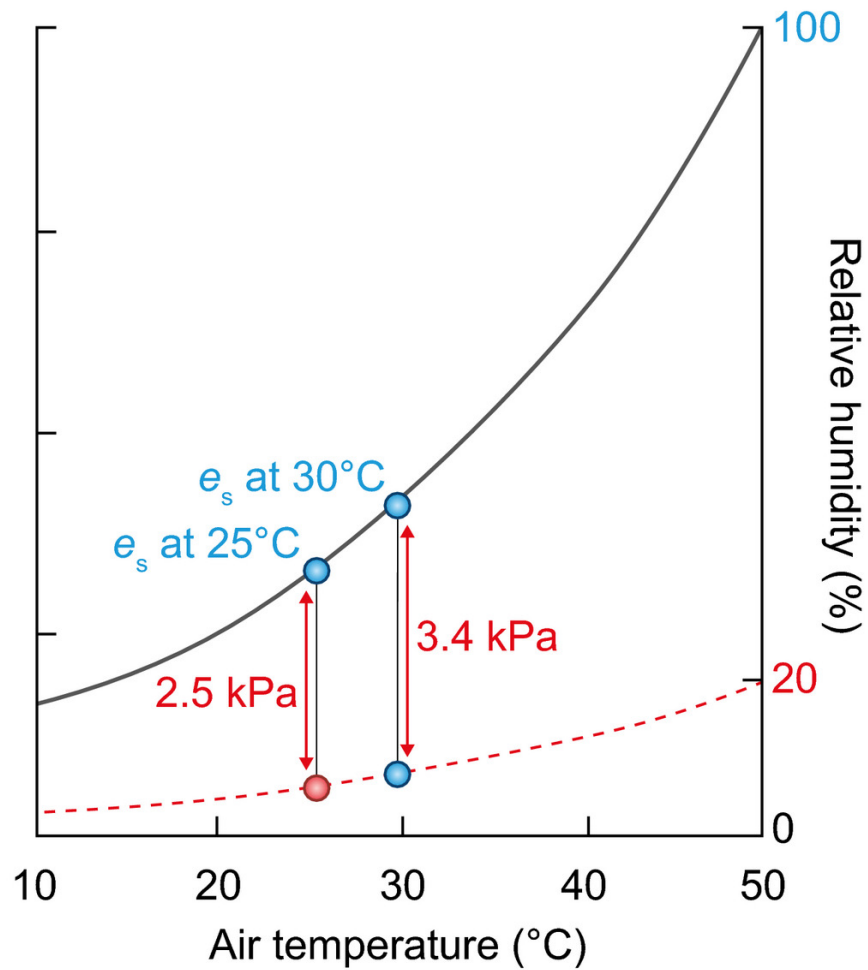


Change (%)



Source: nca2018.globalchange.gov/chapter/2

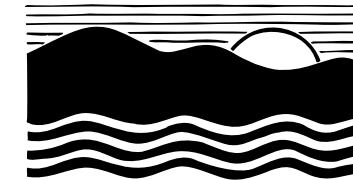
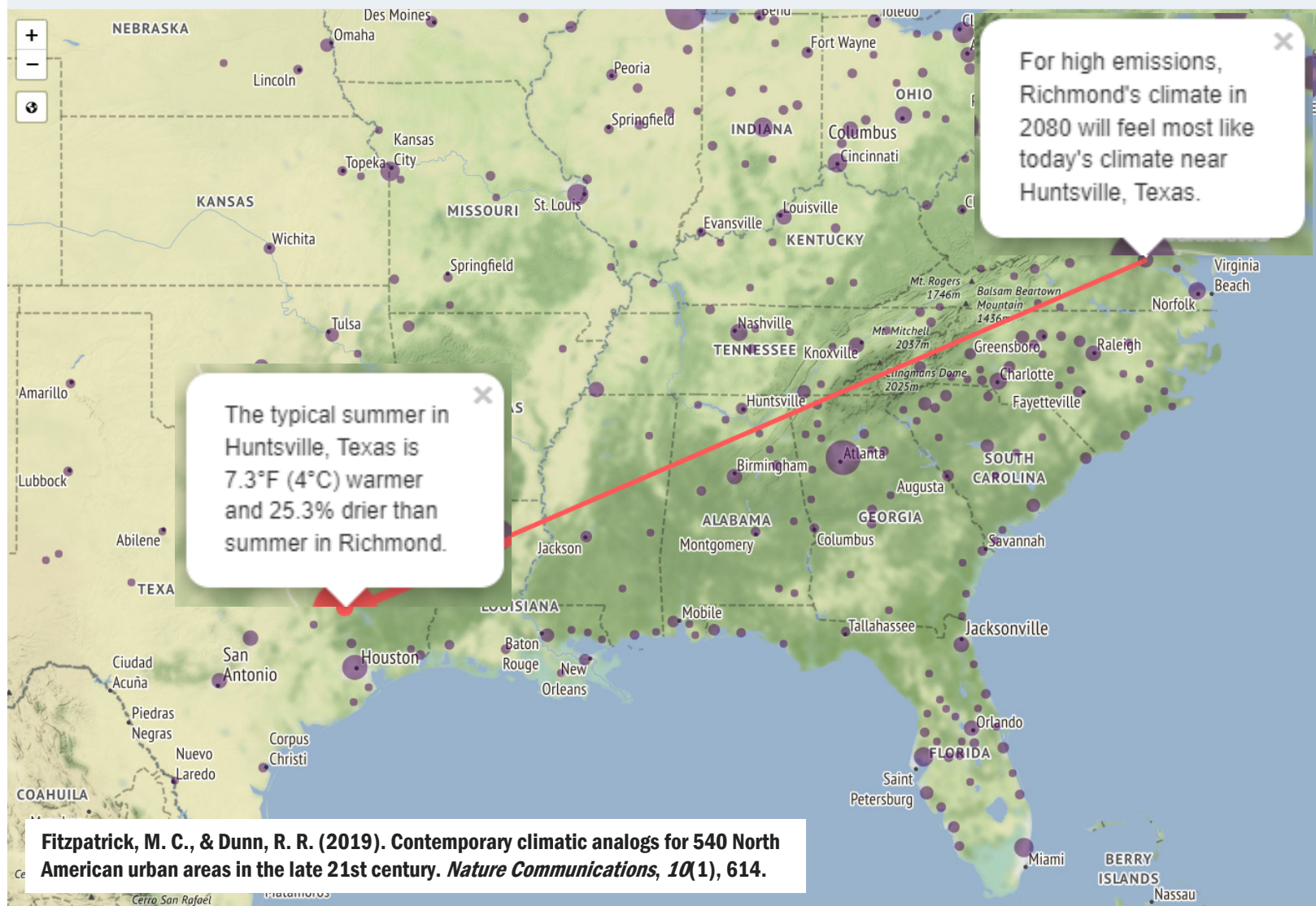
Threats to Urban Forests



Source: Grossiord, Charlotte, et al. "Plant responses to rising vapor pressure deficit." *New Phytologist* 226.6 (2020): 1550-1566.

Threats to Urban Forests

What will climate feel like in 60 years? ☰



University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Source: fitzlab.shinyapps.io/cityapp

Threats to Urban Forests

Ways in which climate change can influence the dynamics of tree pests in urban areas:

- **Range expansion**
- **Increased reproductive rates**
- **Altered life cycles**
- **Weakened tree defenses**
- **Species interactions**

