



# Baltimore Tree species in a changing climate: Generating a list of climate-informed tree species projections for the GBWC



Michigan  
Technological  
University



# Agenda

- Who we are and what we do
- Tools that can help for Baltimore
  - Tree Atlas
  - Heat and Hardiness Zone data



# Northern Institute of Applied Climate Science

Climate

Carbon

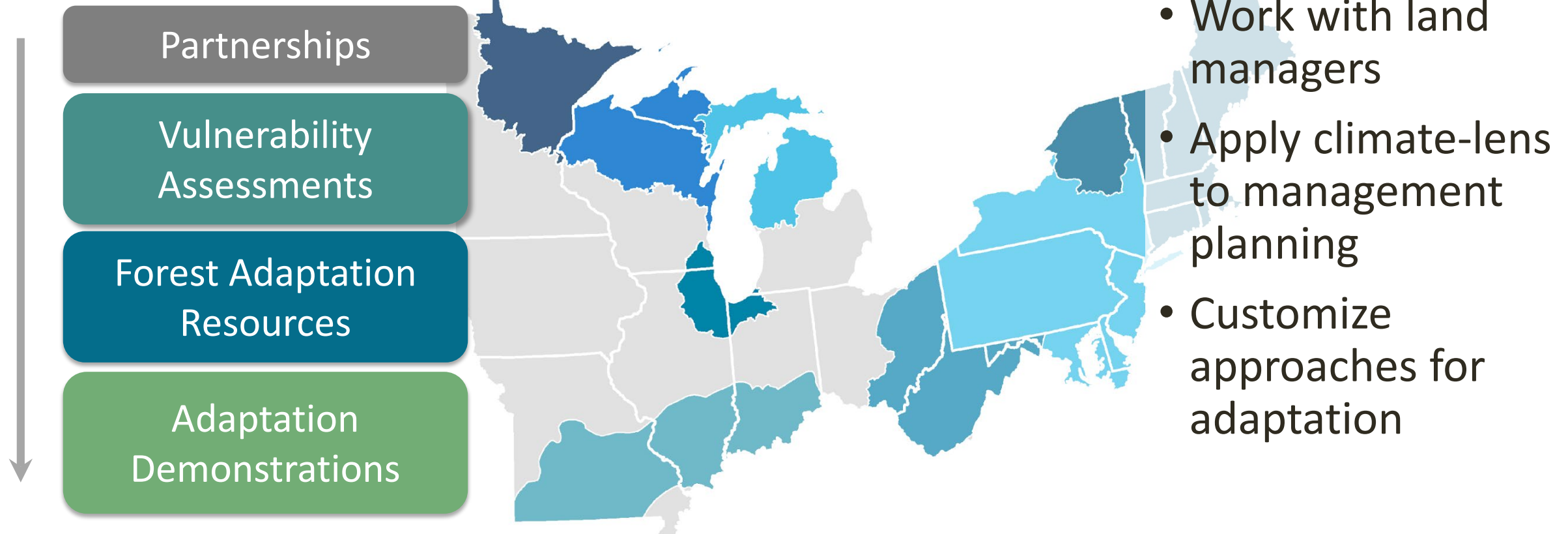
The Northern Institute of Applied Climate Science (NIACS) develops synthesis products, fosters communication, pursues science, and provides technical assistance in climate change adaptation and carbon management.

**Multi-institutional collaborative chartered by USDA Forest Service, universities, and non-profit and tribal conservation organizations**



# Climate Change Response Framework

## 4 COMPONENTS:



# We create practical tools you can use!

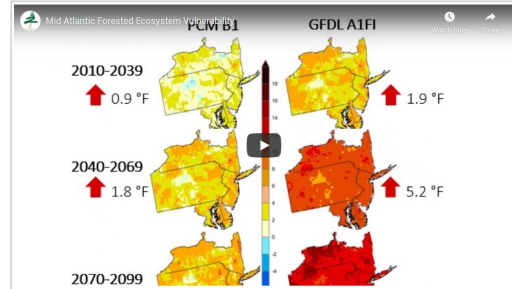
## Video presentations

USDA United States Department of Agriculture

Mid-Atlantic Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the Mid-Atlantic Climate Change Response Framework Project

Forest Service Northern Research Station General Technical Report NRS-181 October 2018

## Vulnerability Assessment for Forested Ecosystems



## Story Map

Climate Change and Adaptation: Mid-Atlantic Forests

Home Changing Climate Effects on Forests Forest Vulnerability Adaptation Stories Credits

Forests are a prominent feature of the landscape across the Mid-Atlantic region. Sweeping from the Atlantic coastal plain to the Catskill Mountains, forests cover approximately half of the 40-million-acre assessment area. These forests provide many benefits to residents of this region, including clean air and water, fish and wildlife, and places for families to spend time outdoors. Working forests also give us lumber, maple syrup, ginseng, and other products that support the local economy.

Foresters, biologists, and land managers are working hard to preserve these forests for future generations, as part of the Mid-Atlantic Climate Change Response Framework. Understanding how our forests are changing now and how they will continue to change in the future is the key to making sustainable choices. To help with these decisions, the Mid-Atlantic Forest Ecosystem Vulnerability Assessment and Synthesis, a report from the Mid-Atlantic Climate Change Response Framework, summarizes the best available information about these forests from published research and local knowledge. The first three sections of this story map highlight key themes from the report and describe the general effects of anticipated changes across the region. The final section shows what foresters and land managers are doing to protect these forests and all of the benefits they provide for us.

Click on each tab to learn more.

## Tree projections & Adaptation tools

CLIMATE CHANGE PROJECTIONS FOR INDIVIDUAL TREE SPECIES MID-ATLANTIC REGION

The region's forests will be affected by a changing climate during this century. A team of forest managers and researchers created an assessment that describes the vulnerability of forests in the Mid-Atlantic region (Blatter-Lepold et al. in review). This report includes information on the current landscape, observed climate trends, and a range of projected future climates. It also describes many potential climate change impacts to forests and summarizes key vulnerabilities for major forest types. This handout is summarized from the full assessment.

**TREE SPECIES INFORMATION:**  
This assessment uses two climate scenarios to "bracket" a range of possible futures. These future climate projections were used with two forest impact models (Tree Atlas and LANDIS) to provide information about how individual tree species may respond to a changing climate. More information on the climate and forest impact models can be found in the assessment. Results for "low" and "high" climate scenarios can be compared on page 2 of this handout.

SPECIES	ADDITIONAL CONSIDERATIONS - 30 MOST COMMON SPECIES
<b>MAY DECREASE</b>	
American basswood	Tolerates shade, susceptible to fire
American beech	Susceptible to beech bark disease, very shade tolerant
Bigtooth aspen	Early successional colonizer, susceptible to drought
Black cherry	Susceptible to insects and fire, mildly drought tolerant
Eastern hemlock	Hemlock woolly adelgid causes mortality
Eastern white pine	Good disperser, but susceptible to drought and insects
Quaking aspen	Early successional colonizer, susceptible to heat & drought
Serviceberry	Competitive colonizer, susceptible to drought
Striped maple	Shade tolerant, easily established, susceptible to drought
Sugar maple	Grows across a variety of sites, tolerates shade
Sweet birch	Susceptible to drought, fire, topkill, and insects
Yellow birch	Good disperser, susceptible to fire, insects, and disease
<b>NO CHANGE</b>	
American hornbeam	Tolerates shade, susceptible to fire and drought
Eastern hophornbeam	Grows across a variety of sites, tolerates shade
Pitch pine	Early successional colonizer, susceptible to insect

SPECIES	ADDITIONAL CONSIDERATIONS - 30 MOST COMMON SPECIES
<b>MAY INCREASE</b>	
American elm	Susceptible to Dutch elm disease
Black locust	Early successional colonizer, susceptible to insect pests
Black oak	Drought tolerant, susceptible to insect pests & diseases
Blackgum	Shade tolerant, fire adapted
Flowering dogwood	Shade tolerant
Northern red oak	Susceptible to insect pests
Pignut hickory	Susceptible to insect pests and drought

Remember that models are just tools, and they're not perfect. Model projections don't account for some factors that could be modified by climate change, like droughts, wildfire activity, and invasive species. If a species is rare or confined to a small area, Tree Atlas results may be less reliable. These factors, and others, could cause a particular species to perform better or worse than a model projects. Human choices will also continue to influence forest distribution, especially for tree species that are projected to increase. Planting programs may assist the movement of future-adapted species, but this will depend on management decisions.

Despite these limits, models provide useful information about future expectations. It's perhaps best to think of these projections as indicators of possibility and potential change. The model results presented here were combined with information from published reports and local management expertise to draw conclusions about potential risk and change in the region's forests.

