Huron River Watershed Council

Climate Resilient Communities

Review of climate impacts to tree species of the Huron River watershed

Contents

Creating Climate Resilient Communities

The familiar patterns of rainfall, snow, and our four seasons are becoming less recognizable.

County officials, public works directors, municipal planners, and natural areas managers in the Huron River watershed are noticing how the increase of extreme temperature and precipitation events is challenging how they do business and assess risk. Many feel ill-equipped to respond to this "weirdness" that results in overtaxed infrastructure, changes to natural systems, public health risks and costs to already-stressed community budgets.

In response, the Huron River Watershed Council (HRWC) is bringing together community partners up and down the river to examine the topic of a changing climate and how communities in the watershed, and Michigan, can maintain quality of life under projected scenarios.

Creating Climate-Resilient Communities is an effort to address local climate change impacts by building resiliency in the watershed. Over the course of a year, HRWC convened interested stakeholders to determine information needs and climate adaptation strategies. An opening plenary session in December 2011 was held to share current climate science and identify project participants. Participants then attended a series of working group sessions to develop and begin implementation of priority climate adaptation strategies. Three working groups were established for key sectors. These sectors are particularly likely to be impacted by climate change, and also able to reduce risks created by these changes.

WATER INFRASTRUCTURE

for practitioners involved with water utilities, wastewater treatment facilities, and stormwater management

IN-STREAM FLOWS

for dam operators, fisheries biologists, and hydrologists

NATURAL INFRASTRUCTURE

for land managers involved with natural areas preservation, restoration, and management

HRWC partnered with the Great Lakes Integrated Sciences and Assessments Center (GLISA) – a collaboration of the University of Michigan and Michigan State University whose goals are to contribute to the long-term sustainability of the region in the face of a changing climate, and facilitate smart decision-making backed by scientific knowledge. GLISA provided data and technical expertise on climate change to the project. Over the course of a year, HRWC, GLISA and project participants reviewed various climate scenarios, discussed best practices and case studies on adaptation strategies and gained commitments for action. The project contributes to the creation of "climate-resilient communities" that know how to reduce their vulnerability and risk associated with current and forecasted conditions.

In this report we detail the outcomes of the Natural Infrastructure Workgroup.

1 Climate adaptation is any action that leads to a reduction in harm or risk of harm, or realization of benefits, associated with climate variability and climate change.

Climate Change in the Huron River Watershed

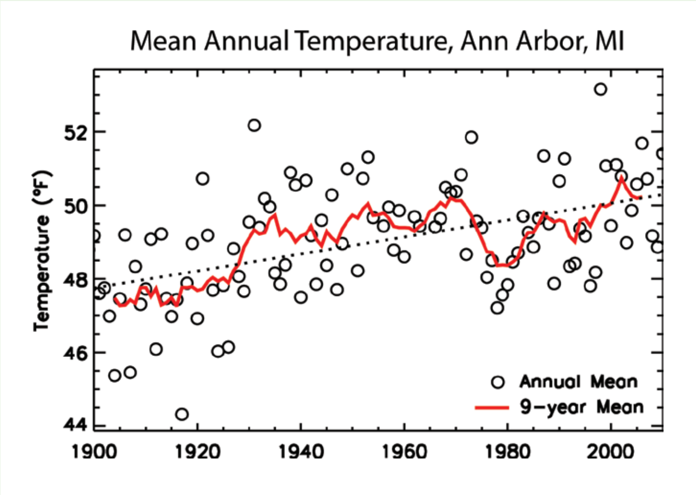
Climate influences daily, seasonal, annual and longer-term weather patterns. History serves as a benchmark for what to expect and what to plan for. In a changing climate, history no longer reliably indicates what is possible or likely. Changes in temperature, precipitation and everything these factors influence are creating a new normal for communities, with implications for planning, development and emergency preparedness.

The Huron River and its watershed, is already experiencing the effects of climate change in the form of more intense and frequent storms, rising temperature and changing precipitation patterns. Winters have shortened, and snow and ice cover have declined. These trends are predicted to continue. These physical changes, among others, will exacerbate existing environmental concerns in Southeast Michigan. Of particular interest in the Huron River watershed are the changing form, frequency and intensity of precipitation events that could drive changes in the distribution and quality of water resources.

The following summary is based on data analyzed by GLISA. The source of the data is the National Climatic Data Center (NCDC) GHCN Daily dataset. GLISA provided the most localized assessment of current and future climate trends that can be made given the availability and quality of source data, reliability and resolution of model projections and appropriateness of scale for a particular climatic variable. Given these limitations, they present results at three geographic scales. Results may be presented for Ann Arbor (as a representative location in the Huron River watershed with good data availability), for the local climatic zone (10 county region in Southeast Michigan), or for the entire Great Lakes region.

Temperature

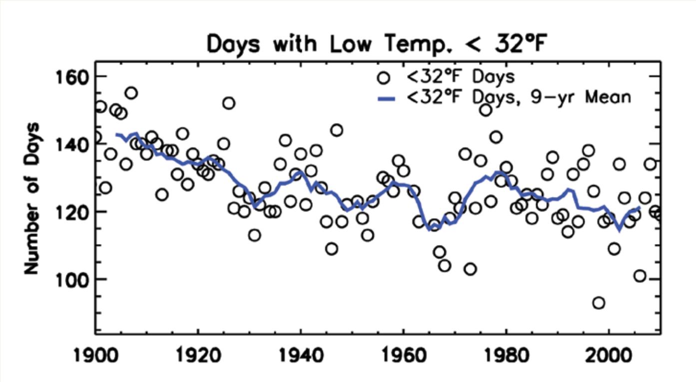
Increased air temperatures have already been observed in the region. Between 1968 and 2002 the average annual air temperature in the lower Great Lakes basin increased by 2.3°F (1.3°C) (Dobiesz and Lester, 2009). Ann Arbor has seen only a modest increase in annual temperature since the 1951-1980 period. The greatest warming has occurred in winter, where the average temperature for 1981-2010 was 1.0°F higher than the average for 1951-1980.



Mean annual temperatures from 1900 to 2010 for Ann Arbor, MI. The solid line represents the 9-year running mean. The dotted line is the linear trend over the period of record.

Throughout the Great Lakes region, winters have typically become shorter as well. Compared to start of the 20th century, the frost-free seasons today are about one week longer, primarily due to earlier dates for the last spring freeze. In Ann Arbor, there are about 3 fewer days per year seeing freezing temperatures when compared to the 1951-1980 average. This trend is consistent with other stations throughout the region. By 2100, the frost-free season is projected to be 4-8 weeks longer (Wuebbles and Hayhoe, 2004).

2 [Reference to climatic zone designations]



Open circles represent the number of days per year in which the daily low temperature dropped below 32°F. The solid line is the 9-year running mean.

