# Assessing Vulnerability of Urban Forests to Climate Change

*A Case Study of the Chicago Wilderness Region*

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The Chicago Wilderness region is an area of about 7 million acres that stretches from southwestern Michigan to southern Wisconsin, reaching through northwestern Indiana and northern Illinois. Chicago Wilderness is a regional alliance of more than 200 organizations that work together to improve the quality of life of the humans and the many other species living in the Chicago area. This region includes 38 counties, over 500 municipalities, and a population of more than 10 million people, one of the most densely-populated metropolitan areas in the United States.

Over the past 20 years since Chicago Wilderness began, partners in the region have worked toward a variety of conservation goals, including understanding and adapting to the impacts of climate change and improving connectivity of green infrastructure. This led to the development of a climate change action plan for nature and a green infrastructure vision plan.

**Leslie Brandt** is a climate change specialist with the Northern Institute of Applied Climate Science and the USDA Forest Service, where she works on climate change adaptation and outreach for natural resource managers.

Beginning in 2013, several representatives from Chicago Wilderness task forces, along with The Morton Arboretum and The Field Museum, were concerned about ensuring that trees lost to Emerald Ash Borer were being replaced with a more diverse mix of species that is adapted to current and future stressors. As part of a broader effort, they were interested in developing tools for adapting the region's urban forest to climate change. The Northern Institute of Applied Climate Science (NIACS), a multi-institutional partnership between the USDA Forest Service, universities, and other organizations was already working on climate change adaptation in rural Midwest forests. NIACS and the Chicago partners decided to work together to develop a framework for climate change adaptation in urban forests, piloting the work in the Chicago Wilderness region. This resulted in a climate change vulnerability assessment, as well as a suite of other tools for adaptation, including a guide to urban forest adaptation strategies, an online urban forest climate change adaptation workbook, and a lessons learned guide.

The following summary highlights key findings from the Chicago Wilderness Urban Forest Vulnerability Assessment and Synthesis, which will be available for free from the USDA Forest Service Northern Research Station. Download or request a paper copy at https://doi.org/10.2737/NRS-168

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# Chicago Wilderness Region

*Urban Forest Vulnerability Assessment and Synthesis*

**SUMMARY AND HIGHLIGHTS**

The urban forest of the Chicago Wilderness region can be viewed as two separate but interconnected entities: natural areas and developed sites. These areas are managed and maintained in vastly different ways and by different stakeholder groups.

Urban forests will experience local climate change impacts in the coming decades. A key step to understanding the potential impacts of climate change on the urban forest is to conduct vulnerability assessments.

As part of the Urban Forestry Climate Change Response Framework Chicago Wilderness pilot, more than 20 scientists and urban forestry professionals collaborated to assess the vulnerability of the region's forest to the likely range of climate change. Learn more other project activities at:

**www.forestadaptation.org/urban**

## The climate has changed

Over the past century, the Chicago Wilderness region has warmed by about 1°F on average. Summer minimum temperatures increased by 2.5 °F (1.4 °C) on average across the region. Changes in summer maximum temperatures differed geographically, with increases around Chicago and several other areas directly adjacent to Lake Michigan and decreases in the far southern part of the region, away from the lake.

The Chicago Wilderness Region is getting warmer and wetter, with more intense precipitation events.

Precipitation has also increased across the region on average. Across the entire area, increases were greatest in the summer. Much of these summer increases have been from heavy storm events.

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Global climate models can help us understand how climate may change in the future given changes in greenhouse gas emissions. In this assessment, we report climate projections for two global climate models under two contrasting greenhouse gas emissions scenarios (high and low) over the next century compared to the average over the last 30 years of the 20th century.