DEFOLIATORS



**Eastern Tent
Caterpillar**



Fall Web Worm



**Tussock Moth
Caterpillar**

SAP-SUCKING PESTS



Red Spider Mite



Aphids



Scale



Lace Bugs

WOOD-BORING PESTS



**Emerald Ash
Borer**



**Southern Pine
Beetle**



Bark Beetle

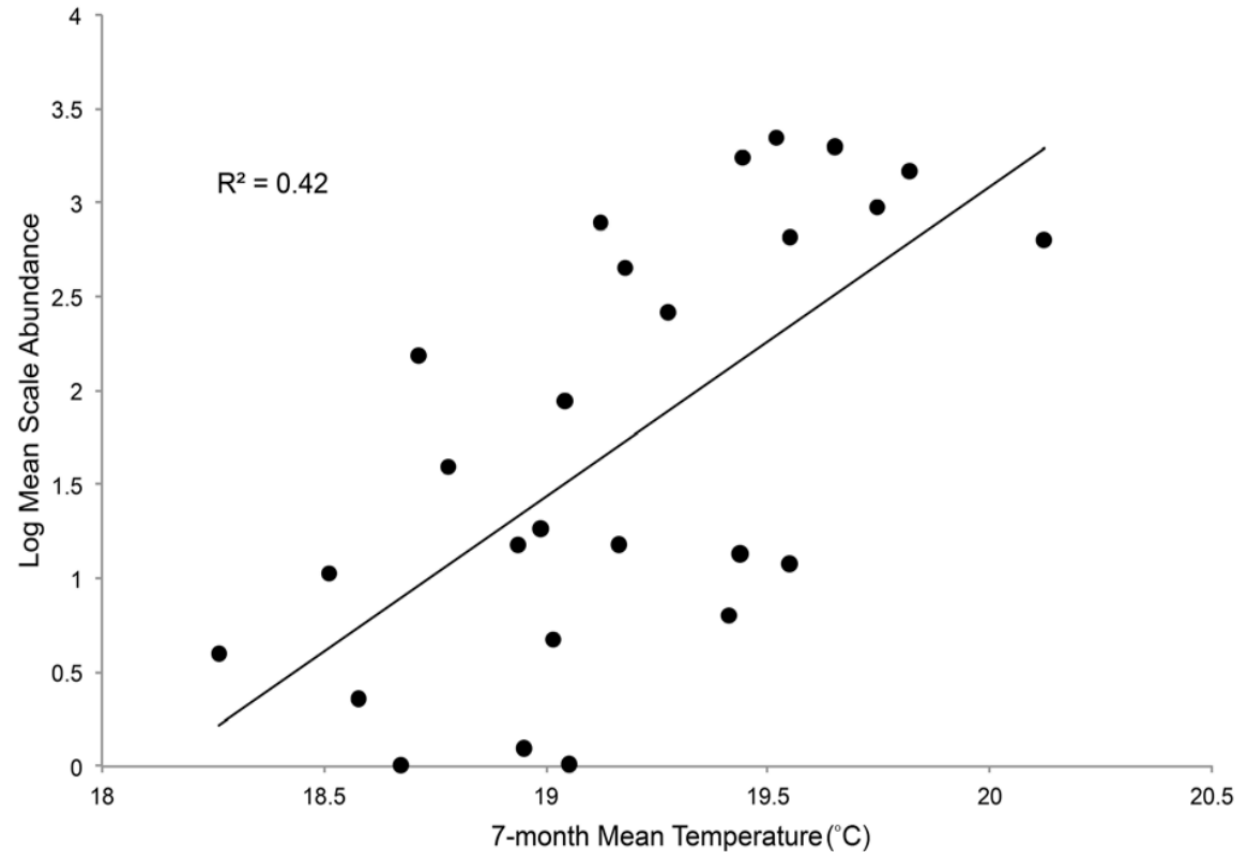
Source: www.cepralandscape.com/news-tree-pests-070920.php

Threats to Urban Forests



Gloomy Scale on Red Maple

Source: content.ces.ncsu.edu/gloomy-scale-1



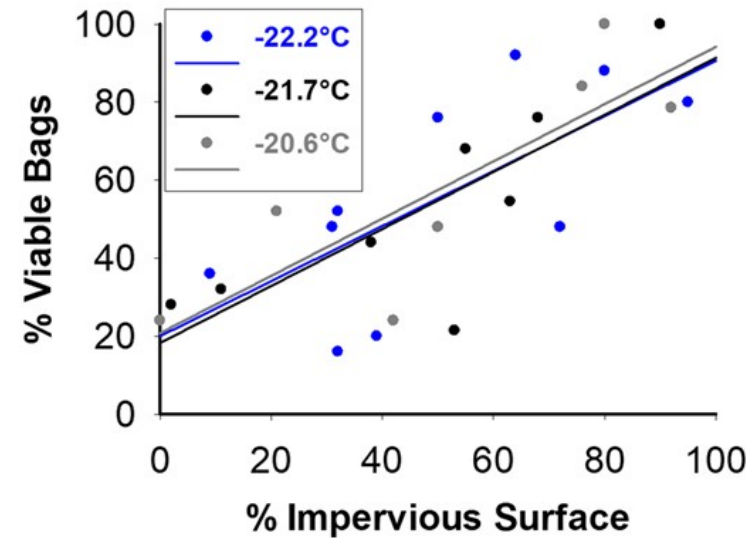
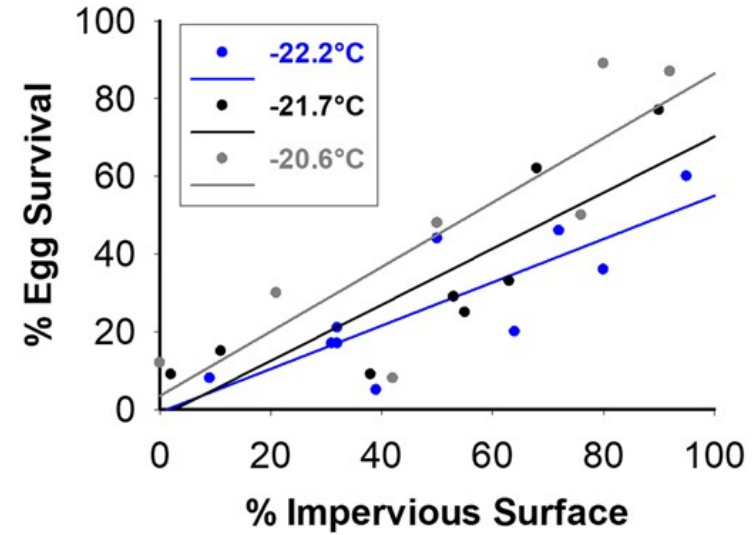
Source: Dale, Adam G., and Steven D. Frank. "The effects of urban warming on herbivore abundance and street tree condition." PloS one 9.7 (2014): e102996.

Threats to Urban Forests



Bagworm on Thuja spp.

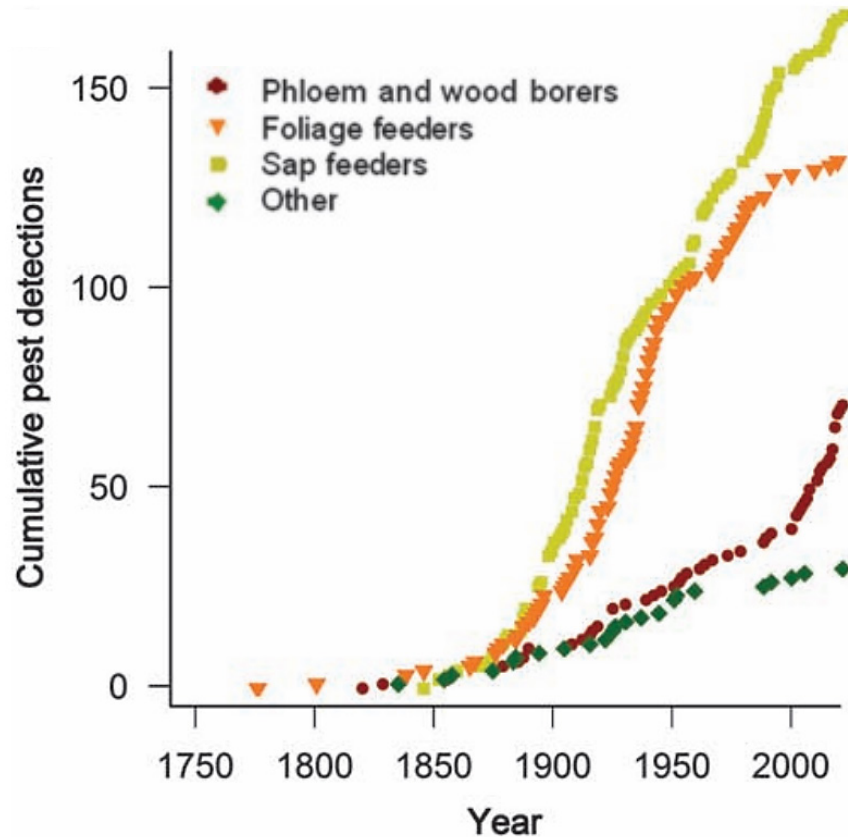
Source: bygl.osu.edu/node/1439



Source: Dawadi, Sujan, and Clifford S. Sadof. "Urban microclimate warming improves overwintering survival of evergreen bagworms." *Journal of Urban Ecology* 8.1 (2022): juac014.