## Real stories of people making climate-informed decisions

CLIMATE CHANGE RESPONSE FRAMEWORK MENU

Demonstrations

Home » Adapt » Demonstrations

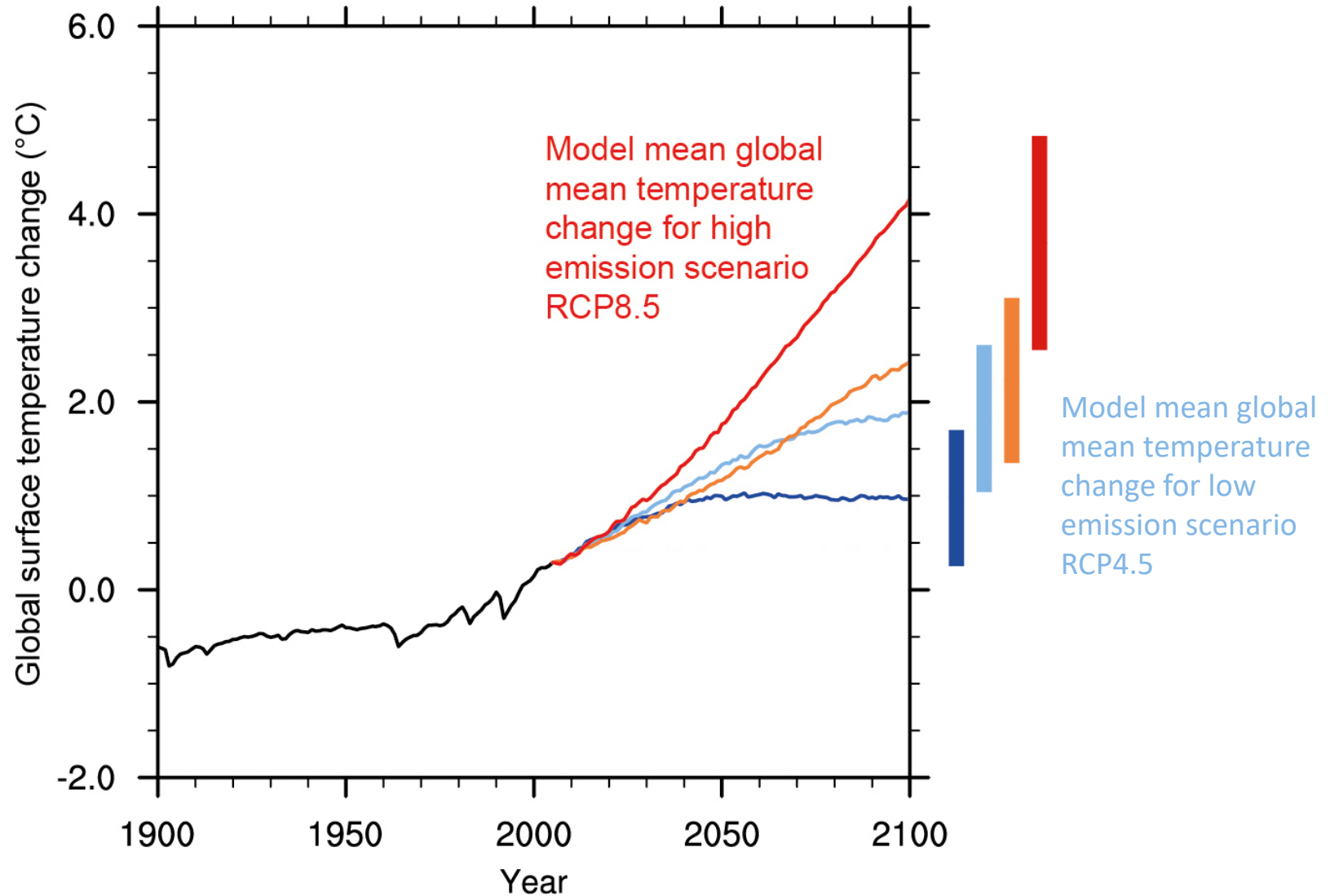
Map Satellite

Silgo Creek Reforestation with Climate Adaptation in Mind

The purpose of this project is to utilize the reforestation priority area GIS analysis to determine where to best utilize fee-in-lieu funds to reforest areas and enhance floodplain depression projects. This area is a highly active stream valley park with an interconnecting trail system in the suburbs of DC. It is a heavily used and disturbed area with a large amount of infrastructure (sewer, water, gas) and surrounding development. The plan is to be used by the Parks Department, Planning Department, and citizens and the major management

Adaptation demonstration projects are real-world examples of how managers have integrated climate considerations into land management planning and activities.

# Representative Concentration Pathways (RCPs)



# Climate Change Projections

\*2009 vs. 2099

Low Climate Change  
RCP 4.5

High Climate Change  
RCP 8.5

Average Temperature

↑ 3.7 °F

↑ 10.4 °F

Growing Season (May-Sept)  
Temperature

↑ 3.7 °F

↑ 11.5 °F

Total Precipitation

↑ 7 inches

↑ 5.1 inches

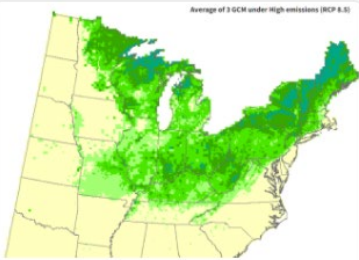
Growing Season (May-Sept)  
Precipitation

↑ 5.3 inches

↓ -0.3 inches

# Tools to inform Baltimore tree planting

## USFS Tree Atlas Baltimore, MD




Average of 3 GCM under High emissions (RCP 8.5)

**Tree Atlas** Version 4

Modeled potential suitable habitat for 125 tree species in the East, with an additional 23 species with current information only.

[Latest Tree Atlas](#)



**Bird Atlas** Version 2

Potential changes in abundance and range for 147 bird species in the East

[Latest Bird Atlas](#)

### Regional Summary Tree Tables

**Current and Potential Future Habitat, Capability, and Migration**


Summaries for tree species are available for a variety of geographies, in both PDF and Excel format. These summaries are based on [Version 4 of the Climate Change Tree Atlas](#)

- [National Forest Summaries](#)
- [National Climate Assessment \(NCA\) 2016 Regional Summaries](#)
- [National Park Summaries](#)
- [1 x 1" Grid Summaries](#)
- [HUC6 Watersheds](#)
- [Eastern United States](#)
- [Ecoregional Vulnerability Assessments \(EVAS\)](#)
- [Urban Areas](#)
- [USDA Forest Service EcoMap 2007 Sections](#)



## Heat & Hardiness Zones Washington, DC

**CLIMATE CHANGE VULNERABILITY OF URBAN TREES**  
WASHINGTON, D.C.



This list was developed to aid Washington, D.C. community forestry practitioners in selecting trees to reduce climate change vulnerability of their urban forests. It is meant to be a complement to other tree selection resources. Other factors may also need to be considered, such as aesthetics, local site conditions, wildlife value, or nursery availability. It is also important to note that some species may have climate benefits but may not be suitable for planting for other reasons, such as having invasive potential or susceptibility to pests or pathogens.

**Vulnerability:** Trees can be vulnerable to a variety of climate-related stressors such as intense heat, drought, flooding, and changing pest and disease patterns. Climate vulnerability is a function of the impacts of climate change on a species and its adaptive capacity. Species with negative impacts on habitat suitability and low adaptive capacity will have high vulnerability and vice versa. The following factors were used to determine climate vulnerability:

**Urban adaptability:** Adaptability scores were generated for each species based on literature describing its tolerance to disturbances such as drought, flooding, pests, and disease, as well as its growth requirements such as shade tolerance, soil needs, and ease of nursery propagation. Scores were assigned to species using methods developed in an urban forest vulnerability assessment for Chicago for trees planted in developed sites. A positive score indicates that a species is tolerant to a wide range of disturbances and can be planted on a variety of sites. A negative score indicates a species is highly susceptible to disturbances and/or is limited to specific planting sites.


**Hardiness and heat zone suitability:** Tree species ranges were recorded from government, university, and arboretum websites. Species tolerance ranges were compared to current and projected heat and hardiness zones for Washington, D.C. using downscaled climate models under low emissions (RCP 4.5) and high emissions (RCP 8.5) scenarios for changes in greenhouse gases. Trees were considered to have suitable zone suitability if the species' tolerance was within the range of current and projected hardiness and heat zone through the end of the 21st century.

NOTE: This list was primarily created for species planted in developed sites, such as streets, yards, boulevards, and parks. If you are interested in projected changes in habitat suitability for native species in natural areas, see the Climate Change Tree Atlas at [www.fs.fed.us/nrs/atlas/](http://www.fs.fed.us/nrs/atlas/).

Current and projected USDA Hardiness Zones and AHS Heat Zones for Washington, D.C. Hardiness zone is determined by the average lowest temperature over a 30 year period. Heat zones are determined by the number of days above 86°F.