Temperatures will continue to increase over most of the Great Lakes region, but projections vary widely on how much. Recent projections suggest that average annual air temperatures in the region will increase by 1.8°F to 5.4°F (1 to 3°C) by 2050 (Hayhoe et al., 2010; Lofgren et al., 2002). Estimates for 2100 range between increases of 3.6 and 11°F (2 and 6.2°C) (Hayhoe et al., 2010; Scheller and Mladenoff, 2005; Wuebbles and Hayhoe, 2004).

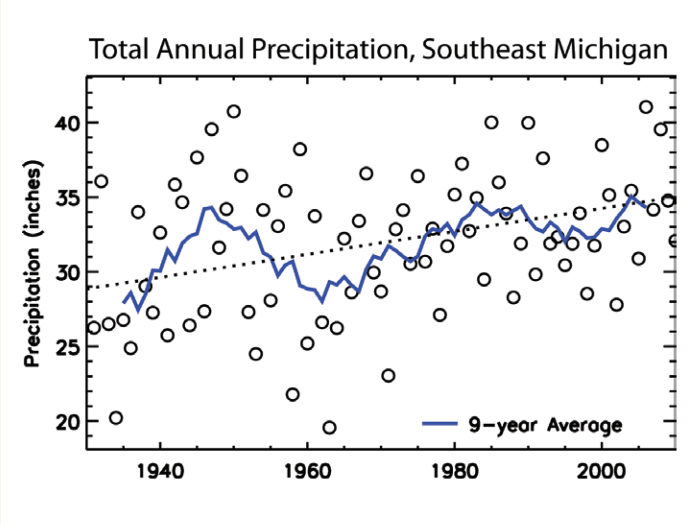
Increases in temperature will not be evenly distributed, however. Nighttime temperatures may warm more than daytime temperatures, and winters will probably warm more than summers during the early 21st century. Later in the century, summer and spring temperatures may rise more than temperatures in the winter and fall.

As average temperatures rise, so will daily maximum temperatures, increasing the probability of more frequent summer heat waves. The number of days that exceed 90°F (32°C) could increase from 15 per year (in 2010) to between 36 and 72 days per year, and events as intense as the 1995 Chicago heat wave are projected to occur as frequently as once every two years to three times in a single year (Vavrus and Van Dorn, 2010; Hayhoe et al., 2010).

Precipitation

The frequency, form, and intensity of precipitation falling in the Great Lakes region will continue to change, but model projections vary on exactly how precipitation will change and on what areas will experience the largest changes. Most researchers expect the amount of precipitation in the Midwest to increase overall. Others expect that the amount of total annual precipitation will remain relatively stable as the seasonal distribution of the precipitation changes. Most models project an increase in winter precipitation of up to 20-30 percent, with potential increases in the autumn and spring as well (Hayhoe et al., 2010).

So far, total annual precipitation has increased in Ann Arbor and southeastern Michigan, mostly due to increases in winter and fall totals. From the 1951-1980 period to the 1981-2010 period, annual precipitation increased by 11% in southeastern Michigan. Ann Arbor saw a more dramatic increase of 25% over the same time period, but local factors may have played a role.



Annual precipitation totals for southeastern Michigan (Climatic Division 10) for 1931 to 2010. An open circle represents the total precipitation for a single year. The solid line represents the 9-year running mean. The dotted line is the linear trend over the period of record.

Snow cover in the Great Lakes region has already experienced one of the most dramatic declines in North America. Since the mid-1970s, the number of days that had snow on the ground decreased at a rate of five days per decade, and the average snow depth across the region dropped by 2 inches (Stewart et al., 2007). As spring temperatures warm, the snowfall season will become shorter and lake-effect rainstorms may replace some lake-effect snowstorms.

The frequency and intensity of extreme storm events has been increasing in this region, and this trend will likely continue as the effects of climate change become more pronounced. Over the Midwest as a whole, the number of 24 hour, once-in-5-year storms was found to have increased by about 4% per decade since the beginning of the 20th century (Changnon, 2009a; Changnon, 2011; Changnon and Westcott, 2002; Hejazi, 2009; Wilson and Sousounis, 2000; Vavrus and Van Dorn, 2010).

The Great Lakes region could experience more frequent droughts despite increases in total annual precipitation. As more precipitation is delivered disproportionately in more intense events, the probability for dry periods may also increase. The region may also become drier overall due to increasing temperatures, increased evaporation, and reduced soil moisture (Frelich et al., 2009; Hayhoe, 2007; Hayhoe and Weubbles, 2008; Karl et al., 2009; Wuebbles, 2006). Droughts and dry periods would be felt most strongly in summer, when groundwater recharge is reduced and there are more low-flow periods (Hayhoe, 2007; Karl et al., 2009).

Great Lakes

The Great Lakes dominate the climate of the region. Changes to the Great Lakes have implications for the weather we experience locally. We have already seen increases in lake temperatures and a decrease in ice cover. Lake levels have also continued to decline in recent years, but it is unclear whether the observed lake level drops are solely the result of climate change. Taken together, these changes have the potential to impact regional climate patterns and the water cycle responsible for maintaining the natural systems of the area.

Climate Impacts to Natural Infrastructure

Over the next century, climate change will exacerbate existing stressors on wildlife and natural resources. A majority of the species in the region will be increasingly challenged, and it is very likely that the rate of species declines and extinctions will accelerate. In the Great Lakes region, the flat terrain and the lakes themselves create natural obstacles that inhibit species' ability to migrate rapidly and adapt to shifting climate zones. The direct effects of warming temperatures will be critical for aquatic species that require cooler stream habitats.

Rivers, Lakes and Wetlands

The shift in frequency and severity of precipitation events has implications for water bodies. Extended dry periods reduce soil moisture and available surface waters affecting wetland area, river baseflows and lake levels resulting in poorer water quality and less habitat for wildlife. These effects would be felt most strongly during the summer, when groundwater recharge is expected to decrease most severely and droughts are most probable. The trend toward more frequent severe storms will result in changes in runoff patterns, erosion and pollution. Urban development typically speeds up stormwater runoff, often creating flashy flows with higher peaks resulting in increased flooding and degraded habitat. These effects will be exacerbated by more frequent severe storms.

Seasonal shifts in precipitation have implications as well. As warming temperatures shorten winters, reduce snow cover and replace snowfall with rain, the seasonal distribution of water availability will also most likely change. Between 1920 and 1995, input into Lakes Michigan and Huron has come earlier in the winter, resulting in less runoff and lake-level rise in the spring. Warmer temperatures are expected to replace some winter snow with winter rain and lead to earlier peak flows, increasing runoff in fall and winter while decreasing runoff in the spring. As sudden severe storms become more intense and deliver a larger portion of total annual precipitation, summer streamflow is expected to increase in flashiness and variability.