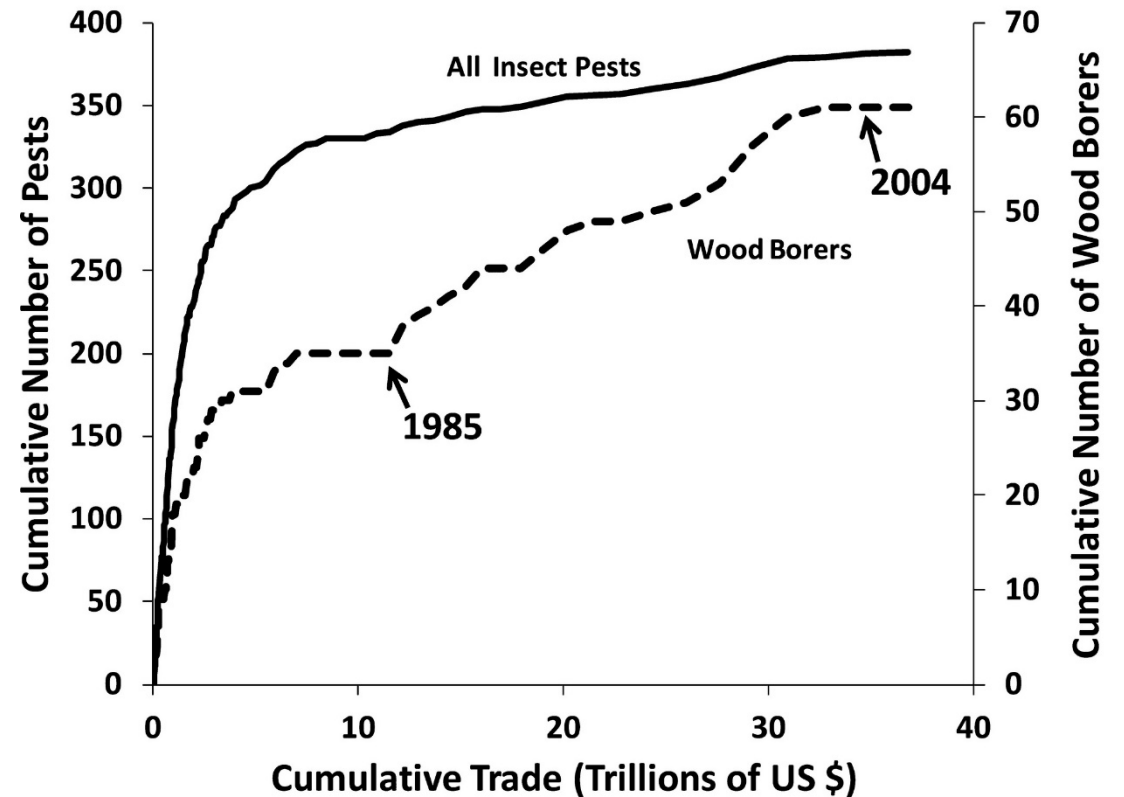
Threats to Urban Forests

Cumulative detections of nonindigenous forest insects by guild over time in U.S.



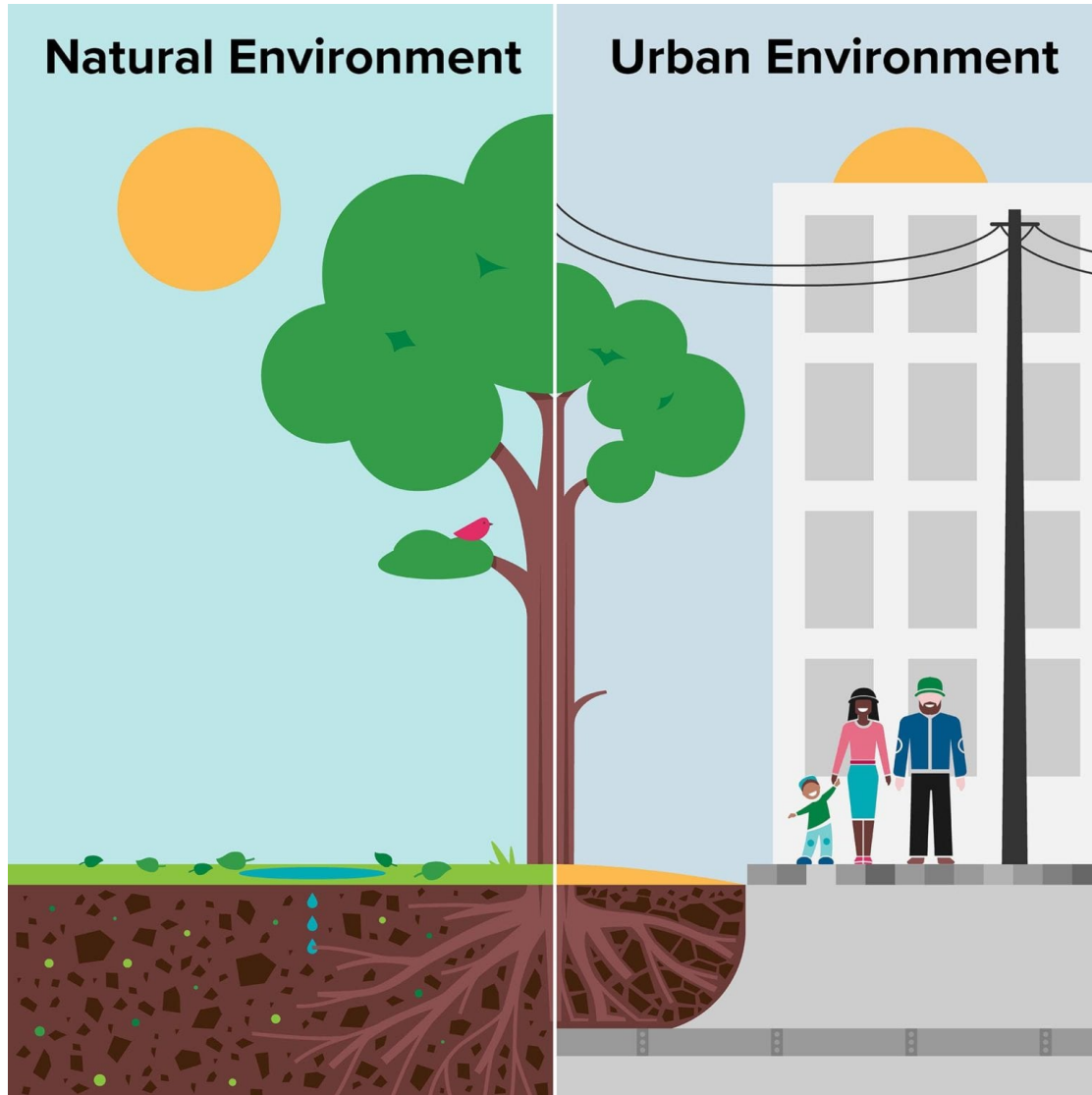
Source: Aukema, J. E. et al. (2010). Historical accumulation of nonindigenous forest pests in the continental United States. *BioScience*, 60(11), 886-897.

Relationship between growth in international trade and pest introductions to U.S.