Time Period	Hardiness Zone Range		Heat Zone Range	
	Low Emissions	High Emissions	Low Emissions	High Emissions
1980-2010	7		7	
2010-2039	7	8	7 to 8	8
2040-2069	7 to 8	8	8	9
2070-2099	8	8 to 9	8	9 to 10

SOURCE: Adaptability scores were assigned using methods developed in an urban forest vulnerability assessment for Chicago by Brandt et al. 2017 ([https://www.fs.fed.us/nrs/urban/vuln\\_2017\\_2018.pdf](https://www.fs.fed.us/nrs/urban/vuln_2017_2018.pdf)). Future heat and hardiness zone information were provided from <https://www.epa.gov/epaospp/observed-and-projected-conditions>.

  
[www.forestadaptation.org](http://www.forestadaptation.org)





# Climate Change Tree Atlas: About

- A tool used to describe tree habitat distribution and colonization under changed climate.
- Model results for 125 species (and relative abundance for 24 species)
- Information about colonization potential (SHIFT) and overall ability to tolerate future conditions (Capability)
- **New tutorials** and explanations throughout the site.

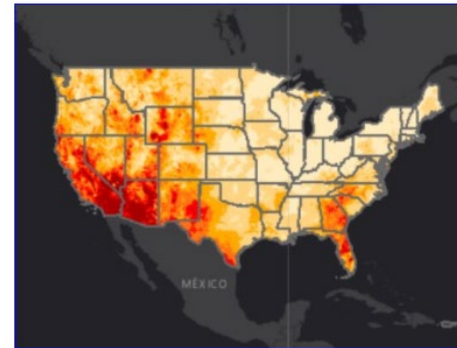
## Regional Summary Tree Tables

### Current and Potential Future Habitat, Capability, and Migration

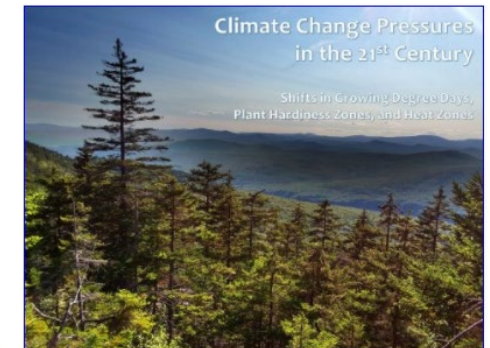
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- [Eastern United States](#)
- [Urban Areas](#)

## Other Products



[Story Map: Drought Over Time](#)



[Story Map: Climate Change Pressures in the 21st Century: Shifts in Growing Degree Days, Plant Hardiness Zones, and Heat Zones](#)



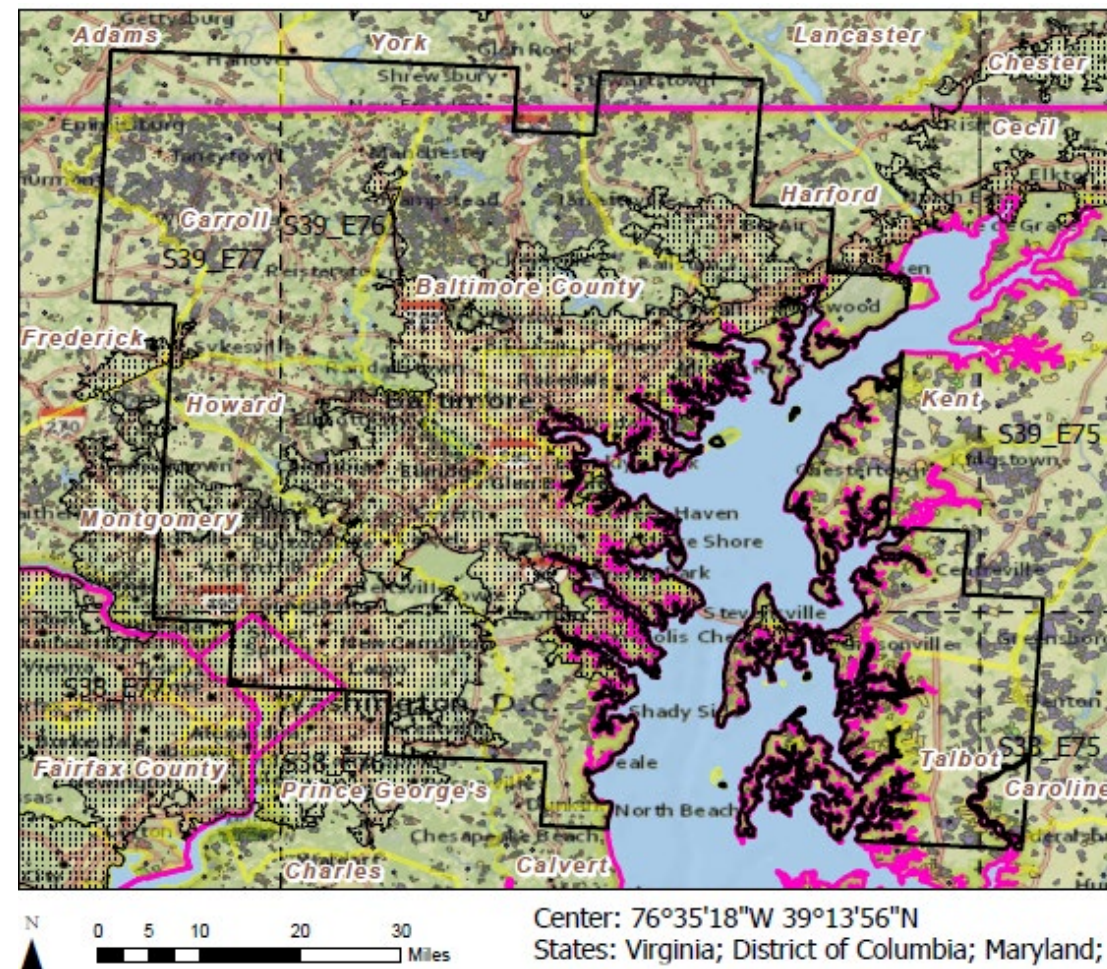
# Climate Change Tree Atlas: Baltimore

Results describe trends across the greater Baltimore area

- Urban area (sq. km) = 1,922
- Urban buffer area (sq. km) = 9,137
  - 90 tree species modeled
  - 22% urban land cover

**Rare, nonnative, or cultivar species are likely not modeled.**

- These species may have vulnerability ratings based on projected heat and hardiness zones.





# Climate Change Tree Atlas: Baltimore

- Common and scientific names
- Range
- Model reliability
- FIA sum
- Habitat change class
- Adaptability
- Capability
- SHIFT

	Scientific Name	Range	MR	%Cell	FIAsum	FIAiv	ChngCl45	ChngCl85	Adap	Abund	Capabil45	Capabil85	SHIFT45	SHIFT85	SSO	N
14	Quercus rubra	WDH	Medium	37.1	117.6	6.5	No change	No change	High	Common	Good	Good	Infill ++	Infill ++	1	13
15	Quercus coccinea	WDL	Medium	27.6	113.9	6.8	Sm. dec.	Sm. dec.	Medium	Common	Fair	Fair	Infill +	Infill +	1	14
16	Carya glabra	WDL	Medium	31.4	112.2	6.9	No change	No change	Medium	Common	Good	Good	Infill ++	Infill ++	1	15
17	Fraxinus americana	WDL	Medium	25.6	104.4	7.7	No change	No change	Low	Common	Good	Good	Infill ++	Infill ++	1	16
18	Sassafras albidum	WSL	Low	35.9	100.5	5.0	Lg. dec.	Sm. dec.	Medium	Common	Fair	Fair	Infill +	Infill +	1	17
19	Juglans nigra	WDH	Low	20.4	91.6	6.8	Sm. dec.	Sm. dec.	Medium	Common	Fair	Fair	Infill +	Infill +	1	18
20	Pinus taeda	WDH	High	12.7	84.5	15.7	Lg. inc.	Lg. inc.	Medium	Common	Very Good	Very Good	Infill ++	Infill ++	2	19
21	Platanus occidentalis	NSL	Low	16	81.1	9.5	Sm. inc.	Sm. inc.	Medium	Common	Very Good	Very Good	Infill ++	Infill ++	2	20
22	Acer negundo	WSH	Low	19.5	77.2	6.0	No change	No change	High	Common	Good	Good	Infill ++	Infill ++	1	21
23	Populus deltoides	NSH	Low	2.8	68.6	28.0	Sm. dec.	Sm. dec.	Medium	Common	Fair	Fair			0	22
24	Picea abies	NSH	FIA	1.1	61.3	50.0	Unknown	Unknown	NA	Common	NNIS	NNIS			0	23
25	Quercus pagoda	NSL	Medium	1	61.3	45.9	No change	No change	Medium	Common	Good	Good			2	24
26	Pinus strobus	WDH	High	1.1	44.9	36.7	Lg. dec.	Lg. dec.	Low	Rare	Poor	Poor			0	25
27	Ulmus rubra	WSL	Low	3.4	42.0	11.4	Sm. dec.	No change	Medium	Rare	Poor	Fair	Infill +	Infill +	2	26
28	Quercus falcata	WDL	Medium	12.5	37.4	6.6	Lg. inc.	Lg. inc.	High	Rare	Good	Good	Infill ++	Infill ++	2	27
29	Acer saccharinum	NSH	Low	6.8	35.0	13.9	Sm. dec.	No change	High	Rare	Poor	Fair			2	28
30	Quercus palustris	NSH	Low	4.5	33.8	6.9	Sm. dec.	Sm. dec.	Low	Rare	Poor	Poor	Infill +	Infill +	2	29
31	Ailanthus altissima	NSL	FIA	8	31.4	6.5	Unknown	Unknown	NA	Rare	NNIS	NNIS			0	30
32	Carya cordiformis	WSL	Low	6.6	29.6	7.2	No change	No change	High	Rare	Fair	Fair	Infill +	Infill +	2	31
33	Ulmus americana	WDH	Medium	15.8	24.3	7.7	Sm. inc.	Lg. inc.	Medium	Rare	Good	Good			2	32
34	Cornus florida	WDL	Medium	16.6	19.5	1.6	Sm. inc.	Sm. inc.	Medium	Rare	Good	Good	Infill ++	Infill ++	1	33
35	Carpinus caroliniana	WSL	Low	7.4	19.1	2.6	Sm. inc.	Sm. inc.	Medium	Rare	Good	Good	Infill ++	Infill ++	1	34
36	Fraxinus pennsylvanica	WSH	Low	4	18.7	5.2	Sm. inc.	Sm. inc.	Medium	Rare	Good	Good			2	35
37	Quercus phellos	NSL	Low	3.8	16.6	4.5	Sm. inc.	Sm. inc.	Medium	Rare	Good	Good			2	36
38	Acer platanoides	NSL	FIA	7.9	14.1	3.9	Unknown	Unknown	NA	Rare	NNIS	NNIS			0	37
39	Quercus imbricaria	NDH	Medium	2.3	12.7	5.2	Sm. dec.	Sm. dec.	Medium	Rare	Poor	Poor			0	38
40	Morus alba	NSL	FIA	10.4	10.7	5.5	Unknown	Unknown	NA	Rare	NNIS	NNIS			0	39
41	Asimina triloba	NSL	Low	6.4	9.8	2.8	Sm. dec.	Lg. dec.	Medium	Rare	Poor	Poor			0	40
42	Ilex opaca	NSL	Medium	13.1	9.0	2.4	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good	Infill ++	Infill ++	1	41

