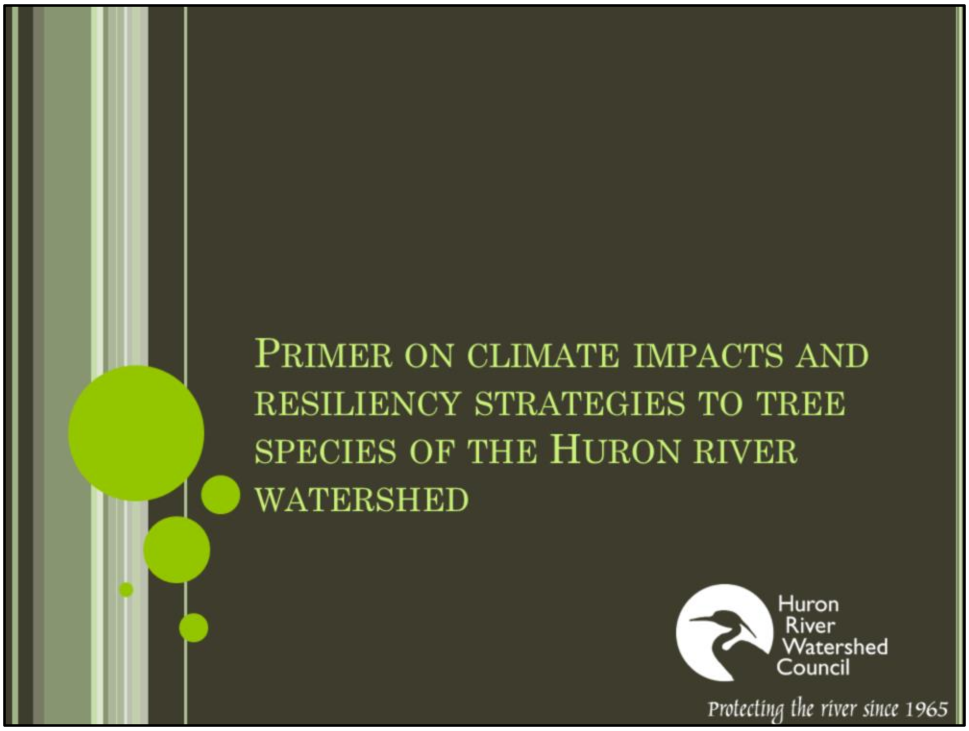
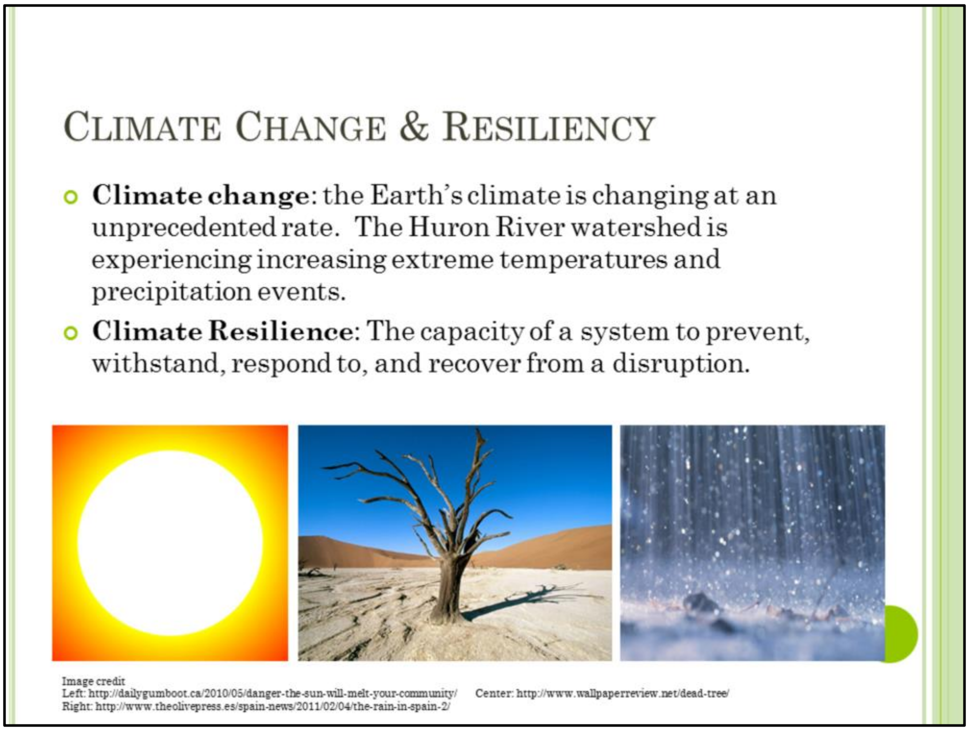


The presentation can be picked up and delivered by you to an appropriate audience. Or, it can be consumed by an individual simply by reading through the presentation on your own time.

What follows is a set of slides with the narrative for each slide captured in the notes section.