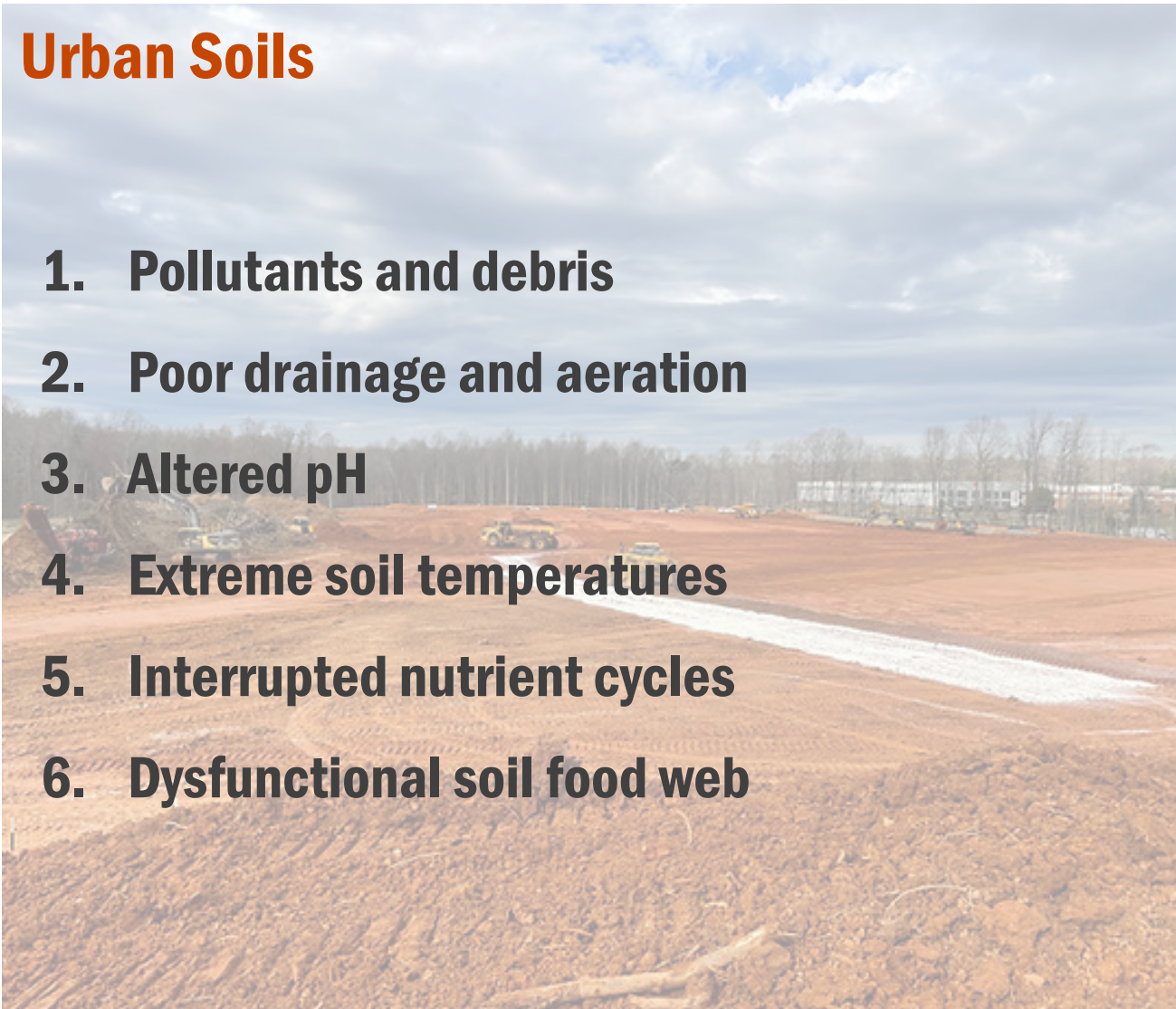
Source: Lovett, G. M. et al. (2016). Nonnative forest insects and pathogens in the United States: Impacts and policy options. *Ecological applications*, 26(5), 1437-1455.

Threats to Urban Forests



Source: cities4forests.com/lg-urban-forests

Urban Soils



Source: www.trianglegradingpaving.com/current-projects

Tree Species Resilience

Grime's Universal Adaptive Strategy Theory

Competitors

- Thrive in areas of low intensity stress and disturbance and excel in biological competition

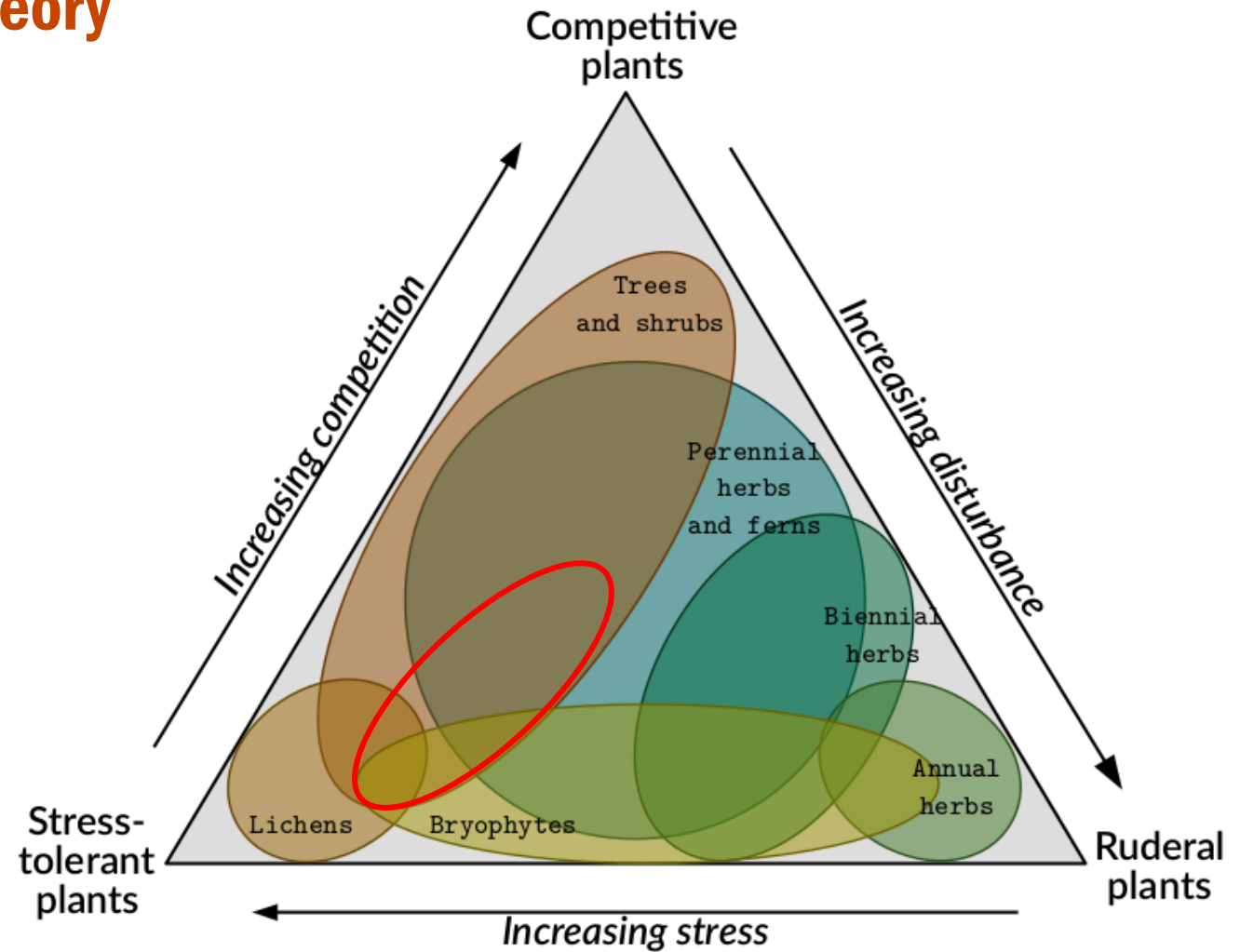
Stress Tolerators

- Thrive in areas of high intensity stress and low intensity disturbance
- Found in stressful environments such as alpine or arid habitats, deep shade, nutrient deficient soils, and areas of extreme pH levels

Ruderals

- Thrive in situations of high intensity disturbance and low intensity stress
- Found colonizing recently disturbed land