# Climate Change Tree Atlas: Results for Greater Baltimore

**NEW!**

## CLIMATE CHANGE PROJECTIONS FOR INDIVIDUAL TREE SPECIES GREATER BALTIMORE, MARYLAND



This list was developed to aid Greater Baltimore community forestry practitioners in selecting trees to reduce climate change vulnerability of their urban forests. It is meant to be a complement to other tree selection resources. Other factors may also need to be considered, such as aesthetics, local site conditions, wildlife value, or nursery availability. It is also important to note that some species may have climate

benefits but may not be suitable for planting for other reasons, such as having invasive potential or susceptibility to pests or pathogens.

The Landscape Change Research Group recently updated the Climate Change Tree Atlas, and this handout summarizes information for the Greater Baltimore region. Full Tree Atlas results are available online at [www.fs.fed.us/nrs/atlas/](http://www.fs.fed.us/nrs/atlas/). Two climate scenarios are presented to "bracket" a range of possible futures. These future climate projections (2070 to 2099) provide information about how individual tree species may respond to a changing climate. Results for "low" and "high" emissions scenarios can be compared on the reverse side of this handout.

### The updated Tree Atlas presents additional information helpful to interpret tree species changes:

- Suitable habitat** - calculated based on 39 variables that explain where optimum conditions exist for a species, including soils, landforms, and climate variables.
- Adaptability** - based on life-history traits that might increase or decrease tolerance of expected changes, such as the ability to withstand different forms of disturbance.
- Capability** - a rating of the species' ability to cope or persist with climate change in this region based on suitable habitat change (statistical modeling), adaptability (literature review and expert opinion), and abundance (FIA data). The capability rating is modified by abundance information; ratings are downgraded for rare species and upgraded for abundant species.
- Migration Potential Model** - when combined with habitat suitability, an estimate of a species' colonization likelihood for new habitats. This rating can be helpful for assisted migration or focused management (see the table section: "New Habitat with Migration Potential").

Remember that models are just tools, and they're not perfect. Model projections can't account for all factors that influence future species success. If a species is rare or confined to a small area, model results may be less reliable. These factors, and others, could cause a particular species to perform better or worse than a model projects. Human choices will also continue to influence forest distribution, especially for tree species that are projected to increase. Despite these limits, models provide useful information about future expectations. It's perhaps best to think of these projections as indicators of possibility and potential change.

SOURCE: This handout summarizes model results for the Greater Baltimore, Maryland area, available at [https://www.fs.fed.us/nrs/atlas/combined/resources/summaries/urban/ua\\_04842.xlsx](https://www.fs.fed.us/nrs/atlas/combined/resources/summaries/urban/ua_04842.xlsx). More information on vulnerability and adaptation in the Mid-Atlantic region can be found at [www.forestadaptation.org/mid-atlantic](http://www.forestadaptation.org/mid-atlantic). A full description of the models and variables are provided in Iverson et al. 2019 [www.nrs.fs.fed.us/pubs/57852/](https://www.nrs.fs.fed.us/pubs/57852/) and [www.nrs.fs.fed.us/pubs/59105/](https://www.nrs.fs.fed.us/pubs/59105/) and Peters et al. 2019 [www.nrs.fs.fed.us/pubs/58353/](https://www.nrs.fs.fed.us/pubs/58353/).

### CLIMATE CHANGE CAPABILITY

#### POOR CAPABILITY

Bigtooth aspen	Pin oak
Black ash	Quaking aspen
Eastern white pine	Shingle oak
Pawpaw	Swamp white oak

#### FAIR CAPABILITY

American beech	Eastern cottonwood
Bitternut hickory	Red mulberry
Black locust	Sassafras
Black walnut	Scarlet oak
Chestnut oak	Virginia pine

#### GOOD CAPABILITY

American elm	Northern red oak
American holly	Pignut hickory
American hornbeam	Red maple
Black cherry	Shagbark hickory
Black oak	Southern red oak
Blackgum	Sugar maple
Boxelder	Swamp chestnut oak
Cherrybark oak	Sweetbay
Eastern hophornbeam	Sweetgum
Eastern redcedar	Sycamore
Flowering dogwood	White ash
Green ash	White oak
Hackberry	Willow oak
Loblolly pine	Yellow Poplar

#### MIXED RESULTS

Silver maple	Common persimmon
Slippery elm	Black willow

#### NEW HABITAT WITH MIGRATION POTENTIAL

Bald cypress	River birch
Blackjack oak	Shortleaf pine
Eastern redbud	Sourwood
Laurel oak	Sugarberry
Longleaf pine	Swamp tupelo
Overcup oak	Water oak
Pond cypress	Water tupelo
Post oak	Winged elm
Redbay	



**ADAPTABILITY:** Life-history factors, such as the ability to respond favorably to disturbance, that are not included in the Tree Atlas model and may make a species more or less able to adapt to future stressors.

- + HIGH Species may perform better than modeled
- MEDIUM
- LOW Species may perform worse than modeled

**HABITAT CHANGE:** Projected change in suitable habitat between current and potential future conditions.

- ▲ INCREASE: Projected increase of >20% by 2100
- NO CHANGE: Projected change of <20% by 2100
- ▼ DECREASE: Projected decrease of >20% by 2100
- ★ NEW HABITAT: Tree Atlas projects new habitat for species not currently present

**ABUNDANCE:** Based on Forest Inventory Analysis (FIA) summed Importance Value data, calibrated to a standard geographic area.

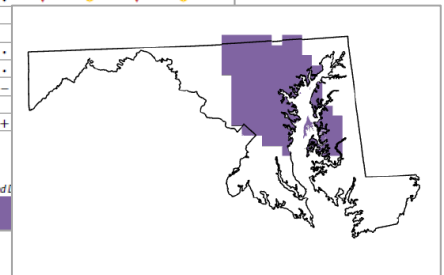
- + ABUNDANT
- COMMON
- RARE

**CAPABILITY:** An overall rating that describes a species' ability to cope or persist with climate change based on suitable habitat change class (statistical modeling), adaptability (literature review and expert opinion), and abundance within this region.