Increases in lake surface temperature could result in longer summer stratification of the water in the lakes. In Lake Michigan, the average stratification season between 1961 and 1990 lasted 135 days, but is projected to last approximately 225 days by 2090. The longer stratification season would decrease the amount of winter-spring mixing in both inland lakes and the Great Lakes. Less mixing between cool and warm water results in more low-oxygen, hypoxic conditions and an increase in the number of fish kills. Warmer waters and more stratification in lakes can also mobilize bottom-sediment pollutants and increase algae growth (Hayhoe and Weubbles, 2008; Karl et al., 2009).

Fish and Wildlife

As habitat zones shift northward with temperature, many animal species may also need to migrate north as well. The Great Lakes region is particularly susceptible to temperature-driven shifts in ecosystems. The relatively flat terrain forces species to migrate great distances to stay within a given temperature range, unlike mountainous terrain where some species can migrate relatively short distances vertically. The Great Lakes themselves are also a major physical barrier for migration to many species, and will be a critical obstacle for those unable to adapt.

Wildlife that rely on wetlands may face the greatest stress, as increased evaporation rates may reduce total wetland coverage, reduce connectivity with adjacent wetlands, and inhibit species from seeking more suitable habitat. When these factors are combined with increasing surface water temperatures, fish communities throughout the Great Lakes region are likely to become less diverse. Increasing water temperatures will likely lead to a decline in coldwater fish populations as warmwater fish populations become more abundant. Species such as trout and salmon may be replaced by increasing numbers of species like carp and bass.

Forests and Vegetation

The impacts of climate change on forests will vary widely based on the species involved and other factors. With increasing CO2, forest productivity will likely increase initially. However, other stressors such as drought, forest fire, pests, and invasive species are expected to increase with climate change. These factors, along with land conversion will override any productivity gains in forests. As temperatures rise, the distribution of many tree species will continue to shift northward. As with wildlife, species that are unable to keep pace with migrating temperature and precipitation conditions may struggle to persist. In practical terms for the Huron River watershed, this translates to a transition from conditions favoring existing maple, beech, and birch to those favoring oak and hickory by 2100. Some species, such as red pine, may be completely lost from the Great Lakes region by the end of the century.

Trees of the Huron River Watershed in a Changing Climate

To help guide natural resource management in the region, the Natural Infrastructure Workgroup has developed a series of tree species change summaries that are available here and as stand-alone fact sheets. As climate zones shift across the Great Lakes region, some populations of native tree species will be stressed, and habitats may become more suitable for species from outside the region.

There is a lot of complexity involved in trying to predict how species distributions will change and what the implications are for natural communities as we know them today. Several groups of experts have assessed the impacts of various climate scenarios on the plant species of North America including the US Forest Service and Natural Resources Canada. The workgroup summarized this research for thirteen tree species significant in the Huron River watershed. The predictions for these species can give natural resource managers insights as to how communities may be impacted by predicted range shifts in the characteristic tree species of these communities.

The contents of this report were developed for natural resource managers, natural areas managers, land conservancies and other individuals or groups who are working to protect, conserve or restore natural areas. The products may also be useful to urban foresters, city planners, landscapers and landscape architects who are interested in making climate informed choices in tree planting efforts.

Presented here are the results of the workgroup's research on tree species characteristic of the natural communities of the Huron River watershed. Fact sheets contain a description of the species, its natural history, current geographic range and predicted future suitable habitat, and implications of climate change for the species. Additionally, associated natural community types are identified and the vulnerability of those communities is summarized from a recent vulnerability assessment conducted by Michigan Natural Features Inventory (2012).

General Trends

Models predicting the potential distribution of tree species generally agree that species habitat is moving north and east in response to climate change. Suitable habitat is shifting 700-800 km north by the end of the century under high emission scenarios (Barnes 2009, Iverson et al 2008). In southern Michigan, climate is shifting such that new conditions will be less favorable for maple and beech and more favorable for oak and hickory.

A recent assessment conducted by Michigan Natural Features Inventory (2012) provided some of the first predictions of how Michigan's natural communities will fare. Under warmer, drier conditions, wetland communities are moderately to highly vulnerable as well as upland communities with a strong conifer component. Upland communities may expand as areas of suitable habitat increase, but this will come at the expense of mesic or wet communities that decline as their current locations become less suitable. Species that make up natural communities often respond to climate change differently and over varying time scales, relative to other species in their community. Given the predicted changes, we can expect that some familiar natural communities will be altered or broken up, as their component species disperse and thrive or decline in the new environmental conditions (Lee et al 2012, Barnes 2009).

Finally, secondary impacts of climate change threaten species success and natural community composition. Climate change is expected to increase disturbance such as flooding, drought and fire. New pests, pathogens and invasive species are likely to appear in the region as climatic conditions become favorable.

Data sources and limitations

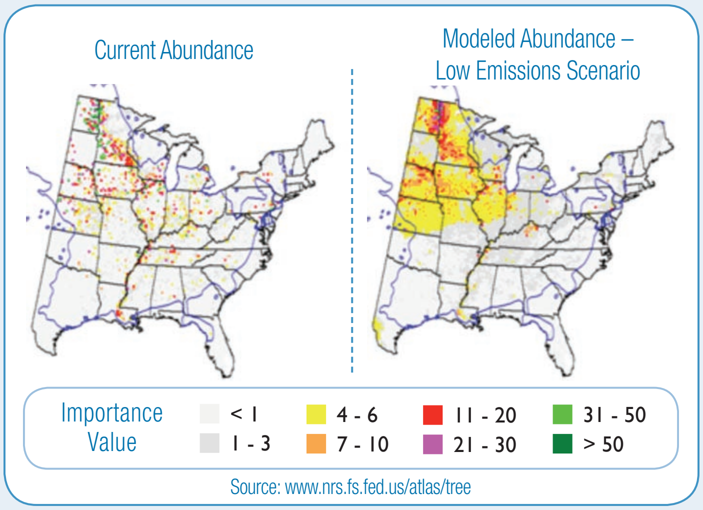
Information for tree species change summaries was derived from several sources. Maps of current and future habitat suitability and species importance were produced by the US Forest Service (Prasad et al., 2007-ongoing). For methods , limitations and model reliability information visit http://www.nrs.fs.fed.us/atlas/tree/. Natural communities vulnerability was assessed by Michigan Natural Features Inventory (Lee et al., 2012). Impacts from climate change were assessed for 11 variables important to natural communities. Vulnerability and confidence values for each of these variables were determined. The analysis did not take into account other human threats to ecosystems such as land use change. It is important to note that observable changes will often lag considerably behind changes in climatic conditions.

Favorability of future climate to tree species of the Huron	
Boxelder	+
Red Maple	0
Sugar Maple	–
Paper Birch	–
Hickory spp.	+
American Beech	–
Tamarack	–
Black Spruce	–
Eastern White Pine	–
White Oak	+
Bur Oak	+
Black Oak	+
American Basswood	0

Boxelder *Acer negundo*

Description: Boxelder is a very common aggressive native maple species that is often encouraged by disturbances such as flooding and silting and can outcompete many native species. It is a shade-intolerant, short-lived species. It does have ecological value in terms of the number of insect species it hosts, however it has become a weedy native and threatens fire-dependent natural communities through invasion and shading.