Source: en.wikipedia.org/wiki/Universal_adaptive_strategy_theory



Source: leca-dev.github.io/RFate/articles/fate_tutorial_1_PFG.html

Tree Species Resilience

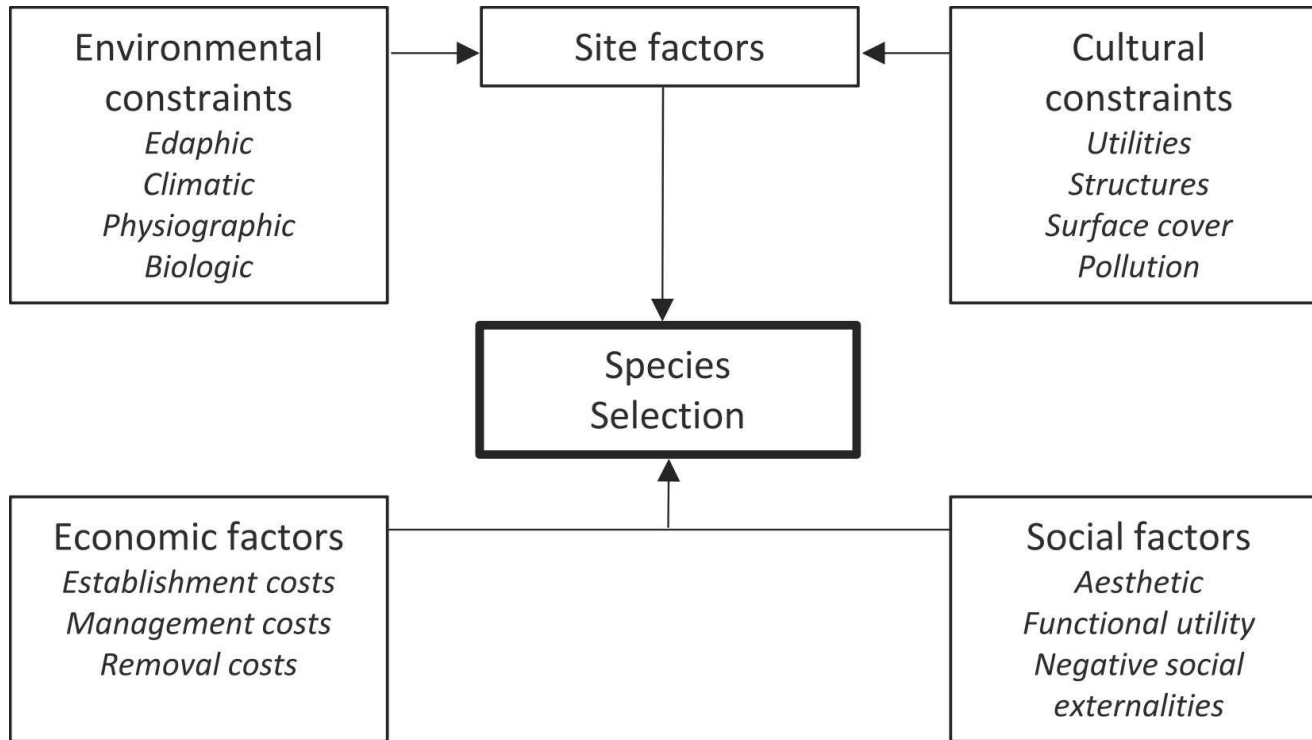
Key Traits of Trees for Resilience

- **Heat tolerance**
- **Drought tolerance**
- **Pollution tolerance**
- **Soil hypoxia tolerance**
- **Pest resistance**
- **Durable wood**
- **Decay resistance**

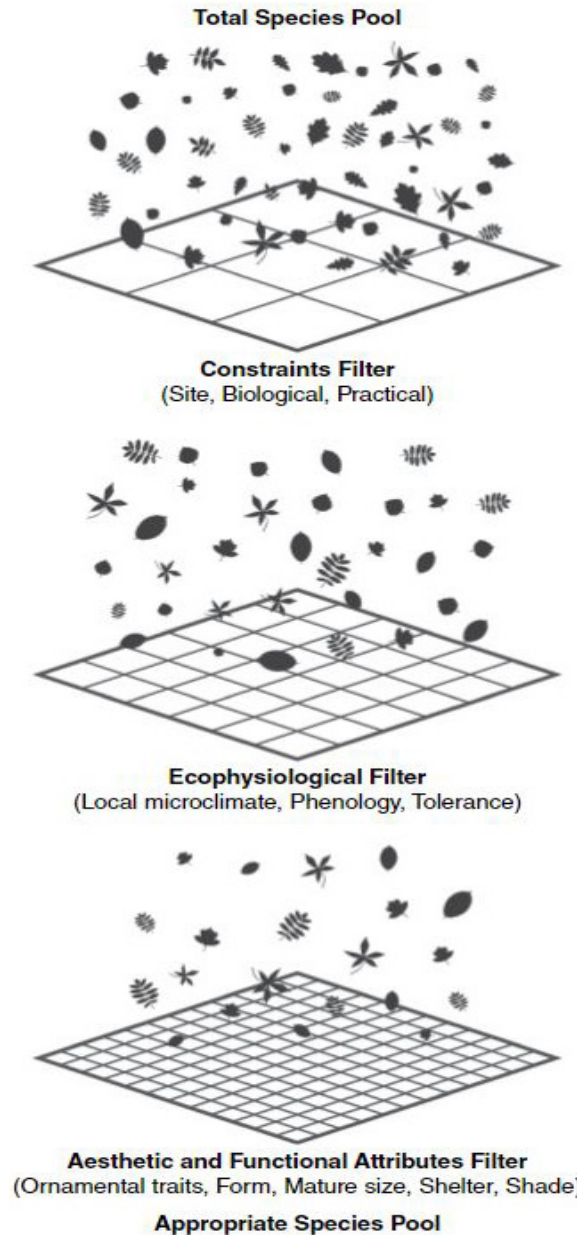


Tree Species Resilience

Key Traits of Trees for Resilience



Source: Farrell, C., et al. "Can we integrate ecological approaches to improve plant selection for green infrastructure?." *Urban Forestry & Urban Greening* (2022): 127732.

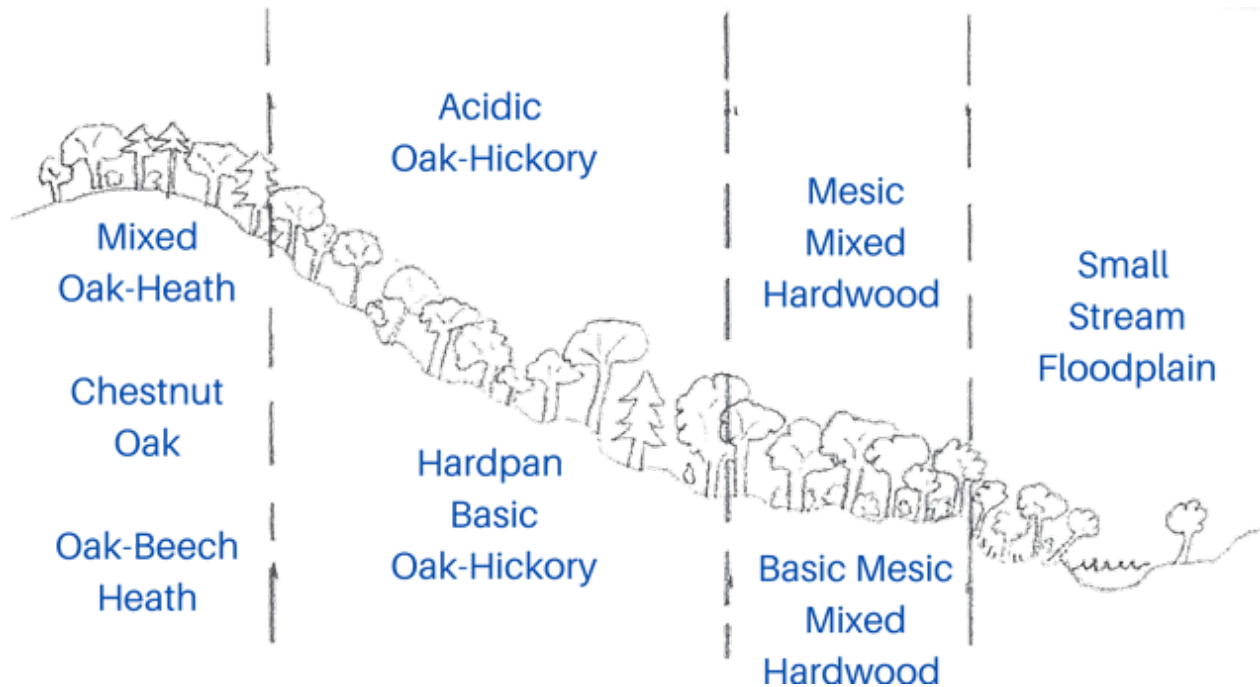


Source: Hirons, Andrew, and Peter A. Thomas. *Applied tree biology*. John Wiley & Sons, 2018.

