Twin Cities Region

Urban Forest Impacts and Vulnerabilities

Urban forests play an important role in helping communities adapt to and mitigate climate change because they reduce the urban heat island effect, control stormwater, and store carbon. Despite this, few urban areas have examined the vulnerability of their trees to current and future climate conditions or developed specific adaptation plans to ensure that their urban forests continue to provide benefits into the future.

Urban forests will experience local climate change impacts in the coming decades. A key first step to adapting to these changes is understanding the potential impacts and vulnerabilities of the urban forest.

As part of the Urban Forestry Climate Change Response Framework, we synthesize the best available science about local climate change impacts and what that means for urban trees and ecosystems. Learn more about other project activities at:

www.forestadaptation.org/urban

The climate has changed

Since 1895, the Twin Cities region has warmed by about 2°F on average. Warming has been more pronounced for nighttime low temperatures than daytime high temperatures across all seasons. The coldest temperatures are the ones warming the fastest: since 1970, winters have been warming 10 times faster than summers across the state.

The area also receives about 4 more inches of rain each year on average. The greatest increases have been in the spring, and more precipitation is falling as heavy rain events.

The Twin Cities Region is getting warmer and wetter, with more intense precipitation events.

NIACS Northern Institute of Applied Climate Science

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

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How may the Twin Cities climate change in the coming decades? Researchers use global climate models to help us understand projected changes in climate under a range of potential future greenhouse gas emissions.

Temperatures will increase

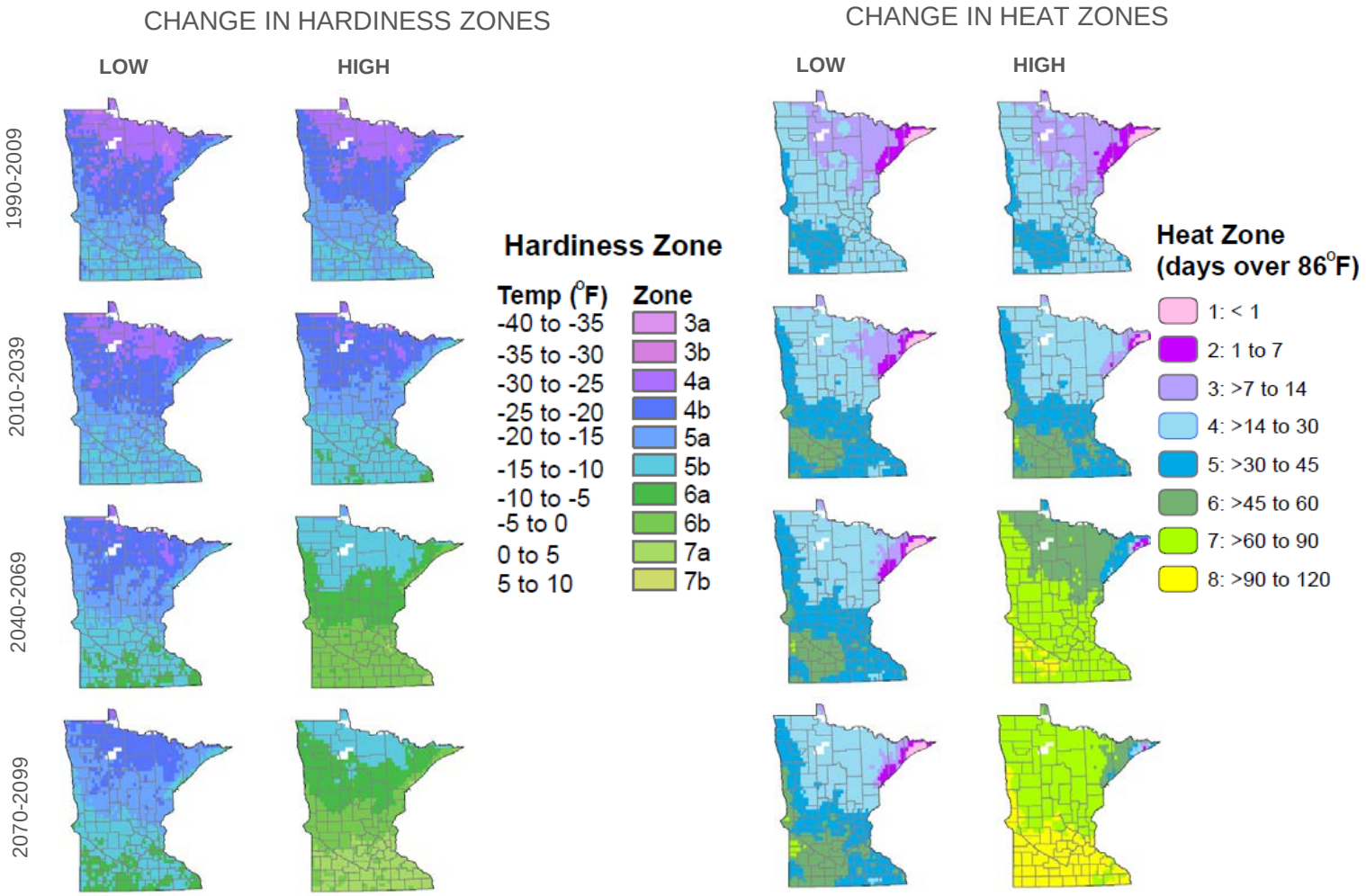
All global climate models project that temperatures will increase in the Twin Cities region. Model projections suggest an increase in temperature over the next century across all seasons by 2 to 8°F. Growing seasons will continue to lengthen due to warmer temperatures, and winter temperatures in particular are projected to increase.