Change Maps:



Implications of Climate Change: According to the model predictions this species may see significant increases in abundance, particularly in its northern and western range in the Midwest. Due to its tolerance of a wide range of conditions and ability to colonize disturbed areas, boxelder may be a species that will not only survive climate change, but may benefit. It may require management to support maintenance of other, more vulnerable native species.

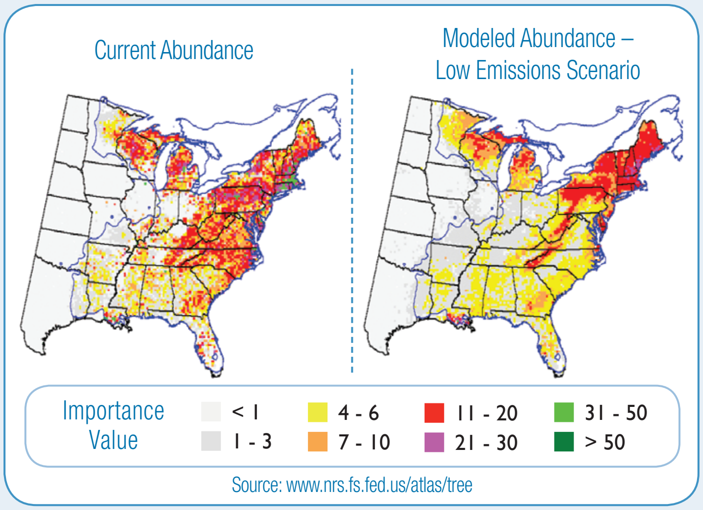
Natural Community Associations: Canopy associate in floodplain forests (Kost et al., 2007).

Vulnerability of Natural Communities: Floodplain forests are restricted to river channels and therefore have limited migration potential. Forests may experience more frequent or larger flood events but it is not known whether this will positively or negatively impact this community. If dryer, warmer summers result in lower groundwater tables and baseflows, this moisture-dependant community could be negatively impacted (Lee et al., 2012). Because boxelder is tolerant of disturbance and relatively less affected by increased flooding, drought, fire and pests, it may become a more dominate species in floodplain forests.

Red Maple *Acer rubrum*

Description: Red maple is one of the most widely distributed tree species in the eastern US and is found in many types of forests and savannahs in Michigan. It occurs on a broad range of sites. While historically it was primarily a wetland tree species, it has become an aggressive colonizer of upland sites, largely due to fire suppression by humans. It has markedly increased in its range and abundance since the time of European settlement. It is moderately shade tolerant, sensitive to fire and moderately long-lived.

Change Maps:

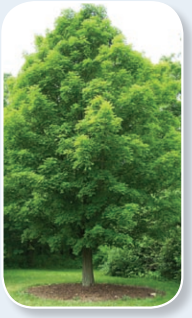


Implications of Climate Change: Red maple is expected to realize a slight reduction in abundance and a subtle shift north. Red maple may prove one of the more resilient tree species to climate change. It is likely to persist in wetlands as they dry (Barnes, 2009) and expand into upland ecosystems where fire is absent. Red maple may be a good candidate as a planting alternative to sugar maple or silver maple.

Natural Community Associations: Canopy dominant in southern hardwood swamps, floodplain forests and wet-mesic flatwoods. Canopy associate in rich tamarack, conifer and hardwood-conifer swamps, and dry-mesic southern forest (Kost et al., 2007).

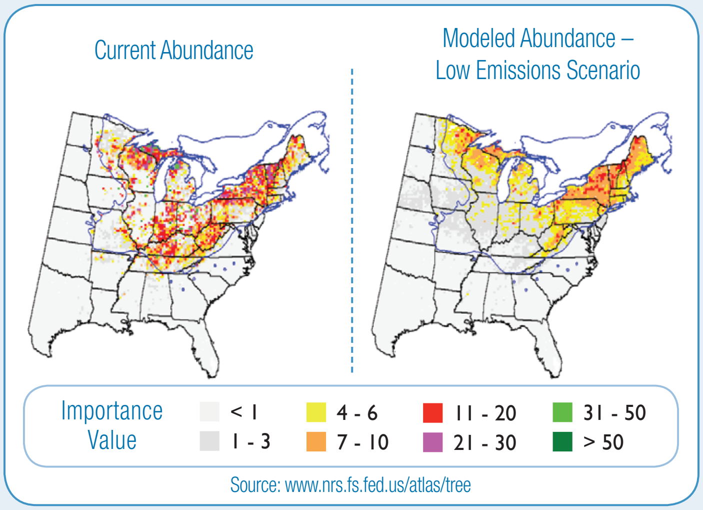
Vulnerability of Natural Communities: Red maple occurs in several communities with wet soils. Significant shifts in these communities are expected under climate change (Lee et al., 2012). However, red maple thrives in drier environments which will allow it to persist as wetland communities dry. Dry-mesic southern forests may thrive and expand as the climate changes (Lee et al., 2012) and red maple's tolerance will help it persist in this community.

Sugar Maple *Acer saccharum*



Description: Sugar maple is found throughout the central Midwest states with its highest abundance in the north. It is a highly shade tolerant, long-lived, slow growing species that is found more in cool climates on rich, moist, well-drained sites. This species does best on highly fertile soils and can form almost pure stands. It is a dominant species of the mesic southern forest, along with American beech, and therefore very important ecologically. It is also very economically valuable for timber and maple syrup production in the upper Midwest, New England and Canada.

Change Maps:



Implications of Climate Change: Climate models show a dramatic and nearly complete loss of this species throughout the south-central Midwest including Michigan except at its northernmost latitudes. Under most scenarios, sugar maple will be far less abundant in the Huron River watershed. Given that both sugar maple and American beech are likely to decline in the area, the composition of mesic southern forest should be considered at risk. For planting and restoration, red maple may be an alternative.

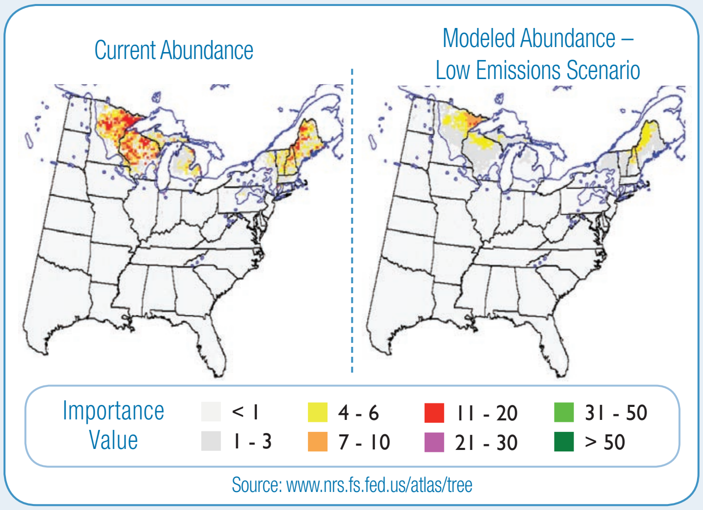
Natural Community Associations: Canopy dominant in mesic southern forest. Canopy associate in floodplain forests (above influence of floodwaters), southern hardwood swamp, and wet mesic flatwoods (Kost et al., 2007).