Tree Species Resilience

Selecting Trees for Resilience

- Look to natural plant communities



Source: www.plantnovanatives.org/plant-communities



Virginia Department of Conservation and Recreation
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The Natural Communities of Virginia Classification of Ecological Community Groups

Third Approximation (Version 3.0)
Information current as of April, 2017

Introduction

- [Why Classify Communities?](#)
- [What is an Ecological Community?](#)
- [Methods and Data Sources](#)
- [Structure of the Virginia Natural Community Classification](#)
- [Future Directions and Feedback](#)
- [Acknowledgments](#)
- [Format of the Ecological Community Group Descriptions](#)

[Overview of the Physiography and Vegetation of Virginia](#)
(PDF)

Terrestrial System

Source: www.dcr.virginia.gov/natural-heritage/natural-communities/nctoc

Tree Species Resilience

Selecting Trees for Resilience

Index of Native Plants for Northern Virginia

- Look to your local experts

Latin Name	Common Name	Region	Height	Sun	Moisture	Soil Type	pH	Page
Trees								
<i>Cercis canadensis</i>	Eastern Redbud	M P C	20–35 ft	☀️ 🌑 🌑	W M D	C L S	6–7.8	
<i>Chionanthus virginicus</i>	Fringe Tree, Old Man's Beard	M P C	20–35 ft	☀️ 🌑 🌑	M D	L S	4.5–6.5	
<i>Cornus florida</i>	Flowering Dogwood	M P C	20–50 ft	☀️ 🌑	M D	L	5–7	
<i>Diospyros virginiana</i>	Common or American Persimmon	M P C	15–100 ft	☀️ 🌑	W M	C L	5–7	27
<i>Fagus grandifolia</i>	American Beech	M P C	50–100 ft	☀️ 🌑 🌑	M	C L S	4.1–6.5	
<i>Ilex opaca</i>	American Holly	M P C	25–60 ft	☀️ 🌑 🌑	M D	C L S	4–7.5	27
<i>Juniperus virginiana</i>	Eastern Red Cedar	M P C	30–40 ft	☀️ 🌑 🌑	M D	C L S	5–8	27
<i>Liquidambar styraciflua</i>	Sweetgum	M P C	60–100 ft	☀️ 🌑	W M	C L S	4.5–7	
<i>Liriodendron tulipifera</i>	Tulip-tree, Tulip-poplar, Yellow Poplar	M P C	70–100 ft	☀️	M	L S	4.5–6.5	
<i>Magnolia virginiana</i>	Sweetbay Magnolia, Swamp Magnolia	P C	12–30 ft	☀️ 🌑	W M	C L S	5–6.5	27
<i>Morella cerifera</i>	Wax Myrtle, Southern Bayberry	P C	6–15 ft	☀️ 🌑	W M D	C L S	5.5–7	
<i>Nyssa sylvatica</i>	Sour Gum, Black Gum, Tupelo	M P C	30–60 ft	☀️ 🌑 🌑	M D	L S	4.5–6	28
<i>Pinus echinata</i>	Shortleaf Pine	M P C	50–130 ft	☀️ 🌑	M D	C L S	4.6–6	28
<i>Pinus rigida</i>	Pitch Pine	M P C	50–75 ft	☀️	D	L S	3.5–5.1	
<i>Pinus taeda</i>	Loblolly Pine	P C	70–90 ft	☀️	W M D	C L S	4.5–7	
<i>Pinus virginiana</i>	Virginia Pine, Scrub Pine	P C	50–80 ft	☀️	M D	C L S	4.5–7.5	
<i>Prunus americana</i>	American Wild Plum	M P C	20–35 ft	☀️ 🌑	M D	L S	5–7	
<i>Prunus angustifolia</i>	Chickasaw Plum	P C	12–36 ft	☀️ 🌑	D	L S		
<i>Quercus alba</i>	White Oak	M P C	40–100 ft	☀️ 🌑	M D	L S	4.5–6.8	28
<i>Quercus bicolor</i>	Swamp White Oak	M P C	60–100 ft	☀️ 🌑	W M D	C L S	4.3–6.5	
<i>Quercus coccinea</i>	Scarlet Oak	M P C	40–75 ft	☀️	M D	L S	4.5–6.9	
<i>Quercus falcata</i>	Southern Red Oak, Spanish Oak	M P C	70–80 ft	☀️	M D	C L S	4.8–7	
<i>Quercus marilandica</i>	Blackjack Oak	P C	35–50 ft	☀️ 🌑	D	L S	4.6–5.6	
<i>Quercus michauxii</i>	Swamp Chestnut Oak, Basket Oak	P C	50–80 ft	☀️	W M	L	4.5–6.5	
<i>Quercus montana</i> (<i>Quercus prinus</i>)	Chestnut Oak, Rock Chestnut Oak	M P C	40–80 ft	☀️	M D	L S	4.5–7	
<i>Quercus muehlenbergii</i>	Chinquapin, Chinkapin or Yellow Oak	M P C	35–50 ft	☀️	M D	L	6.5–8	

Source:
www.novaregion.org/DocumentCenter/View/10615/Northern-Virginia-Native-Plant-Guide---FINAL

Tree Species Resilience

Selecting Trees for Resilience

- Look to states further south



Shade Trees for Georgia

Prepared by Matthew R. Chappell, Extension Horticulturist
 Kim D. Coder, Professor of Tree Biology & Health Care
 Gary Peiffer, DeKalb County ANR Extension Agent

Source:
secure.caes.uga.edu/extension/publications/files/pdf/C%201013_6.PDF

Common Name/ Botanical Name	Mature Height/ Canopy Diameter	Good Fall Color	Messy/Requires Consistent Maintenance	Flower (color)	Distinctive Bark	Tolerates Wet Soils	Tolerates Dry Soils	Use in Hardiness Zone(s)
Very Desirable (Tolerates wide range of sites and/or possesses outstanding features.)								
Baldcypress / <i>Taxodium distichum</i>	60-100' / 40-50'	X			X	X	X	6,7,8
Chinese dogwood / <i>Cornus kousa</i>	20-30' / 15-25'	X		White to pink				6,7,8
Chinese fringe tree / <i>Chionanthus retusus</i>	15-25' / 15-20'	X		White			X	6,7,8
Crapemyrtle / <i>Lagerstroemia indica x fauriei</i>	20-30' / 15-25' *Based on cultivar	X		White to red	X		X	7,8
Ginkgo / <i>Ginkgo biloba</i>	35-50' / 25-35'	X			X		X	6,7,8
Northern red oak / <i>Quercus rubra</i>	60-70' / 50-60'	X					X	6,7
Overcup oak / <i>Quercus lyrata</i>	30-40' / 30-40'						X	6,7,8
River birch / <i>Betula nigra</i>	50-60' / 40-50'		X		X	X	X	6,7,8
Sawtooth oak / <i>Quercus acutissima</i>	50-60' / 30-60'						X	6,7,8
Scarlet oak / <i>Quercus coccinea</i>	40-60' / 35-55'	X					X	6,7,8
Shumard oak / <i>Quercus shumardii</i>	55-80' / 50-60'						X	6,7,8
Texas redbud / <i>Cer- cis Canadensis</i> var. <i>texensis</i>	20-25' / 15-20'	X		Lavender			X	6,7,8
Trident maple / <i>Acer buergerianum</i>	20-35' / 20-35'				X		X	6,7,8
Tulip poplar / <i>Liriodendron tulip- ifera</i> *	80-100' / 30-40'	X	X					6,7,8
Willow oak / <i>Quercus phellos</i>	40-60' / 30-60'					X		6,7,8
Zelkova / <i>Zelkova serrata</i>	45-55' / 35-45'	X			X		X	6,7,8

Tree Species Resilience

Chicago Botanic Garden

< Back to [Plant Information](#)