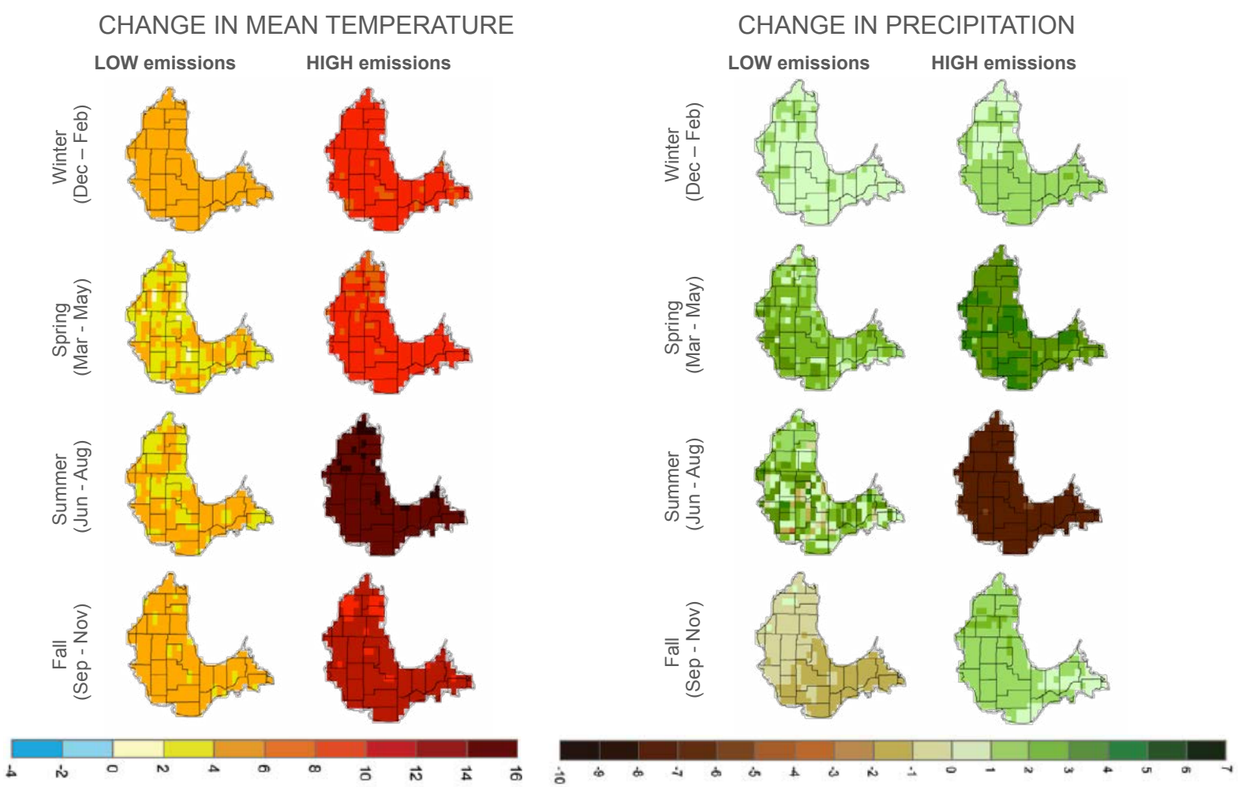
## Temperatures will increase

All global climate models project that temperatures will increase in the Chicago Wilderness 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.

Evidence suggests that winter temperatures will increase in the area, even under low emissions, leading to changes in snow and soil frost.

## Precipitation will change

Precipitation is projected to increase in winter and spring. There is a difference in model projections for later in the growing season, but evidence seems to indicate there may be a decrease in precipitation in either summer or fall, depending on scenario. Even if the total annual amount of precipitation does not change substantially, some evidence suggests it may occur as heavier rain events interspersed among relatively drier periods




*Projected difference in mean daily temperature and total seasonal precipitation at the end of the century (2070 through 2099) compared to 1971 through 2000 for two climate model-emissions scenario combinations.*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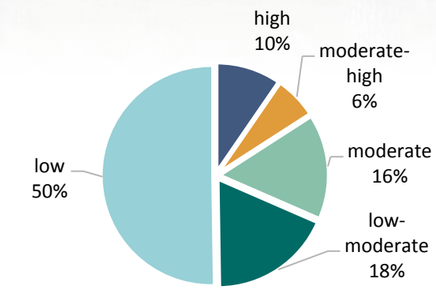
**SUMMARY AND HIGHLIGHTS**


## The region's urban forest will experience both direct and indirect impacts from a changing climate

Information from tree species habitat suitability models, hundreds of scientific papers, and local urban forestry professionals' expertise were combined to assess the effects of climate change on the region's urban forest and trees.