Vulnerability of Natural Communities: Mesic southern forests are likely to expand in range northward. However, the sensitivity of sugar maple indicates that this species will not do well in lower Michigan and may only be a significant part of this community in its northernmost latitudes. Under drier, warmer conditions southern hardwood swamps and wet mesic flatwoods will be negatively impacted as local hydrology is altered (Lee et al., 2012).

Paper Birch *Betula papyrifera*

Description: Paper birch is a pioneer species that is fast-growing and short-lived. The species can occur on a wide variety of soil types. They are shade intolerant and are therefore found in areas recently disturbed by fires or logging. Paper birch is at is southernmost limit in southern Michigan. As such it only occurs in two natural communities of the Huron River watershed. It prefers cold climates where average July temperatures are below 70° F (Burns and Honkala, 1990).

Change Maps:



Implications of Climate Change: As can be expected in a species that has a range limited by high temperatures, nearly all climate change models predict that paper birch will become extinct in the United States, with its general range adjusting several hundred miles northward in Canada. Paper birch is a common planted tree in the Huron River watershed. As temperatures increase, birch will be increasing less suitable for landscaping.

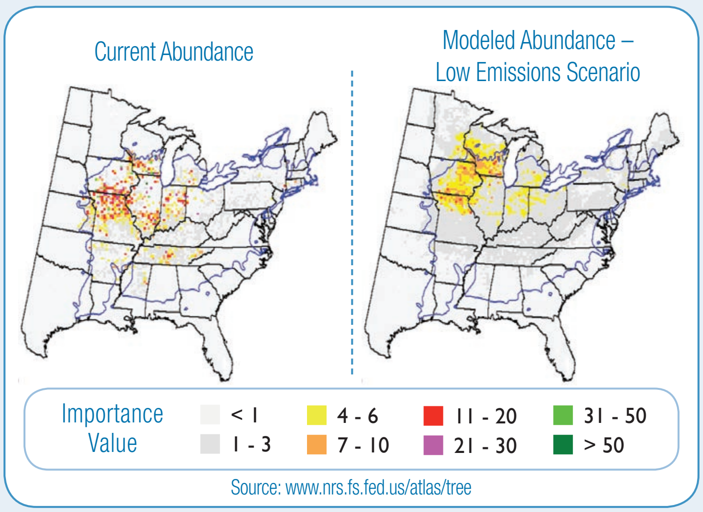
Natural Communities Associations: Canopy associate in poor conifer swamp, rich conifer swamp (Kost et al., 2007).

Vulnerability of Natural Communities: Forested wetlands with a dominant conifer component such as poor and rich conifer swamps, are expected to realize significant range contractions as climate changes in Michigan (Lee et al., 2012). Already at the southern extent of these communities, the climate in the Huron River watershed will likely be unfavorable for supporting these communities including the paper birch.

Hickory *Carya spp.*

Description: There are four hickory species native to Michigan. Hickories are large, long-lived trees with high quality wood. Shagbark Hickory (Carya ovata) and Pignut Hickory (Carya glabra) are the most commonly represented species in the Huron River watershed. Hickories can thrive in a variety of habitats. They tend to prefer well drained, upland sites. Despite their preference for good drainage, hickories grow best in a humid climate, adapting successfully to a wide range of temperature extremes and rainfall amounts.

Change Maps:



Implications of Climate Change: Climate change models predict little change in the native range of hickories, perhaps because they already exhibit wide adaptability to warmer, southern climates. They may prove to be some of the few Michigan native tree species that can cope with warming trends with little impact on survival. Increased precipitation in spring may support hickories in flood prone areas (Barnes, 2009).

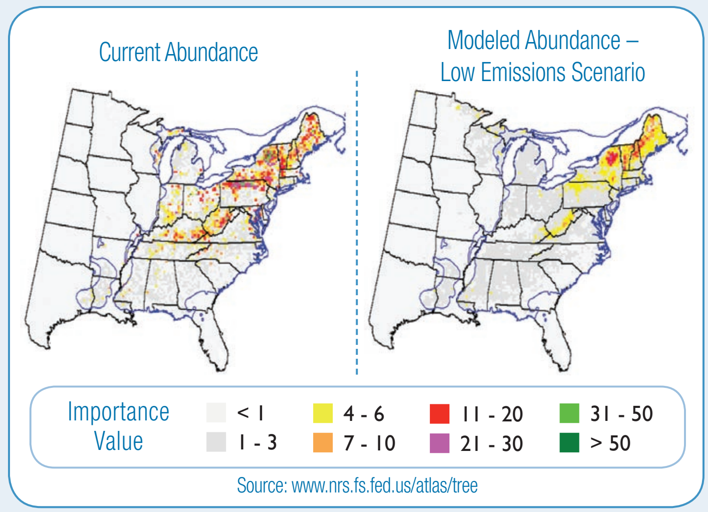
Natural Communities Associations: Canopy dominant in Dry-mesic Southern Forest and Dry Southern Forest, Wet Mesic Flatwoods. Canopy associate in Floodplain forest, Mesic Southern Forest and Lakeplain Oak Openings, Oak Openings (Kost et al., 2007).

Vulnerability of Natural Communities: Dry to mesic southern forest systems are expected to have low vulnerability to climate change. Longer growing season and warmer temperatures may increase productivity. Because these systems are widespread, dispersal is more likely except in areas of significant fragmentation. Communities supporting hickory that have high moisture requirements and/or occur as isolated occurrences such as Wet Mesic Flatwoods and Lakeplain Oak Openings have high vulnerability. Oak openings may benefit from climate change (Lee et al., 2012).

American Beech *Fagus grandifolia*

Description: American beech occurs in the eastern United States and is a slow-growing, long-lived species. Common in mesic habitats of Michigan, the beech is shade tolerant and prefers humid summers. Climatically, rainfall averages 30-50" per year throughout the native range of beech, with some locations in Michigan supporting beech with only 23 inches of annual rainfall (Burns and Honkala, 1990). Beech is a mesophytic species requiring more water for growth and transpiration than most species. It is drought-intolerant.

Change Maps:



Implications of Climate Change: Under most climate scenarios, American beech will disappear from much of its current range. Some populations will remain primarily in higher elevations and higher latitudes. While an increase in annual rainfall expected during a warming climate would be beneficial to beech trees, the increased heat index is considered to be a much more limiting factor. Protecting alluvial soils and large canopy trees will help maintain beech stands.