Precipitation will change

Precipitation is projected to increase in winter and spring and potentially decrease in the summer and fall. Even if the total annual amount of precipitation does not change substantially, models suggest it may occur as heavier rain events interspersed among relatively dry periods.

Shifting heat and hardiness zones

Planting suitability for trees and other plants is determined by hardiness zones, which are based on minimum temperatures, and heat zones, which are based on the number of days above 86°F. Both heat and hardiness zones are projected to shift over the next century, changing what can be planted.



Projected changes in hardiness zones and heat zones under a low (dramatic reduction in emissions) and high (business as usual) greenhouse gas emission scenario for 30-year periods in Minnesota.

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Effects on Twin Cities urban trees

Trees in the Twin Cities area will be affected by changing temperatures and precipitation patterns. Warmer summers can create stress for some species that cannot tolerate high temperatures. Milder winters may allow some species to survive in the area that previously would have suffered freezing damage. Warmer springs and falls may change the timing of leaf-out, flowering, and senescence.

Precipitation patterns will also affect local trees. More heavy precipitation events may increase the frequency or severity of flooding. Storms may break limbs or damage trees. Drier conditions in fall coupled with warmer temperatures could cause soil moisture deficits.

A changing climate can also affect the range and severity of pests, diseases, and invasive plant species. These biological stressors can also affect the survival and health of urban trees.

These lists highlight species that may be more or less vulnerable to projected changes in the climate and other stressors of the Twin Cities in the coming decades. Some vulnerable species may still be an important part of the landscape; they just may require extra care or specific planting sites. Considerations of species vulnerability are meant to be factored in with other managements goals, such as enhancing biodiversity or providing wildlife habitat.

Low Vulnerability: *Adapted to future climate and a range of other stressors*	
Acer truncatum	Shantung maple
Acer x freemanii	Freeman maple
Aesculus pavia	red buckeye
Amelanchier arborea	downy serviceberry
Amelanchier canadensis	Canadian serviceberry
Amelanchier laevis	Allegheny serviceberry
Carpinus caroliniana	American hornbeam
Celtis occidentalis	northern hackberry
Cladrastis kentukea	yellowwood
Gingko biloba	gingko/maidenhair tree
Gymnocladus dioicus	Kentucky coffeetree
Juniperus virginiana	eastern redcedar
Maclura pomifera	Osage orange
Ostrya virginiana	ironwood (eastern hophornbeam)
Prunus maackii	Amur cherry
Quercus bicolor	swamp white oak
Quercus coccinea	scarlet oak
Quercus imbricaria	shingle oak
Quercus macrocarpa	bur oak
Quercus prinus	chestnut oak
Quercus x macdanielii	heritage oak
Tilia cordata	little leaf linden
Ulmus spp	disease-resistant elm cultivars
Viburnum lentago	nannyberry