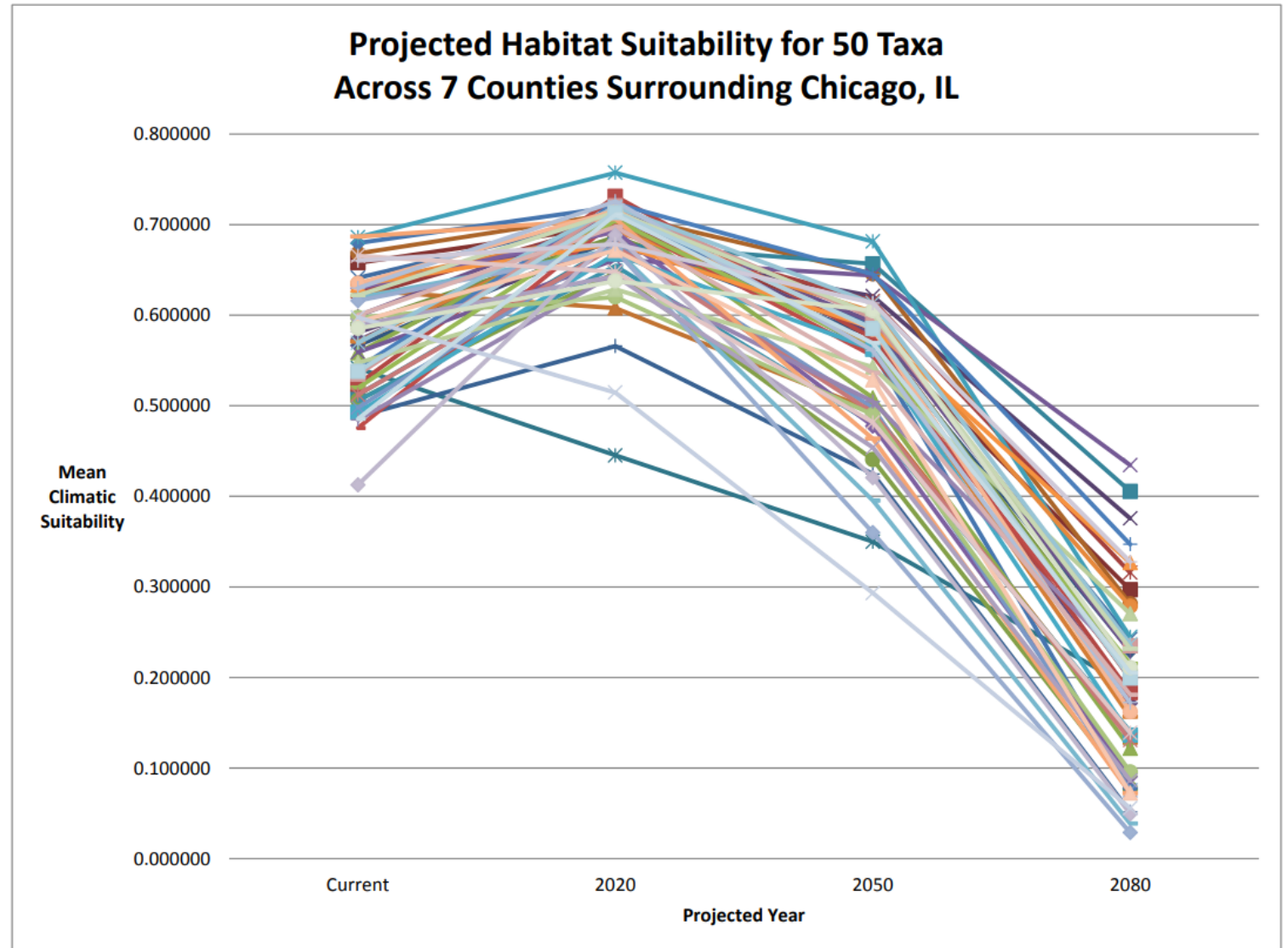
Trees for 2050

CHICAGO BOTANIC GARDEN

RECOMMENDING TREES FOR ADAPTI...

Many common trees in Chicago's urban forests will adapt to a steadily warming climate through 2050, according to a 2013 study led by Dr. Andrew Bell, the Garden's former curator of woody plants.

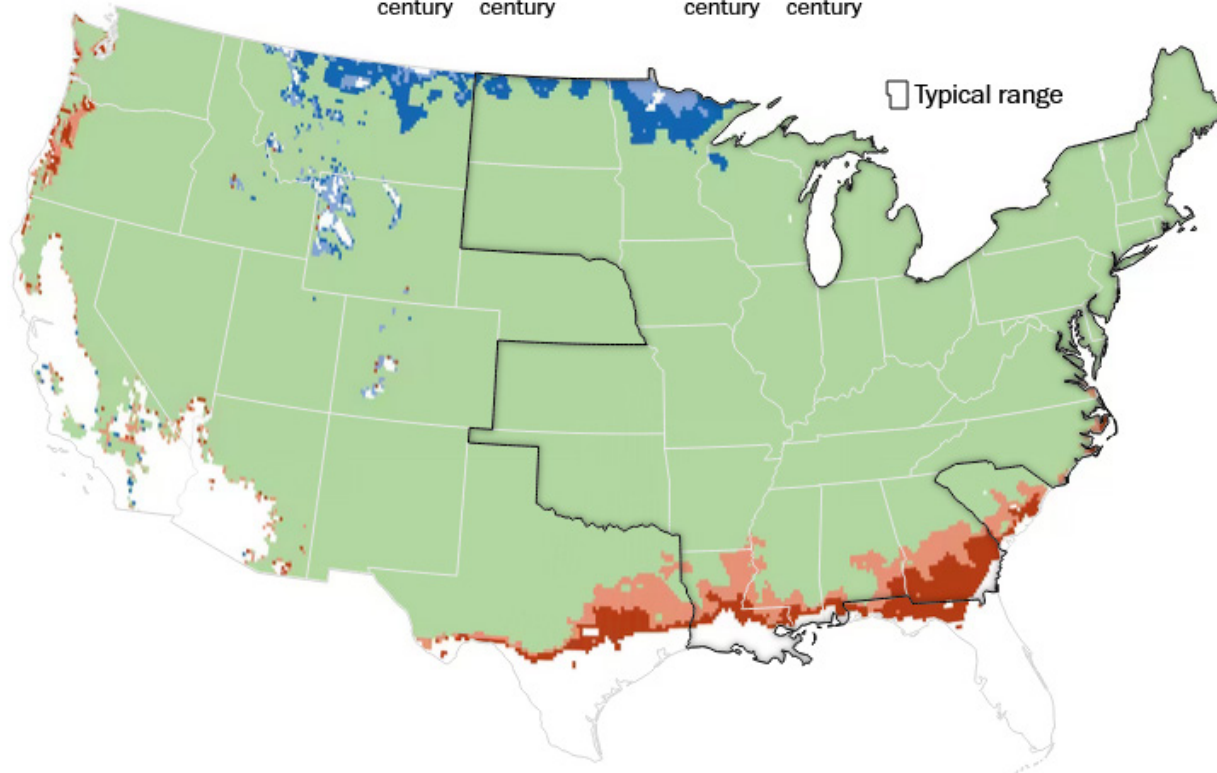
Source: www.chicagobotanic.org/plantinfo/tree_alternatives



Tree Species Resilience

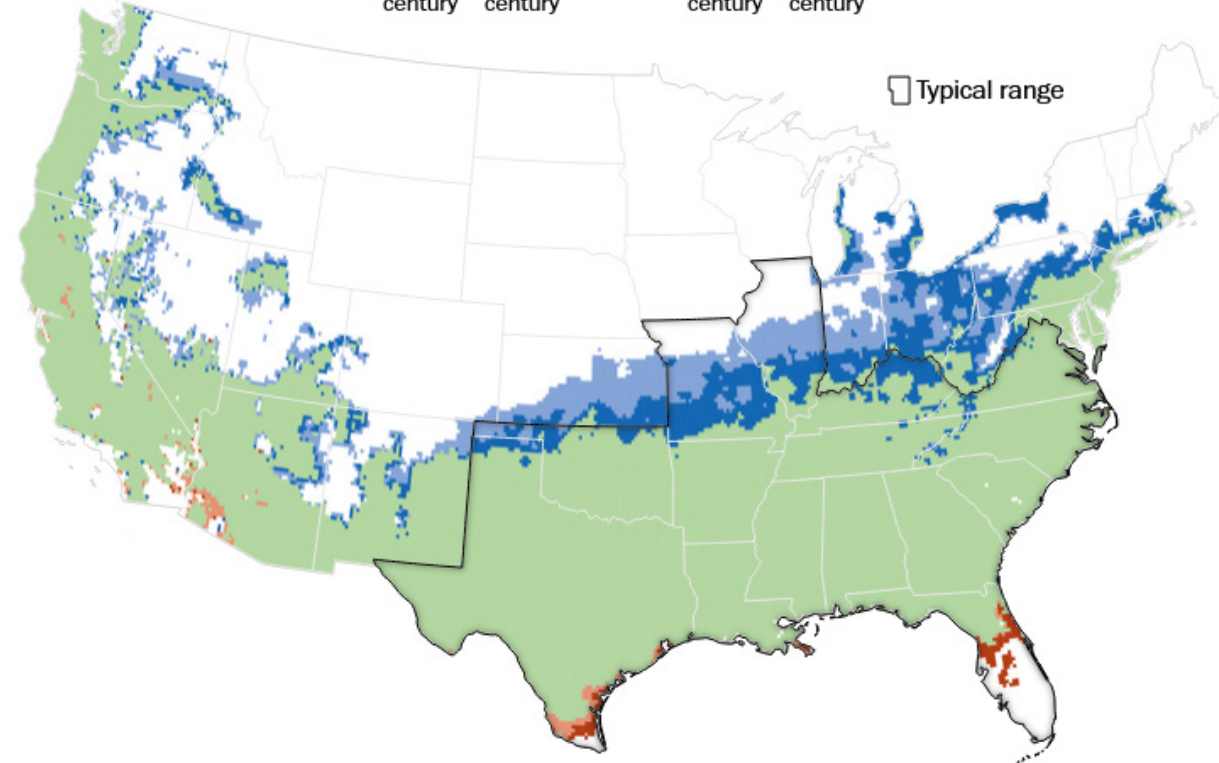
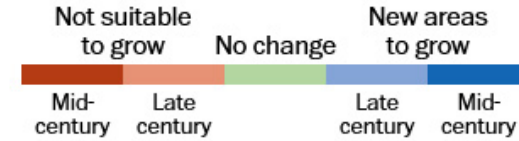
Where will trees move?