- ▲ GOOD: Increasing suitable habitat, medium or high adaptability, and common or abundant
- FAIR: Mixed combinations, such as a rare species with increasing suitable habitat and medium adaptability
- ▼ POOR: Decreasing suitable habitat, medium or low adaptability, and uncommon or rare

SPECIES	LOW CLIMATE CHANGE (RCP 4.5)			HIGH CLIMATE CHANGE (RCP 8.5)			SPECIES	LOW CLIMATE CHANGE (RCP 4.5)			HIGH CLIMATE CHANGE (RCP 8.5)		
	ADAPT	ABUN	CHANGE	HABITAT	CAPABIL-	HABITAT		CAPABIL-	ADAPT	ABUN	CHANGE	HABITAT	CAPABIL-
American beech	-	-	▲	○	▼	○	Pignut hickory	-	-	●	▲	●	▲
American elm	-	-	▲	▲	▲	▲	Pin oak*	-	-	▼	▼	▼	▼
American holly	-	-	▲	▲	▲	▲	Pond cypress	-	-	*	*	*	*
American hornbeam*	-	-	▲	▲	▲	▲	Post oak	+	*	*	*	*	*
Bald cypress	-	-	*	*	*	*	Quaking aspen	-	-	▼	▼	▼	▼
Bigtooth aspen	-	-	▼	▼	▼	▼	Red maple	+	+	▲	▲	▲	▲
Bitternut hickory*	+	-	●	●	●	●	Red mulberry*	-	-	●	●	●	●
Black ash	-	-	▼	▼	▼	▼	Redbay*	+	*	*	*	*	*
Black cherry	-	-	●	●	●	●	River birch*	-	-	*	*	*	*
Black locust*	-	-	▼	▼	▼	▼	Sassafras*	-	-	○	○	○	○
Black oak	-	-	▲	▲	▲	▲	Scarlet oak	-	-	○	○	○	○
Black walnut*	-	-	○	○	○	○	Shagbark hickory	-	-	▲	▲	▲	▲
Black willow*	-	-	●	●	●	●	Shingle oak	-	-	▼	▼	▼	▼
Blackgum	+	-	▲	▲	▲	▲	Shortleaf pine	-	-	*	*	*	*
Blackjack oak	+	*	*	*	*	*	Silver maple*	+	-	▼	▼	●	○
Boxelder*	+	*	▲	▲	▲	▲	Slippery elm*	-	-	▼	▼	●	○
Cherrybark oak	-	-	○	○	○	○	Sourwood	+	*	*	*	*	*
Chestnut oak	+	-	▼	▼	▼	▼	Southern red oak	+	-	▲	▲	▲	▲
Common persimmon*	+	-	○	○	○	○	Sugar maple	+	-	▲	▲	▲	▲
Eastern cottonwood*	-	-	○	○	○	○	Sugarberry	-	-	*	*	*	*
Eastern hophornbeam*	+	-	▲	▲	▲	▲	Swamp chestnut oak*	-	-	▲	▲	▲	▲
Eastern redbud*	-	-	*	*	*	*	Swamp tupelo	-	-	*	*	*	*
Eastern redcedar	-	-	▲	▲	▲	▲	Swamp white oak*	-	-	▼	▼	▼	▼
Eastern redbud	-	-	▼	▼	▼	▼	Sweetbay	-	-	▲	▲	▲	▲
Flowering dogwood	-	-	▲	▲	▲	▲	Sweetgum	-	-	▲	▲	▲	▲
Green ash*	-	-	▲	▲	▲	▲	Sycamore*	+	*	▲	▲	▲	▲
Hackberry	+	-	▲	▲	▲	▲	Virginia pine	-	-	○	○	○	○
Laurel oak	-	-	*	*	*	*	Water oak	-	-	-	-	-	-
Loblolly pine	-	-	▲	▲	▲	▲	Water tupelo	-	-	-	-	-	-
Longleaf pine	-	-	*	*	*	*	White ash	-	-	-	-	-	-
Mockernut hickory	+	-	▲	▲	▲	▲	White oak	+	-	*	*	*	*
Northern red oak	+	-	●	●	●	●	Willow oak*	-	-	-	-	-	-
Overcup oak	-	-	*	*	*	*	Winged elm	-	-	-	-	-	-
Pawpaw*	-	-	▼	▼	▼	▼	Yellow Poplar	+	+	*	*	*	*

\*Species with low model reliability based on five statistical metrics of the habitat models that affect change class. See maps and tables for more information ([www.fs.fed.us/nrs/atlas/combined/resources/summaries/](https://www.fs.fed.us/nrs/atlas/combined/resources/summaries/)).



Created 8/2019

# Climate Change Tree Atlas: Results for Greater Baltimore

## POOR CAPABILITY

Bigtooth aspen	Pin oak
Black ash	Quaking aspen
Eastern white pine	Shingle oak
Pawpaw	Swamp white oak

## FAIR CAPABILITY

American beech	Eastern cottonwood
Bitternut hickory	Red mulberry
Black locust	Sassafras
Black walnut	Scarlet oak
Chestnut oak	Virginia pine

## GOOD CAPABILITY

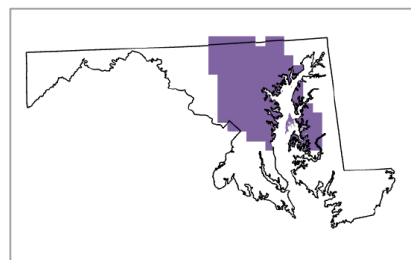
American elm	Northern red oak
American holly	Pignut hickory
American hornbeam	Red maple
Black cherry	Shagbark hickory
Black oak	Southern red oak
Blackgum	Sugar maple
Boxelder	Swamp chestnut oak
Cherrybark oak	Sweetbay
Eastern hophornbeam	Sweetgum
Eastern redcedar	Sycamore
Flowering dogwood	White ash
Green ash	White oak
Hackberry	Willow oak
Loblolly pine	Yellow Poplar
Mockernut hickory	

## MIXED RESULTS

Silver maple	Common persimmon
Slippery elm	Black willow

## NEW HABITAT WITH MIGRATION POTENTIAL

Bald cypress	River birch
Blackjack oak	Shortleaf pine
Eastern redbud	Sourwood
Laurel oak	Sugarberry
Longleaf pine	Swamp tupelo
Overcup oak	Water oak
Pond cypress	Water tupelo
Post oak	Winged elm
Redbay	





# NIACS Washington DC climate change resources

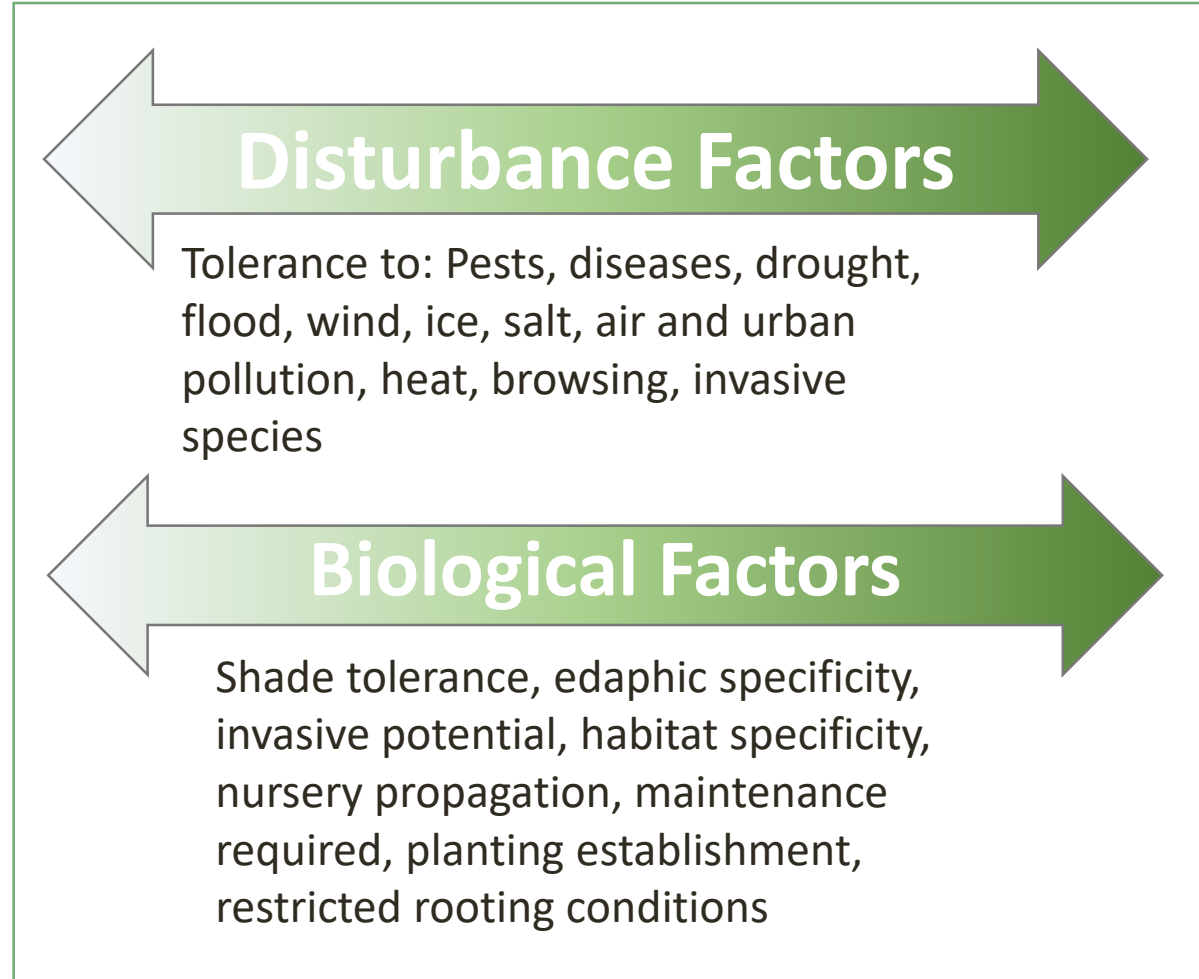
Tree species projections (simplistic):