Low-Moderate Vulnerability: *Adapted to future climate and most stressors*	
Abies koreana	Korean Fir
Acer rubrum	red maple
Acer saccharinum	silver maple
Aescleus glabra	Ohio buckeye
Aescleus hippocastanatum	horsechestnut
Aesculus flava (octandra)	yellow buckeye
Carya cordiformis	bitternut hickory
Carya glabra	pignut hickory
Carya ovata	shagbark hickory
Catalpa ovata	Chinese catalpa
Celtis laevigata	sugarberry
Cercis canadensis	eastern redbud
Fagus grandifolia	American beech
Fagus sylvatica	European beech
Gleditsia triacanthos	honeylocust
Juglans nigra	black walnut
Magnolia acuminata	cucumbertree
Metasequoia glyptostroboides	dawn redwood
Morus rubra	red mulberry
Platanus occidentalis	American sycamore
Platanus x acerifolia	planetree
Prunus americana	American plum
Quercus alba	white oak
Quercus muehlenbergii	chinkapin oak
Quercus palustris	pin oak
Quercus velutina	black oak
Salix babylonica	weeping willow
Thuja occidentalis	northern white cedar
Ulmus americana	American elm
Ulmus pumila	Siberian elm
Ulmus rubra	slippery elm

Some species will be more vulnerable to these changes than others. The species listed here were assessed for changes in species habitat suitability from climate impacts models and heat and hardiness zones. Traits that may make species more adaptable to stress, such as resistance to pests, diseases, drought, and flooding were also considered.

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Moderate Vulnerability: *May experience some stress from climate change or other stressors*	
Acer negundo	boxelder
Acer platanoides	Norway maple
Acer triflorum	threeflower maple
Betula alleghaniensis	yellow birch
Betula nigra	river birch
Carya illinoinensis	pecan
Carya laciniosa	shellbark hickory
Catalpa speciosa	northern catalpa
Cercidiphyllum japonicum	Katsura tree
Cornus alternifolia	pagoda dogwood
Crataegus acutifolia	cockspur hawthorn
Liriodendron tulipifera	tuliptree
Maackia amurensis	Amur maackia
Magnolia stellata	star magnolia
Malus spp	crabapple species
Morus alba	white mulberry
Phellodendron amurense	Amur corktree
Picea abies	Norway spruce
Picea canadensis (glauca)	White spruce
Picea pungens	blue spruce
Pinus nigra	Austrian pine
Pinus resinosa	red pine
Populus balsamifera	balsam poplar
Populus deltoides	cottonwood
Prunus cerasus	sour Cherry
Prunus serrulata 'Kwanzan'	Kwanzan Cherry
Prunus x cistena	purpleleaf Sand Cherry
Pyrus spp.	pear
Quercus ellipsoidalis	northern pin oak (Hill's Oak)
Quercus rubra	northern red oak
Rhus typhina	staghorn sumac
Salix nigra	black willow
Sorbus alnifolia	Korean mountain-ash
Syringa reticulata	Japanese tree lilac
Tilia x euchlora	Crimean linden

Moderate-High Vulnerability: *Will likely experience considerable stress from climate or other stressors*	
Abies balsamea	balsam fir
Abies concolor	white fir
abies fraseri	Fraser Fir
Acer ginnala	Amur maple
Acer nigrum	black maple
Acer saccharum	sugar maple
Acer tataricum	tatarian maple
Betula papyrifera	paper birch
Betula pendula	European white birch
Picea glauca var. densata	Black Hills spruce
Pinus ponderosa	ponderosa pine
Pinus strobus	white pine
Pinus sylvestris	Scotch pine
Prunus mandshurica	Manchurian apricot
Prunus virginiana	common chokecherry
Pyrus ussuriensis	Ussurian pear
Salix amygdaloides	peachleaf willow
Salix discolor	pussy willow
Sorbus aucoparia	European mountain Ash
Tilia americana	American basswood

High Vulnerability: *Will likely experience severe declines from climate or other stressors*	
Betula populifolia	gray birch
Populus tremuloides	quaking aspen
Populus grandidentata	big-toothed aspen
Prunus pensylvanica	pin cherry
Prunus serotina	black cherry
Pseudotsuga mucronata	Douglas fir
Sorbus decora	showy mountain ash
Fraxinus americana	white ash
Fraxinus nigra	black ash
Fraxinus pennslyvanica	green ash

Eastern redbud, native to areas south of the Twin Cities, may benefit from milder winters.