**Percentage of trees in the region within each vulnerability category**

Hardiness zones and, more recently, heat zones are used to determine suitability for planting. We used downscaled climate model projections to estimate how heat and hardiness zones may change in the coming decades. Increases in temperature may lead to an increase of 1-2 hardiness zones and 2-4 heat zones.

| | Low emissions | | | | High emissions | | | |
|---|---|---|---|---|---|---|---|---|
| | 1980 to 2009 | 2010 to 2039 | 2040 to 2069 | 2070 to 2099 | 1980 to 2009 | 2010 to 2039 | 2040 to 2069 | 2070 to 2099 |
| **Hardiness zone** | 5b-6a | 5b-6a | 6a-6b | 6a-6b | 5b-6a | 6a-6b | 6b-7a | 7a-7b |
| **Heat zone** | 4-5 | 5-6 | 5-6 | 5-6 | 4-5 | 6-7 | 7-8 | 8 |

There are many species not commonly planted in the area are likely to do well under future conditions. These can be considered as an alternative to invasive species or those that may be vulnerable.

We used habitat suitability models, projected changes in heat and hardiness zones, and assessments of species adaptability to stressors such as pests, flooding, wind, and temperature extremes to estimate the overall vulnerability of species commonly planted in the Chicago region as well as those recommended for planting.

Overall, half of all species in the region have low vulnerability, but many of the low vulnerability species are nonnative invasive or weedy species.

| Common Species with Low Vulnerability | Common Species with High Vulnerability | Trees to Try with Low Vulnerability |
|---|---|---|
| Amur Honeysuckle[i] | Balsam Fir | American Elm Cultivars ('Accolade', 'Discovery', 'Frontier', 'Triumph') |
| Black Locust | Black Cherry | Chestnut Oak |
| Black Oak | Douglas Fir | Chinese Juniper |
| Boxelder | Eastern Hemlock | Common Persimmon |
| Bur Oak | Gray Birch | Kousa Dogwood |
| European and Glossy Buckthorn[i] | Jack Pine | Scholar Tree |
| Freeman Maple | Paper Birch | Shantung Maple |
| Gingko | Quaking Aspen | Sunset Maple |
| Littleleaf Linden | White Pine | Willow Oak |
| Northern Hackberry | White Spruce | Yellowwood |

[i] invasive species

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## Vulnerability Case Studies

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. Ten case studies were developed in the Chicago Wilderness region using this approach. Most of the variation in vulnerability among communities was in adaptive capacity. In general, communities that had urban forests with high species, genetic, and age class diversity and had sufficient organizational, technical, social, and economic resources were less vulnerable to climate change impacts.

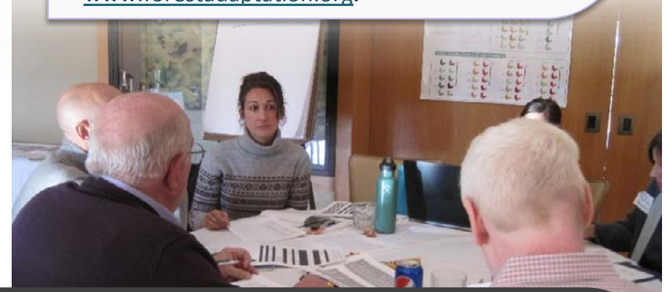
This process can be used by communities to help identify potential areas were they may wish to develop adaptation strategies.

## 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.

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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*The Climate Change Response Framework is a core forest adaptation effort of the USDA Northern Forests Climate Hub*