(Original publication date: August 2013; Most recent update: December 2015)

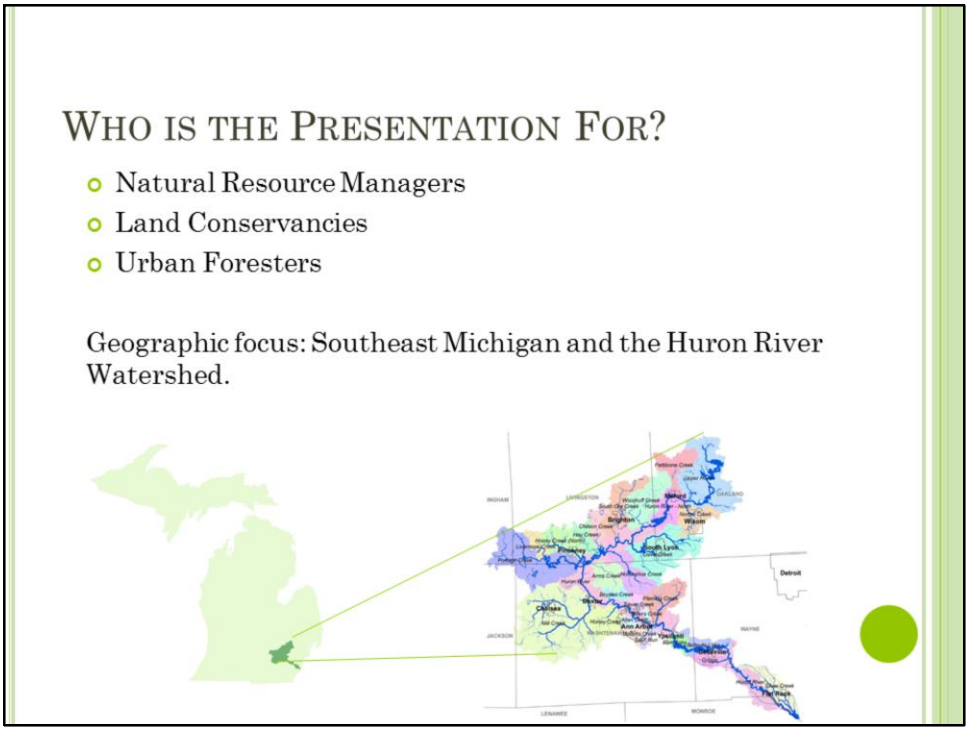


The Earth's climate is and will continue changing as greenhouse gases (GHG) increase in our atmosphere driving global climate change. Even if all GHG emission halted tomorrow, we will be dealing with the consequences of climate change for decades.

In the Huron River watershed and the rest of Southeast Michigan we are experiencing shifts in temperature and precipitation that have repercussions for our natural systems.

What are these repercussions for our forests and trees? And how can we manage our resources in a way that provides them the best chance at adapting to a new climate? In other words, how can we build resilience in our systems?

Climate Resilience, in the context of this presentation refers to the capacity of a forest system (including urban forests) and tree species to prevent, withstand, respond to and recover from disruption from climate change.



As natural resource managers responsible for our forest and tree resources, it is increasingly important to understand the implications of climate change on our natural systems and begin to consider how this may impact management and acquisition practices.

This presentation, and the associated resources, were developed by a team of natural resource managers, urban foresters and land conservationist working in the Huron River watershed. Climate data is focused on the Great Lakes region and southeast Michigan and tree species and system information is most relevant to southeast Michigan as well. Many of the resources and reports that focus on management strategies will be applicable to any geography.

Goals of Presentation

- Understand how temperature and precipitation patterns are changing in southeast Michigan
- Know how these changes are expected to impact forest systems
- Learn emerging strategies for managing systems in a changing climate
- Ready you to disseminate info within this presentation and toolkit to your communities and constituents

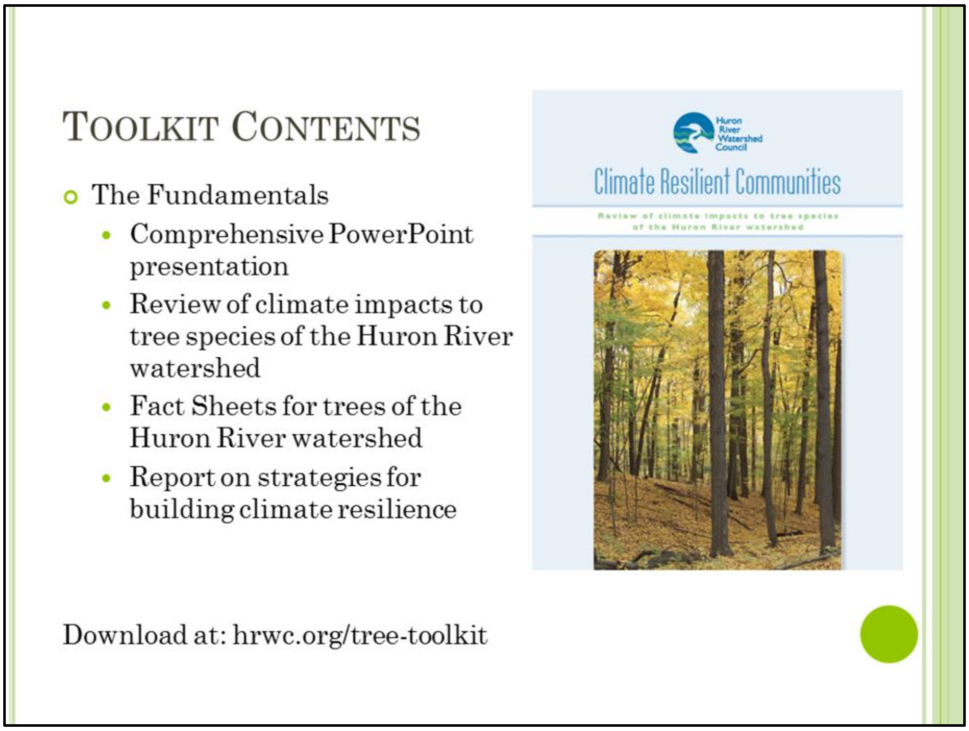
Trees image credit: http://footage.shutterstock.com/clip-1045822-stock-footage-short-clip-of-a-spinning-view-of-tall-trees-in-a-dense-forest-with-sun-beams-breaking-through.html