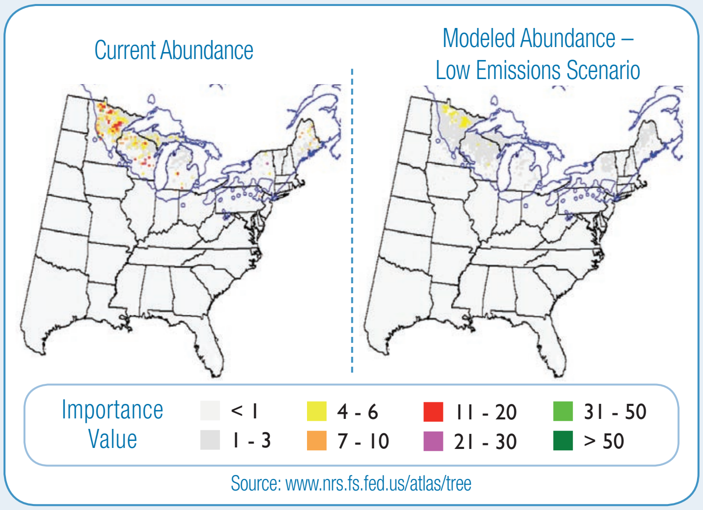
Natural Communities Associations: Canopy dominant species in mesic southern forest. Canopy associate in floodplain forests above influence of floodwaters, southern hardwood swamp and wet mesic flatwoods (Kost et al., 2007).

Vulnerability of Natural Communities: Mesic southern forest is widespread and therefore less vulnerable to predicted changes but still vulnerable to threats such as invasive species and deer herbivory likely to increase under climate change. Because of low dispersal potential and expected alterations to hydrology, floodplain forests, southern hardwood swamps and wet mesic flatwoods are highly vulnerable to climate change (Lee et al., 2012).

Tamarack *Larix laricina*

Description: In the northern Midwest states, tamarack is found in peatlands and various other open wet areas including swamps, bogs, and shores. It is generally low in abundance within its current US range. Tamarack is a very shade-intolerant, fast-growing, and short-lived species. It tolerates both acidic and basic soil conditions (bogs and fens). It is a pioneer of cold, open, wet areas where there is little competition.

Change Maps:



Implications of Climate Change: As a primarily wetland species, tamarack will decline as summers dry and warm (Barnes 2009). Models predict an almost total loss of this species from the U.S. due to climate change. In the Huron River watershed, declines in this species could prove an indicator of developing stresses on its associated ecosystems. Tamarack may survive in this area in very moist soils as a landscape planting.

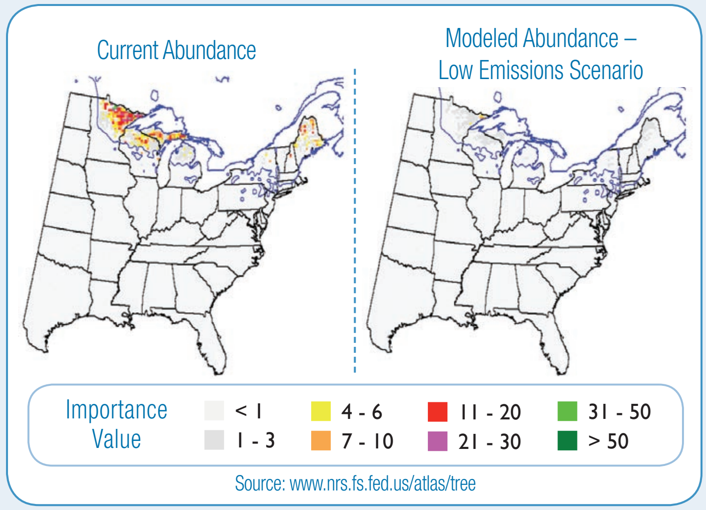
Natural Community Associations: Canopy dominant in rich tamarack swamp and prairie fen. Canopy associate in southern hardwood swamps and bogs (Kost et al., 2007).

Vulnerability of Natural Communities: As wetland communities that typically occur in isolated patches of unique conditions, each of the natural communities in which tamarack occurs, has a high vulnerability to climate change both due to altered hydrology and limited dispersal potential (Lee et al., 2012).

Black Spruce *Picea mariana*

Description: Black spruce is common at northern latitudes and in boreal environments. Southeast Michigan is at the southernmost extent of its range. Here the species is rare and almost exclusively found growing on the sphagnum mats of bogs. The species is somewhat shade tolerant, very slow growing and can form dense stands following fire.

Change Maps:



Implications of Climate Change: Models predict nearly complete loss of this species across its entire range in the US Midwest including in the Huron River watershed. As a wetland species, this species is likely to decline with warmer, drier summers (Barnes, 2009). Indications of decline in this species may provide an important sign of climate change stresses that will impact bogs. Restoring fire where black spruce occurs may help species persist for some time.

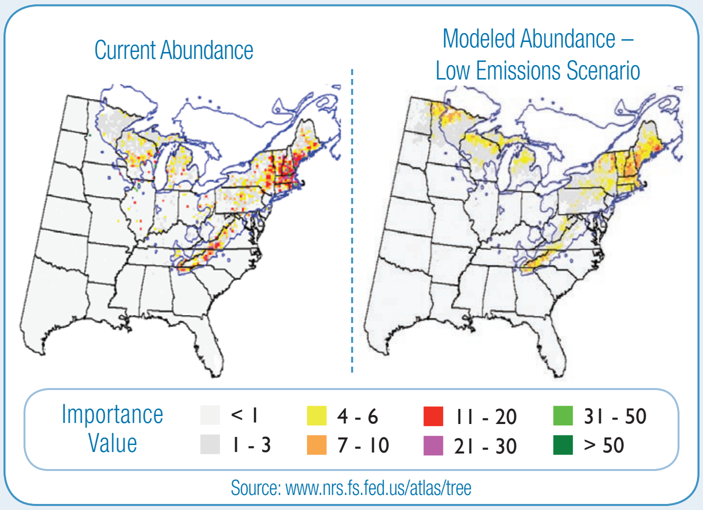
Natural Community Associations: Canopy dominant, and almost exclusively found, in bogs at the southern extent of its range in lower Michigan (Kost et al., 2007).

Vulnerability of Natural Communities: Bogs are likely highly vulnerable natural communities. Decreases in soil moisture and increased evapotranspiration rates will negatively impact this system. While increased storms and fire may help support bogs, drought will harm this community. Due to unique physiographic requirements, dispersal potential is low (Lee et al., 2012).

Eastern White Pine *Pinus strobus*

Description: Eastern white pine is a very large, long lived and fast growing conifer which is frequent from Detroit northward but is also often found planted as an ornamental tree in southern Michigan. It grows well on a variety of soil types from, poorly to well drained, and is moderately shade tolerant. White Pine is fire-resistant and fire-dependent.