Confronting the challenge of climate change presents opportunities for land managers to plan ahead, foster resilient landscapes, and ensure that the benefits that forests provide are sustained into the future.

Resources are available to help forest managers and planners incorporate climate change considerations into forest management. A set of Forest Adaptation Resources is available at **www.forestadaptation.org**.

More information at: www.forestadaptation.org/urban

Species Model Projections

Common Name	Low Emissions	High Emissions	Source	Planted Adapt Class	Natural Adapt Class
Allegheny serviceberry	●	●	HH	+	+
American basswood	●	●	TA	·	·
American beech	★	★	TA	·	·
American elm	●	●	TA	·	+
American hornbeam	●	●	TA	+	+
American plum	●	▲	TA	·	·
American sycamore		★	TA	·	na
Amur cherry	●	●	HH	+	na
Amur corktree	●	●	HH	·	na
Amur maackia	●	▼	HH	+	na
Amur maple	●	▼	HH	·	na
apricot (Manchurian)	●	●	HH	–	na
Austrian pine	●	●	HH	·	na
balsam fir	▼	▼	HH	·	na
balsam poplar	●	●	TA	–	·
big-toothed aspen	●	▼	TA	–	+
bitternut hickory	▲	●	TA	·	·
black Ash	●	●	TA	–	–
black cherry	●	●	TA	–	·
Black Hills spruce	●	▼	HH	·	na
black locust	▲	▲	TA	·	+
black maple	▼	▼	TA	·	+
black oak	▲	●	TA	·	+
black walnut	▲	▲	TA	·	·
black willow	●	●	TA	–	–
blue spruce	●	●	HH	·	na
boxelder	●	●	TA	·	+
bur oak	●	●	TA	+	+
chestnut oak	▲	▲	HH	+	+
Chinese catalpa	▲	▲	HH	·	na
chinkapin oak	★	★	TA	·	na
cockspur hawthorn	●	▼	HH	+	na
common chokecherry	●	▼	TA	·	·
cottonwood	●	▲	TA	–	·
crabapple species	●	●	HH	·	na
Crimean linden	●	▼	HH	+	na
cucumbertree	▲	▲	HH	·	na
dawn redwood	▲	▲	HH	·	na
douglas fir	●	▼	HH	–	na
downy serviceberry	●	●	HH	+	+
eastern redbud		★	TA	·	+
eastern redcedar	▲	▲	TA	+	·
elm cultivars	●	●	HH	+	na
European beech	●	●	HH	·	na
European buckthorn	●	●	HH	+	+
European Mountain Ash	●	▼	HH	·	na
European White birch	●	▼	HH	–	na
Fraser Fir	●	▼	HH	·	na
Freeman maple	●	●	HH	+	na
gingko/maidenhair tree	●	●	HH	+	na
gray birch	▼	▼	HH	–	·
Green ash	●	●	TA	·	·
heritage oak	●	●	HH	+	na
honeylocust	●	●	TA	·	+
horsechestnut	●	●	HH	·	na
Ironwood (easternhophornbeam)	●	●	TA	+	+
jack pine	●	●	TA	–	na
Japanese tree lilac	●	▼	HH	+	na
Katsura tree	●	●	HH	–	na