**Tree characteristics**

+

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Climate informed habitat projections



# NIACS Washington DC climate change resources

Tree species projections (simplistic):

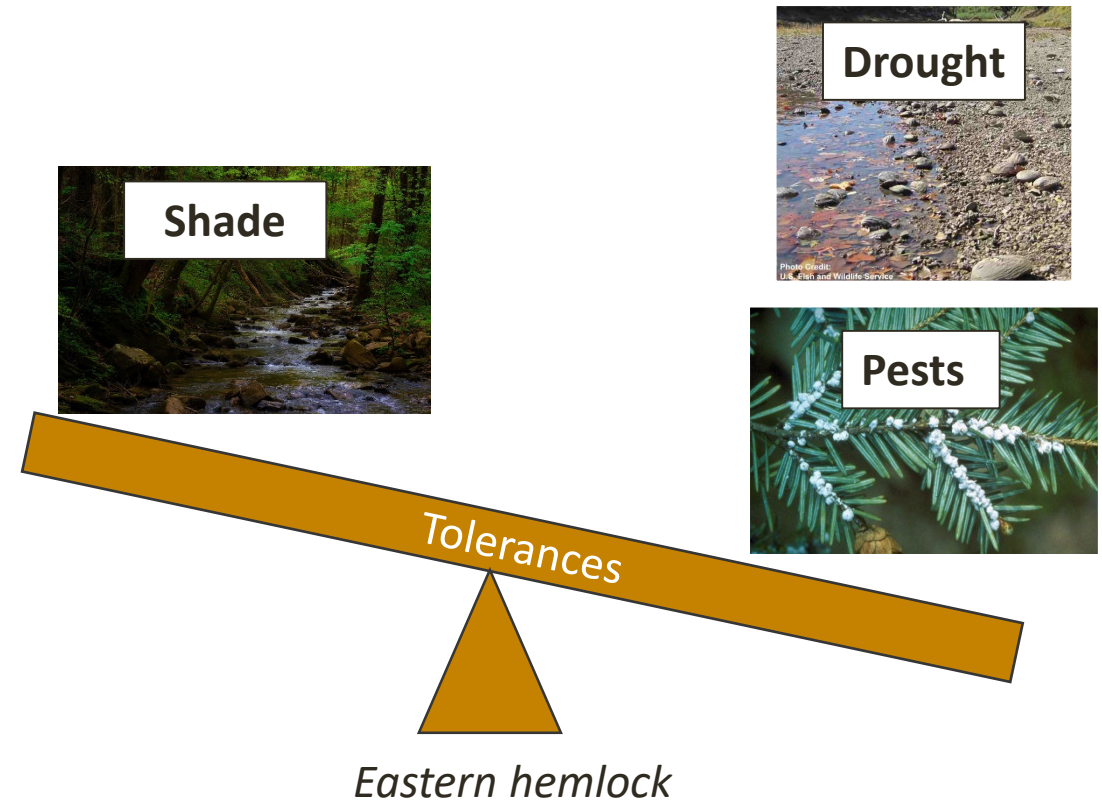
Tree characteristics

**Adaptive capacity scoring**

+

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Climate informed habitat projections

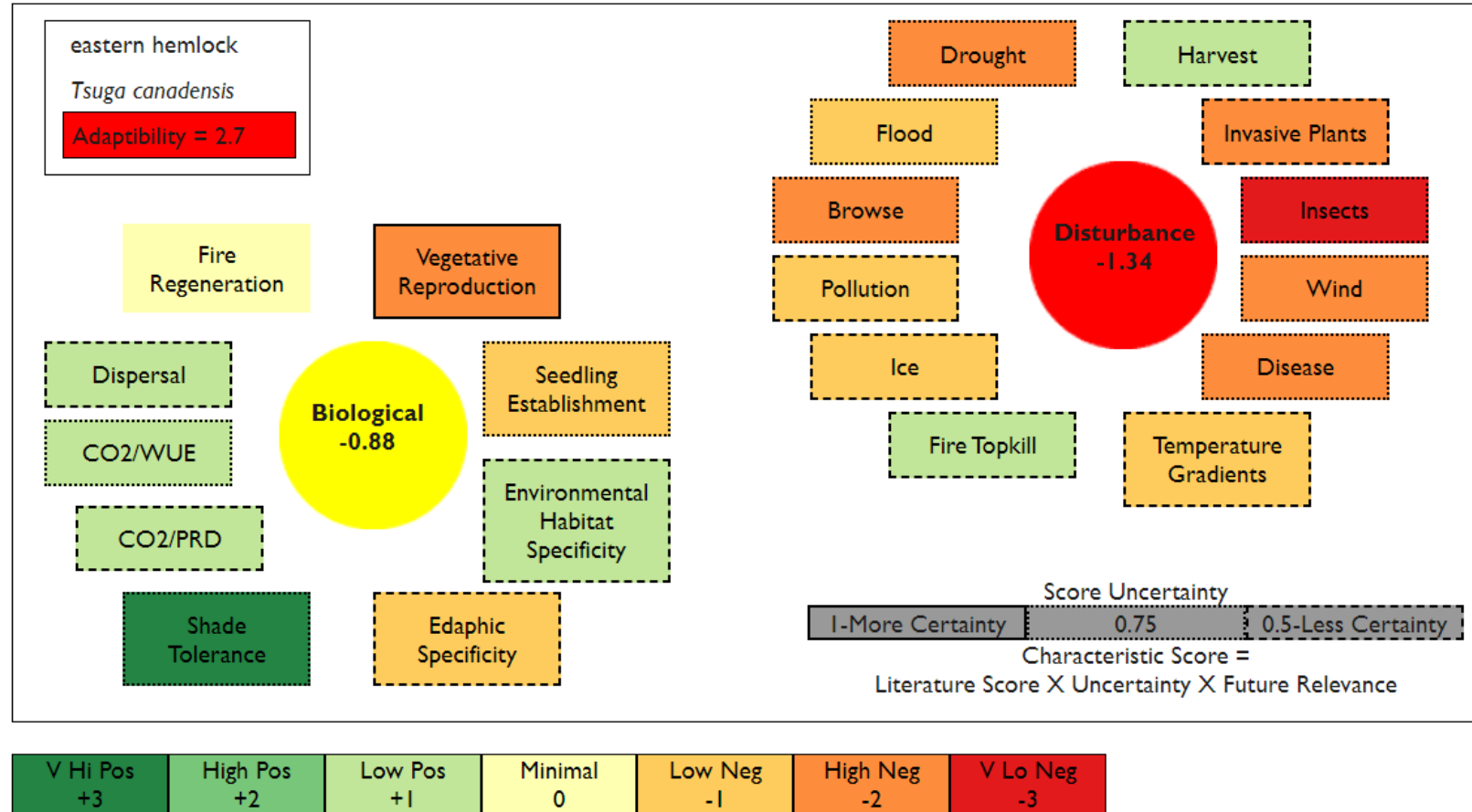




# How do we determine vulnerability of individual trees?

## Adaptive Capacity Scoring

Example of Planted Modification Factor Scores Generated for the Species **Eastern hemlock**.



Matthews, S. N., Iverson, L. R., Prasad, A. M., Peters, M. P., & Rodewald, P. G. (2011). Modifying climate change habitat models using tree species-specific assessments of model uncertainty and life history factors. *Forest Ecology and Management*, 262, 1460-1472.

*This image is available on the Tree Atlas website!*

# How do we determine vulnerability of individual trees? Adaptive Capacity Scoring

Example of Planted Modification Factor Scores Generated for the Species **Boxelder**.