Sugar maple (*Acer saccharum*), suitable to Zones 4 - 8



Where will trees move?

Florida maple (*Acer barbatum*), suitable to Zones 7 - 9



Source: www.washingtonpost.com/climate-environment/interactive/2023/tree-species-climate-change-north-shift

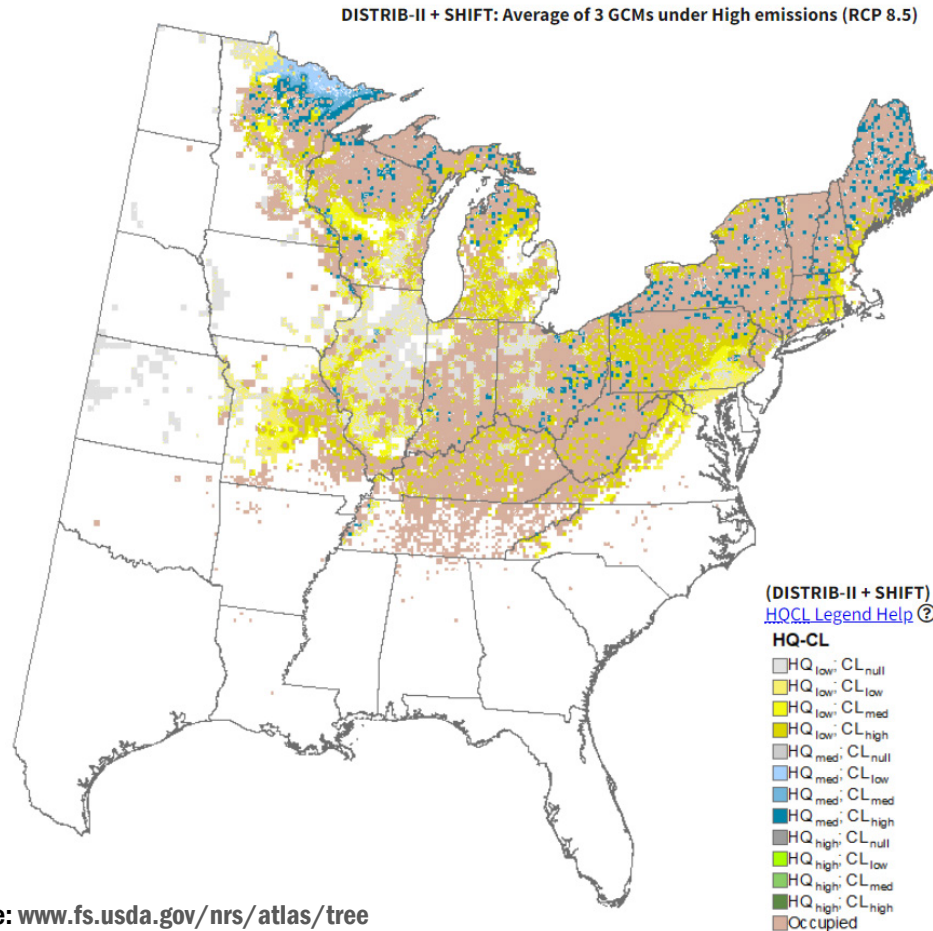
Tree Species Resilience



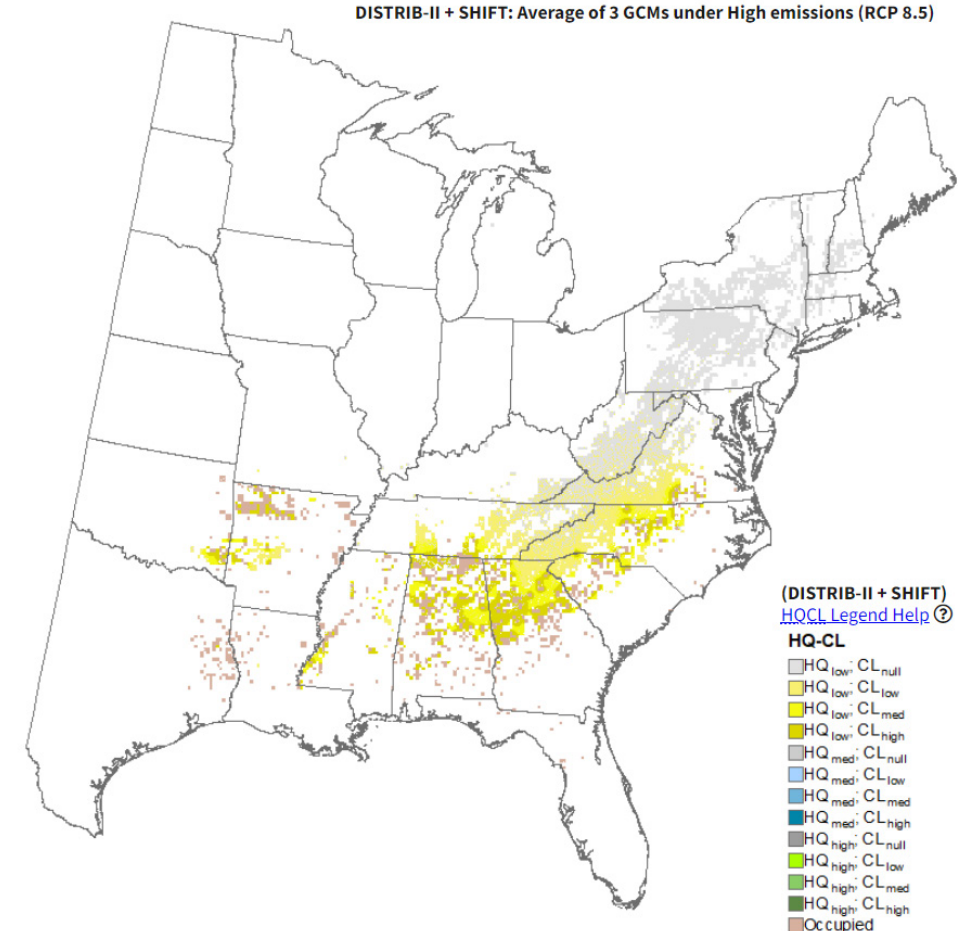
Climate Change Atlas

sugar maple (*Acer saccharum*)

florida maple (*Acer barbatum*)



Source: www.fs.usda.gov/nrs/atlas/tree



Take Home Messages

- **Ecosystem resilience is important for sustainability of urban forests**
- **Urban forest resilience relies on tree species resilience**
- **Evolutionary forces have conferred survival strategy traits in tree species**
- **We can select tree species for these traits to improve urban forest resilience**



Source: unsplash.com/photos/UewgGfZgYf0

Resilient Tree Species for Urban Environments in Virginia

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