Change Maps:



Implications of Climate Change: Models predict that the frequency of eastern white pine will decrease in southern Michigan. Increased competition from hardwoods and the absence of fire, may prevent natural regeneration. The tree is likely to see declines in dry communities as they become drier but may be favored in more mesic communities as they dry (Barnes, 2009). The species may remain a good choice for landscaping because of its ability to grow in many soil and moisture conditions.

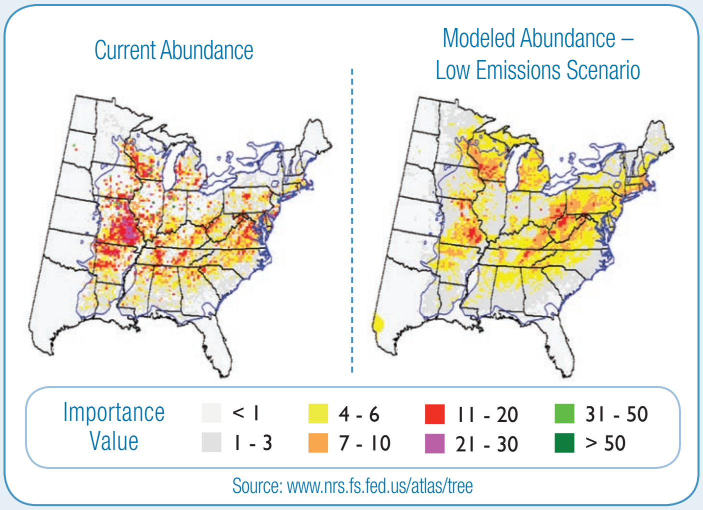
Natural Community Associations: Canopy dominant or associate in oak pine barrens. Canopy associate in some occurrences of southern dry forest and dry mesic southern forest (Kost et al., 2007).

Vulnerability of Natural Communities: Oak pine barrens are already rare systems with isolated occurrences in SE Michigan. Its low dispersal potential and predicted range movement north will likely lead to declines in the Huron River watershed. Dry southern forest communities may be less vulnerable because of their wide extent and ability to tolerate warmer, drier conditions (Lee et al., 2012). While these communities are likely to persist, hardwoods are expected to increase and the conifer component decline.

White Oak *Quercus alba*

Description: White oak is a very large, strong, long-lived tree. It is found throughout the Lower Peninsula of Michigan, however that is the northern limit of its range. White oak is moderately shade tolerant but is poorly adapted to hard winter freezes. White oak is found on a variety of well-drained upland soils ranging from sandy to mesic. Oaks are among the tree species most valuable to wildlife due to the abundance of acorns that they produce which serve as a high-quality food source.

Change Maps:



Implications of Climate Change: Climate change scenarios predict that the range will shift northward due primarily to milder winter conditions. Oaks in the white oak group will likely be favored over red oaks because they germinate in the fall and are therefore less likely to be impacted by summer droughts. White oak may also colonize wet sites as they become increasingly dry (Barnes, 2009).

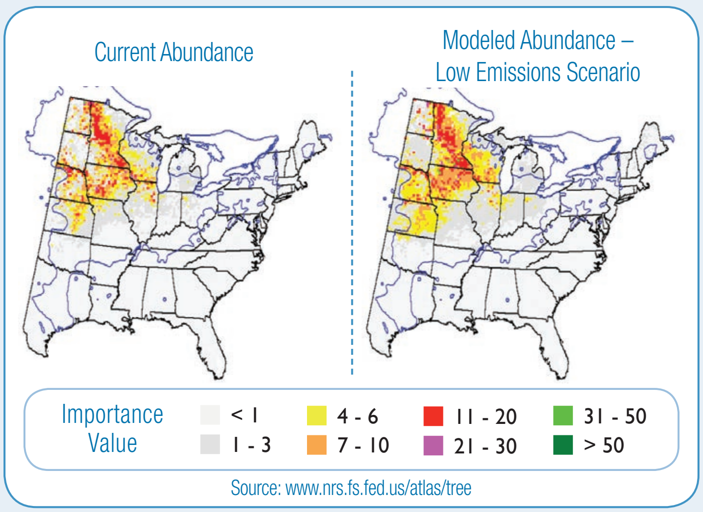
Natural Communities Associations: Canopy dominant in dry southern forest, dry-mesic southern forest, oak barrens, oak openings and oak-pine barrens (Kost et al., 2007).

Vulnerability of Natural Communities: Dry southern forest systems are expected to have low vulnerability to climate change. Longer growing season and warmer temperatures may increase productivity. Because these systems are widespread, there is greater potential for dispersal except in areas of significant fragmentation. The climate envelope for oak barrens and oak-pine barrens will likely shift north, moving these systems out of southeast Michigan. Savannah systems may benefit from increased temperatures and disturbance therefore oak openings have low vulnerability to climate change (Lee et al., 2012).

Bur Oak *Quercus macrocarpa*

Description: Bur Oak is a large, strong, long-lived tree. It is common in southern Michigan. It is moderately shade tolerant and can tolerate a wide variety of sites from upland with poor, sandy soils to mesic and seasonally wet. Bur oak is very drought resistant and fire tolerant. Like other oaks, it is poorly adapted to hard winter freezes. Oaks are among the tree species most valuable to wildlife due to the abundance of acorns that they produce which serve as a high quality food source.

Change Maps:



Implications of Climate Change: Bur oak should continue to do well as climate changes in the area. Models predict that the distribution of bur oak will shift northward, primarily as a result of milder winter conditions. Southern Michigan will become more favorable for this species however its abundance will be limited by increased competition from other species. Restoring savannah systems, reducing invasive species and prescribed burns will help this species persist.

Natural Community Associations: Canopy dominant in bur oak plains, lakeplain oak openings, oak openings and oak pine barrens (Kost et al., 2007).

Vulnerability of Natural Communities: Most of the savannah systems in which bur oak occurs are already very rare and isolated making them very vulnerable to threats such as invasive species or land use change, especially bur oak plains and lakeplain oak openings. However, savannah systems in general may benefit from warmer, drier conditions expected in the Huron River watershed (Lee et al., 2012). Oak openings are the most common natural system in the area supporting bur oak. The climate envelope for oak pine barrens will likely shift north (Lee et al., 2012), moving this system out of southeast Michigan.

Black Oak *Quercus velutina*

Description: Black oak is a large, strong, moderately long-lived tree. It is frequent in southern Michigan but not commonly found further north except along the Great Lakes. Like other oaks, it is poorly adapted to hard winter freezes. Black oak likes dry, sandy, well drained soils that reduce competition from other species and cannot tolerate high water tables. This species is significant canopy component of many natural communities in the Huron River watershed and a high quality food source.