Factor Type	ModFactor	Score	Uncert	FutureRelevance	Weighted
Disturbance	Disease	-1	0.75	2	-1.50
Disturbance	Insect Pests	-3	0.5	5	-7.50
Disturbance	Browse	-1	0.75	1	-0.75
Disturbance	Invasive Plants	0	0.5	2	0.00
Disturbance	Drought	3	0.75	3	6.75
Disturbance	Flood	2	0.75	3	4.50
Disturbance	Ice	-1	0.5	2	-1.00
Disturbance	Wind	-1	0.75	2	-1.50
Disturbance	Salt	1	0.5	1	0.50
Disturbance	Temperature Gradients	3	0.75	3	6.75
Disturbance	Air Pollution	-2	0.75	3	-4.50
Disturbance	Soil & Water Pollution	-2	0.5	1	-1.00
Biological	Competition-Light	2	0.5	1	1.00
Biological	Edaphic Specificity	2	0.75	2	3.00
Biological	Land Use & Planting Site Specificity	1	0.75	3	2.25
Biological	Restricted Rooting Conditions	1	0.75	3	2.25
Biological	Nursery Propagation	-1	0.75	4	-3.00
Biological	Planting Establishment	2	0.75	2	3.00
Biological	Maintenance Required	-1	0.75	2	-1.50
Biological	Invasive Potential	-3	0.75	3	-6.75
	Adapt Score				4.41
	Adapt Class				Medium

Matthews, S. N., Iverson, L. R., Prasad, A. M., Peters, M. P., & Rodewald, P. G. (2011). Modifying climate change habitat models using tree species-specific assessments of model uncertainty and life history factors. *Forest Ecology and Management*, 262, 1460-1472.

# NIACS Washington DC climate change resources

Tree species projections (simplistic):

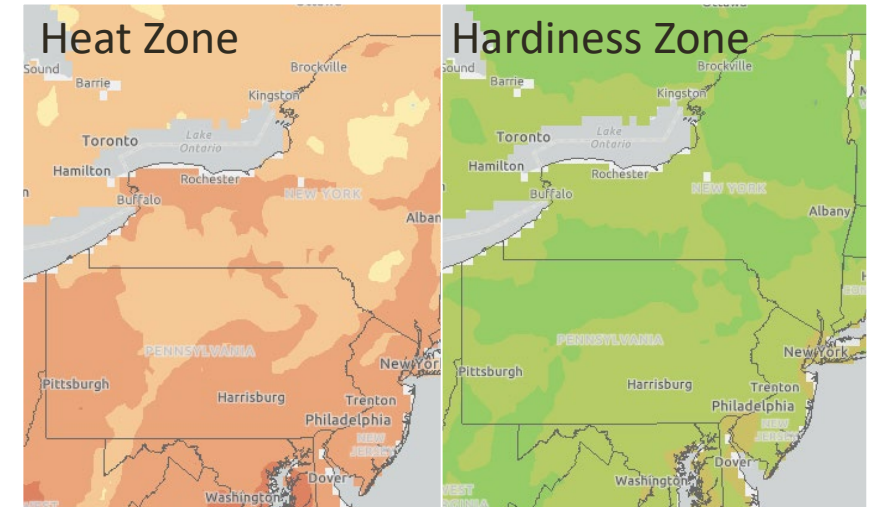
Tree characteristics

Adaptive capacity scoring

+ **Future heat zone and hardiness zone projections**

Climate informed habitat projections

## High Climate Change Scenario (RCP 8.5)



Time Period	Hardiness Zone Range		Heat Zone Range	
	Low Emissions	High Emissions	Low Emissions	High Emissions
1980–2010		7		7
2010–2039	7	8	7 to 8	8
2040–2069	7 to 8	8	8	9
2070–2099	8	8 to 9	8	9 to 10

Current and projected USDA Hardiness Zones and AHS Heat Zones for Washington, D.C. Hardiness zone is determined by the average lowest temperature over a 30 year period. Heat zones are determined by the number of days above 86°F.

# NIACS Washington DC climate change resources

Tree species projections (simplistic):

Tree characteristics

Additional vulnerability considerations

+ Future heat zone and hardiness zone projections

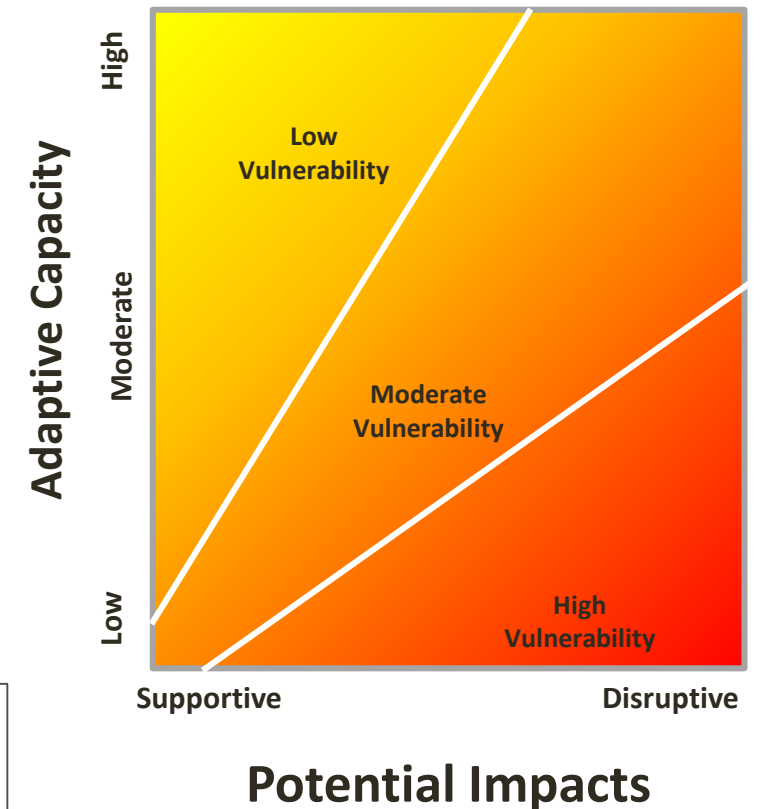
## Climate informed habitat projections

### ZONE SUITABILITY:

- ✓ *Suitable*
- ✗ *Not Suitable*

### VULNERABILITY:

- ▼ *Low: Suitable zone, high adaptability*
- *Low-moderate: Suitable zone, medium adaptability*
- ⊖ *Moderate: Suitable zone, low adaptability or zone not suitable, high adaptability*
- *Moderate-high: Zone not suitable, medium adaptability*
- △ *High: Zone not suitable, low adaptability*



# NIACS Washington DC climate change resources

URBAN ADAPTABILITY:	ZONE SUITABILITY:	VULNERABILITY:	
+ <b>High:</b> Species may perform better than modeled	✓ <b>Suitable</b>	▼ <b>Low:</b> Suitable zone, high adaptability	○ <b>Moderate-high:</b> Zone not suitable, medium adaptability
• <b>Medium</b>	✗ <b>Not Suitable</b>	● <b>Low-moderate:</b> Suitable zone, medium adaptability	△ <b>High:</b> Zone not suitable, low adaptability
- <b>Low:</b> Species may perform worse than modeled		⊖ <b>Moderate:</b> Suitable zone, low adaptability or zone not suitable, high adaptability	

\*Invasive species

COMMON NAME	LOW EMISSIONS			HIGH EMISSIONS		COMMON NAME	LOW EMISSIONS			HIGH EMISSIONS	
	ADAPT	ZONE SUIT	VULN	ZONE SUIT	VULN		ADAPT	ZONE SUIT	VULN	ZONE SUIT	VULN
Alleghany serviceberry	+	✓	▼	✗	⊖	Honeylocust*	•	✓	●	✗	○
American linden, Basswood	•	✓	●	✗	○	Ironwood	+	✓	▼	✓	▼
American sweetgum, fruitless	+	✓	▼	✓	▼	Japanese flowering cherry	-	✗	△	✗	△
American beech	•	✓	●	✓	●	Japanese pagoda tree	•	✓	●	✗	○
American elm	•	✓	●	✓	●	Japanese tree lilac	+	✗	⊖	✗	⊖
American sycamore	•	✓	●	✓	●	Japanese zelkova	+	✓	▼	✗	⊖
Amur corktree*	+	✗	⊖	✗	⊖	Jefferson elm	+	✓	▼	✓	▼
Amur maackia	+	✗	⊖	✗	⊖	Katsura tree	-	✓	⊖	✗	△
Amur maple*	•	✗	○	✗	○	Kentucky coffeetree	+	✓	▼	✗	⊖
Bald cypress	+	✓	▼	✓	▼	Kousa dogwood	+	✓	▼	✗	⊖
Bipinnate goldenrain tree	+	✓	▼	✓	▼	Lacebark elm	+	✓	▼	✓	▼
Black alder	•	✗	○	✗	○	Littleleaf linden	+	✗	⊖	✗	⊖
Black locust	•	✓	●	✗	○	London planetree	•	✓	●	✗	○
Black oak	•	✓	●	✗	○	Musclewood	+	✓	▼	✓	▼
Black tupelo, Black gum	+	✓	▼	✓	▼	New Harmony elm	+	✓	▼	✓	▼
Black walnut	-	✓	⊖	✓	⊖	Northern red oak	+	✓	▼	✗	⊖
Blackjack oak	-	✓	⊖	✓	⊖	Northern white cedar, Arborvitae	•	✗	○	✗	○
Boxelder	•	✓	●	✗	○	Norway maple*	+	✗	⊖	✗	⊖

More information: [forestadaptation.org/washington-dc](https://forestadaptation.org/washington-dc)

# NIACS Washington DC climate change resources


Tree species projections can be used to:

- Understand the overall **vulnerability** of the region's urban forest (developed using tree inventories)
- Used as a tool to help inform **decision-making**
- Integrate into **adaptation** projects to support approaches & tactics


Washington D.C.