Common Name	Low Emissions	High Emissions	Source	Planted Adapt Class	Natural Adapt Class
Kentucky coffeetree	●	●	HH	+	na
Korean Fir	●	▲	HH	·	na
Korean mountain-ash	●	●	HH	·	na
Kentucky coffeetree	●	●	HH	+	na
Kwanzan Cherry	▲	▲	HH	–	na
little leaf linden	●	●	HH	+	na
nannyberry	●	●	HH	+	+
northern catalpa	●	●	HH	–	–
northern hackberry	▲	▲	TA	+	+
northern pin oak (Hill's Oak)	●	●	TA	·	·
northern red oak	●	▼	TA	+	+
northern white cedar	●	●	TA	·	·
Norway maple	●	▼	HH	+	+
Norway spruce	●	●	HH	·	na
Ohio buckeye		★	TA	·	–
Osage orange	★	★	TA	+	na
pagoda dogwood	●	▼	HH	·	·
paper birch	▼	▼	TA	·	·
peachleaf willow	●	●	TA	–	–
pear	●	●	HH	·	na
pecan		★	TA	–	na
pignut hickory	★	★	TA	·	+
pin cherry	▼	▼	TA	–	·
pin oak		★	TA	·	·
planetree	●	●	HH	·	na
ponderosa Pine	●	●	HH	–	na
purpleleaf Sand Cherry	●	●	HH	·	na
pussy willow	●	●	HH	–	·
quaking aspen	●	▼	TA	–	·
red buckeye	▲	▲	HH	+	na
red maple	●	●	TA	·	+
red mulberry	★	★	TA	·	·
red pine	●	●	TA	–	na
river birch	●	●	TA	·	·
scarlet oak	▲	▲	HH	+	na
Scotch pine	●	▼	HH	·	na
shagbark hickory	★	★	TA	·	+
Shantung maple	▲	▲	HH	+	na
shellbark hickory	▲	▲	HH	–	·
shingle oak		★	TA	+	na
showy Mountain Ash	▼	▼	HH	–	na
Siberian elm	●	●	HH	·	+
silver maple	▲	▲	TA	·	+
slippery elm	●	●	TA	·	·
sour Cherry	●	●	HH	·	na
staghorn sumac	●	●	HH	·	+
star magnolia	●	●	HH	·	na
sugar maple	●	▼	TA	·	+
sugarberry		★	TA	·	na
swamp white oak	●	●	TA	+	·
tatarian maple	●	▼	HH	·	na
threeflower maple	▲	▼	HH	·	na
tuliptree	▲	▲	HH	–	na
Ussurian Pear	●	●	HH	–	na
weeping willow	▲	▲	HH	·	na
white ash	●	▲	TA	–	·
white fir	●	▼	HH	·	na
white mulberry	●	●	HH	·	+
white oak	●	●	TA	·	+
white pine	●	▼	TA	–	·
White spruce	●	●	TA	·	na
yellow birch	▼	▼	TA	+	+
yellow buckeye	●	●	HH	·	na
yellowwood	●	●	HH	+	na

Future Projections

Projected habitat suitability for the end of the century is summarized for two climate change scenarios. **TA:** future habitat suitability is based on the The Climate Change Tree Atlas models (www.fs.fed.us/nrs/atlas). **HH:** future habitat suitability is estimated based on comparing species' temperature tolerances with projected changes in hardiness and heat zones.

▲ Increase
TA: Projected increase of >20% by 2100. HH: increase in hardiness zone benefits species

● No change
TA: Little change (<20%) projected by 2100; HH: heat and hardiness zone will remain favorable.

▼ Decrease
TA: Projected decrease of >20% by 2100; HH: heat or hardiness zone will exceed species' tolerance.

★ New habitat
Tree Atlas projects new habitat for species not currently present

Adaptability

Factors not included in the Tree Atlas model, such as the ability to respond favorably to disturbance, 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

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Local Vulnerability Assessments

Climate change will not affect all communities in the landscape in the same way. Some communities may be more vulnerable than others if they lack biodiversity, are in areas susceptible to climate change impacts, or lack the resources to adapt.

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.

We developed a process for municipalities, park districts, and forest preserve districts to assess their vulnerability to climate change based on impacts and adaptive capacity. Through this process, communities can discover what factors are the primary contributors to climate

This process can be used by communities to help identify potential areas were they may wish to develop adaptation strategies.

What can managers do?

Confronting the challenge of climate change presents opportunities for land managers to plan ahead, foster resilient landscapes, and ensure that the benefits that forests provide are sustained into the future.

Climate change impacts will vary across the landscape. Examples of characteristics that make systems more adaptable include high species diversity, landscape connectivity, and the ability to bounce back following a disturbance, such as a drought, flood, or fire. Managers can use scientific information from the assessment and other sources to better understand which places may be most vulnerable.

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More information

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www.forestadaptation.org/urban

Begin considering climate change in your land management today.
Learn more at: forestadaptation.org/adaptation-workbook