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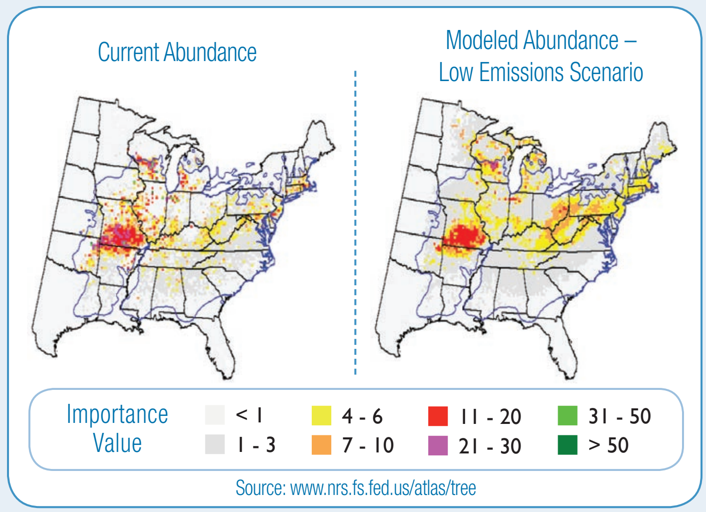


Implications of Climate Change: Black oak should continue to do well as climate changes in the area. Models predict that black oak distribution will shift northward, primarily as a result of milder winter conditions though summer droughts may impact germination and therefore, regeneration (Barnes, 2009). Restoring savannah systems, reducing invasive species and prescribed burns will help this species persist.

Natural Community Associations: Canopy dominant in dry southern forest, dry mesic southern forest, oak and oak-pine barrens and lakeplain oak openings. Canopy associate in bur oak plains, oak openings (Kost et al., 2007).

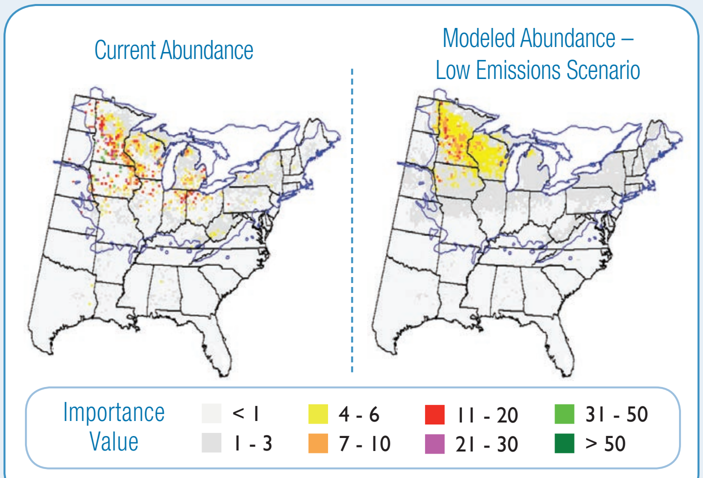
Vulnerability of Natural Communities: Dry southern forest systems are expected to have low vulnerability to climate change. Because these systems are widespread, there is greater potential for dispersal except in areas of significant fragmentation. The climate envelope for oak and oak-pine barrens will likely shift north, moving these systems out of SE Michigan. Savannah and dry prairie systems may benefit from increased temperatures, drought and disturbance therefore oak openings have low vulnerability to climate change. Oak plains and lakeplain oak openings are currently very rare (Lee et al., 2012).

American Basswood

Tilia americana

Description: American basswood, the northernmost Tilia species, is a large, slow-growing tree of eastern and central hardwood forests. Basswood prefers deep, moist soils and is often found in floodplains and bottomlands. Climatic conditions associated with the species range are generally continental-cold winters, warm summers, and a humid moisture regime. Basswood thrives in areas averaging 65° to 80° F in July and receiving 10-15 inches of precipitation during the growing season (Burns and Honkala, 1990).

Change Maps:



Source: www.nrs.fs.fed.us/atlas/tree

Implications of Climate Change: Climate model predictions show a decline in importance for this species in this region. A gradual rise in average temperature will have a more deleterious effect on basswood survival than will changing rainfall levels, as basswood appears to be more adaptable to moisture variances than temperature increases. Basswood may colonize wetlands as summers become more dry (Barnes, 2009).

Natural Communities Associations: Canopy dominant in wet-mesic flatwoods. Canopy associate in mesic and dry-mesic southern forests. Often present in floodplain forest, hardwood conifer swamps and southern hardwood swamps (Kost et al., 2007).

Vulnerability of Natural Communities: Wet to mesic natural communities are more vulnerable to climate change especially for those species that require moist soils such as basswood. Dry to dry-mesic communities are less vulnerable to climate change but may be negatively impacted by increased invasive species and more extreme events (Lee et al., 2012) which will impact species differently.

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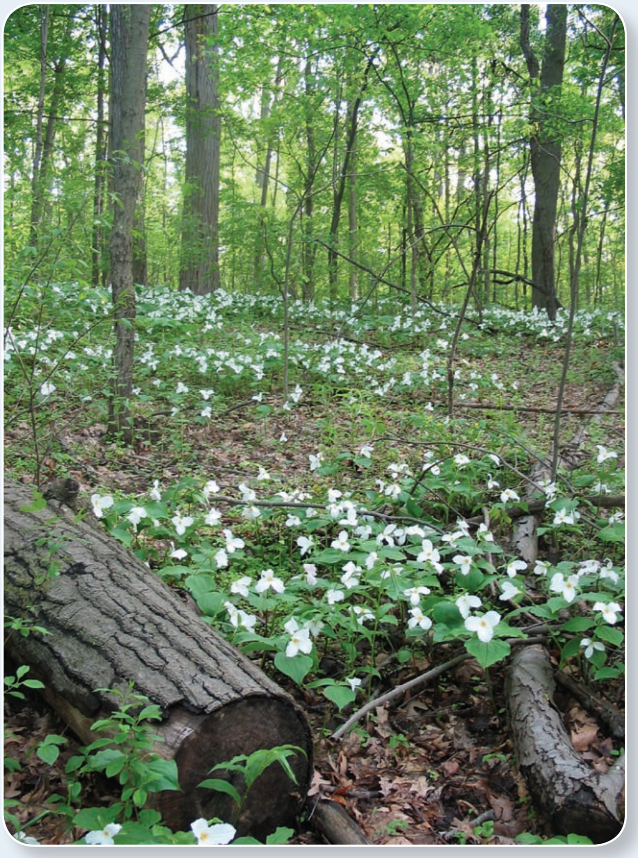
HRWC is a nonprofit coalition of local communities, businesses, and residents established in 1965 to protect the Huron River and its tributary streams, lakes, wetlands, and groundwater. HRWC works to inspire attitudes, behaviors, and economies that protect, rehabilitate, and sustain the Huron River system. Services include hands-on citizen education, technical assistance in policy development, and river protection and monitoring projects. See www.hrwc.org for information.

Notes



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