Home ▸ Assess ▸ Ecosystem Vulnerability ▸ Urban Forests ▸ Washington D.C.

Map Satellite



United States



Washington D.C. Cherry Blossoms. Source: Flickr, PeterPanFan.

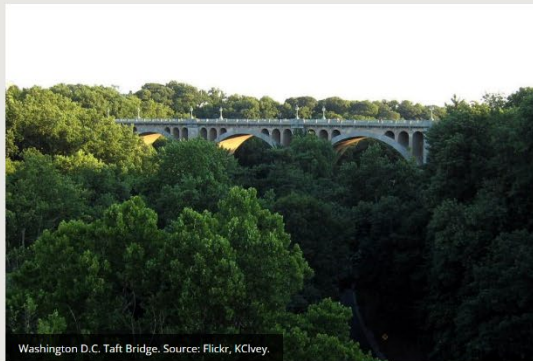
### Short Summary

Located at the center of the Mid-Atlantic seaboard amid the intense urban development of Maryland and Virginia, Washington, D.C. hosts the nation's federal government and the myriad associated industries. The urban forest covers roughly 38% of the city's area (down from 50% a half century ago), providing residents with vital ecological services during the long, humid summers and giving birth to the historical nickname "the city of trees." That canopy, however, is not evenly distributed - studies have found that the most affluent neighborhoods have 42% more cover than the least. Compounding these disparities, Washingtonians have no representation in the U.S. congress and no voice at the federal level in the climate change debate. Though there are considerable social challenges to contend with, understanding tree species vulnerability and key climate change impacts is critical to Washington's climate adaptation and management efforts in the 21st century.

### Tree Species Vulnerability

Species distribution modeling suggests that the changing climate will shift suitable habitat and heat and hardiness zones for various tree species in the capital region. The city's urban forest fortunately includes many native species that are projected to do well or at least survive, even in higher emissions scenarios. The city also has unique considerations, like historical and aesthetic species that may be particularly vulnerable, such as the elms lining the National Mall, which Dutch Elm disease only through regular inoculation. Climate change vulnerability of urban trees, including adaptive capacity and zone suitability under low and high emissions scenarios, is outlined in the tree species handout below.

WashingtonDC\_TreeSpeciesVulnerability.pdf (296.58 KB)



Washington D.C. Taft Bridge. Source: Flickr, KClvey.

### Climate Change Impacts

The capital is situated on the confluence of the Potomac and Anacostia rivers, near the Potomac's mouth on the Chesapeake Bay, making the city's waters tidal, and subject to a projected 2-5 feet of sea level increase by century's end. The region has already seen an increase of precipitation, particularly in acute events, which have led to damaging floods. Known for its hot and humid summers, Washington D.C. is likely to experience three times as many dangerously hot days in heat waves of the future. The urban heat island effect is particularly pronounced in

# Tools to inform Baltimore tree planting

## Summary:

- NIACS combined multiple datasets into one list for GBWC
- Each dataset (Tree Atlas, DC results) uses different methodologies to establish predictions
- Approaches have differing levels of uncertainty
- Requires local expertise and judgement when interpreting results!

### Climate Change Atlas



**Tree Atlas** Version 4  
Modeled potential suitable habitat for 125 tree species in the East, with an additional 23 species with current information only.  
[Latest Tree Atlas](#)



**Bird Atlas** Version 2  
Potential changes in abundance and range for 147 bird species in the East.  
[Latest Bird Atlas](#)

**Search or Browse the Atlas**

Search for Trees or Birds  
  
Browse Previous Tree Atlas  
[Version 3](#) [Version 2](#)  
Browse Previous Bird Atlas  
[Version 1](#)

### Regional Summary Tree Tables

Current and Potential Future Habitat, Capability, and Migration

Summaries for tree species are available for a variety of geographies, in both PDF and Excel formats. Summaries are based on [Version 4 of the Climate Change Tree Atlas](#).

- [National Forest Summaries](#)
- [National Park Summaries](#)
- [HUCs Watersheds](#)
- [Ecoregional Vulnerability Assessments \(EVAS\)](#)
- [USDA Forest Service EcoMap 2007 Sections](#)
- [National Climate Assessment \(NCA\) Summaries](#)
- [1 x 1° Grid Summaries](#)
- [Eastern United States](#)
- [Urban Areas](#)

### CLIMATE CHANGE VULNERABILITY OF URBAN TREES WASHINGTON, D.C.



This list was developed to aid Washington, D.C. community forestry practitioners in selecting trees to reduce climate change vulnerability of their urban forests. It is meant to be a complement to other tree selection resources. Other factors may also need to be considered, such as aesthetics, local site conditions, wildlife value, or nursery availability. It is also important to note that some species may have climate benefits but may not be suitable for planting for other reasons, such as having invasive potential or susceptibility to pests or pathogens.

**Vulnerability:** Trees can be vulnerable to a variety of climate-related stressors such as intense heat, drought, flooding, and changing pest and disease patterns. Climate vulnerability is a function of the impacts of climate change on a species and its adaptive capacity. Species with negative impacts on habitat suitability and low adaptive capacity will have high vulnerability and vice versa. The following factors were used to determine climate vulnerability.

**Urban adaptability:** Adaptability scores were generated for each species based on literature describing its tolerance to disturbances such as drought, flooding, pests, and disease, as well as its growth requirements such as shade tolerance, soil needs, and ease of nursery propagation. Scores were assigned to species using methods developed in an urban forest vulnerability assessment for Chicago for trees planted in developed sites. A positive score indicates that a species is tolerant to a wide range of disturbances and can be planted on a variety of sites. A negative score indicates a species is highly susceptible to disturbances and/or is limited to specific planting sites.

**Hardiness and heat zone suitability:** Tree species ranges were recorded from government, university, and arboretum websites. Species tolerance ranges were compared to current and projected heat and hardiness zones for Washington, D.C. using downscaled climate models under low emissions (RCP 4.5) and high emissions (RCP 8.5) scenarios for changes in greenhouse gases. Trees were considered to have suitable zone suitability if the species' tolerance was within the range of current and projected hardiness and heat zone through the end of the 21st century.

**NOTE:** This list was primarily created for species planted in developed sites, such as streets, yards, boulevards, and parks. If you are interested in projected changes in habitat suitability for native species in natural areas, see the Climate Change Tree Atlas at [www.fs.fed.us/csp/atlas/](http://www.fs.fed.us/csp/atlas/).

Current and projected USDA Hardiness Zones and AHS Heat Zones for Washington, D.C. Hardiness zone is determined by the average lowest temperature over a 30 year period. Heat zones are determined by the number of days above 66°.

Time Period	Hardiness Zone Range		Heat Zone Range	
1980-2010	7		7	
	Low Emissions	High Emissions	Low Emissions	High Emissions
2010-2039	7	8	7 to 8	8
2040-2069	7 to 8	8	8	9
2070-2099	8	8 to 9	8	9 to 10

SOURCE: Adaptability scores were assigned using methods developed in an urban forest vulnerability assessment for Chicago by Brinnett et al. 2017 <https://www.fs.fed.us/csp/atlas/>.  
www.fs.fed.us/csp/atlas/ Heat Zones and Hardiness Zone Information  
www.fs.fed.us/csp/atlas/ Heat Zones and Hardiness Zone Information  
www.fs.fed.us/csp/atlas/ Heat Zones and Hardiness Zone Information  
www.fs.fed.us/csp/atlas/ Heat Zones and Hardiness Zone Information

[www.forestadaptation.org](http://www.forestadaptation.org)

# GBWC's Climate-informed tree species list: Key terms.

~200 trees and cultivars organized by botanical name and common name

## Washington DC urban tree results

- Adapt
- Zone suitability
- Vulnerability

## USFS Tree Atlas results for the Greater Baltimore Urban region

- Adapt score
- Abundance
- Habitat change
- Capability

**Results** describe habitat suitability under a future with

- Less warming RCP 4.5
- High, more warming RCP 8.5





# What this data can and can't do

## *Can do -*

- Describe regional habitat suitability for certain trees given climate change (from less warming to greater warming)
- Links to peer-reviewed, unbiased and scientific data on the topic
- Create connections to broader climate-informed thinking across the region through the NIACS urban effort.

## *Can't do -*

- Tell you what to do.
  - These are model results and require additional **expertise** and **judgement** to determine site-level suitability

# Additional reading: Urban tree species assessment

Read a technical description:

Brandt, Leslie A., Gary R. Johnson, Eric A. North, Jack Faje, and Annamarie Rutledge, “Vulnerability of Street Trees in Upper Midwest Cities to Climate Change” *Frontiers in Ecology and Evolution* (2021): 623. <https://doi.org/10.3389/fevo.2021.721831>

Thank you!

**Contact us with any questions!**

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