This presentation is an introduction to a set of resources we have developed and packaged into the Tree Resilience Toolkit.
By the end of the presentation you will

(1) Have an understanding of how temperature and precipitation patterns are changing in southeast Michigan
(2) Know how these changes are expected to impact forest systems and native tree species
(3) Be introduced to some of the emerging strategies for managing forest systems in a changing climate

This toolkit is designed to be shared. Once receiving this presentation and familiarizing yourself with the contents of the toolkit, we encourage you to share it with other natural resource managers and relevant audiences.

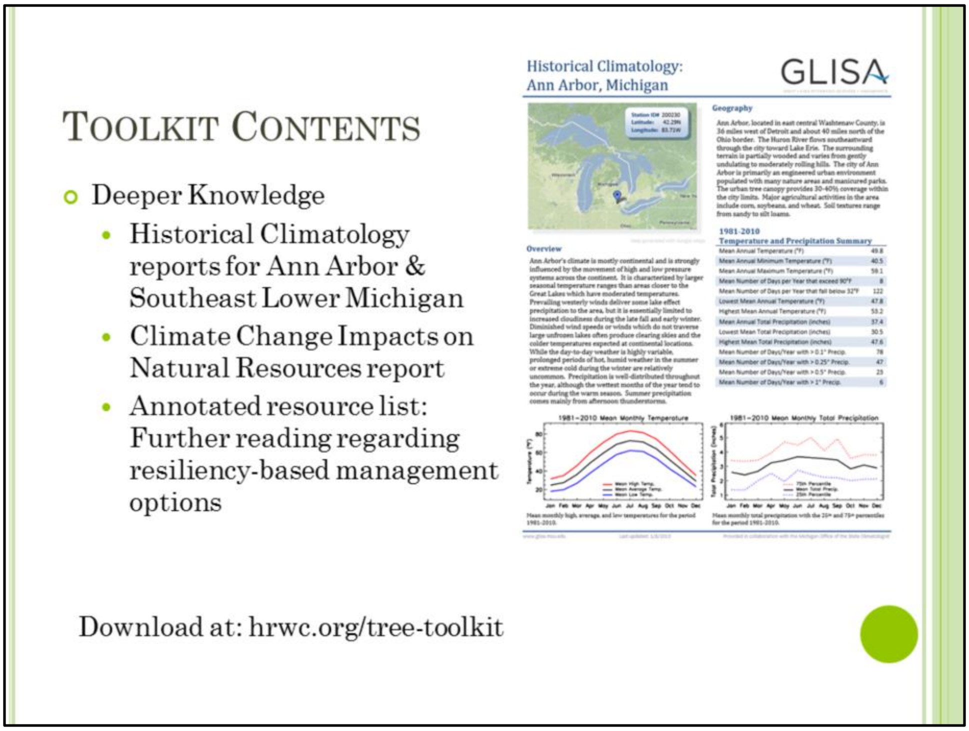
We also hope, through discussions after the presentation, you begin to think about the implications of this information for your work. How will climate change alter the way you approach land management, acquisition and/or urban forestry practices?



The Toolkit contains a number of reports and fact sheets as well as this narrated presentation.
Core materials include:

- Comprehensive PowerPoint presentation with narrative
- The HRWC Report: Review of climate impacts to tree species of the Huron River watershed - This overview report has three sections. It provides an overview of precipitation and temperature data showing trends in the existing record and projections for the future, a discussion of how these changes impact our natural infrastructure (ecosystems and species) and the implications of climate changes on 13 native tree species.
- Fact Sheets for trees of the Huron River watershed – 1 page summaries for 30 native tree species common in our forests and urban canopy sharing species attributes and how the species is expected to fare as the climate of southeast Michigan changes
- Report on strategies for building climate resilience in native and urban forests – summarizing literature on emerging strategies for forest management in the face of climate change

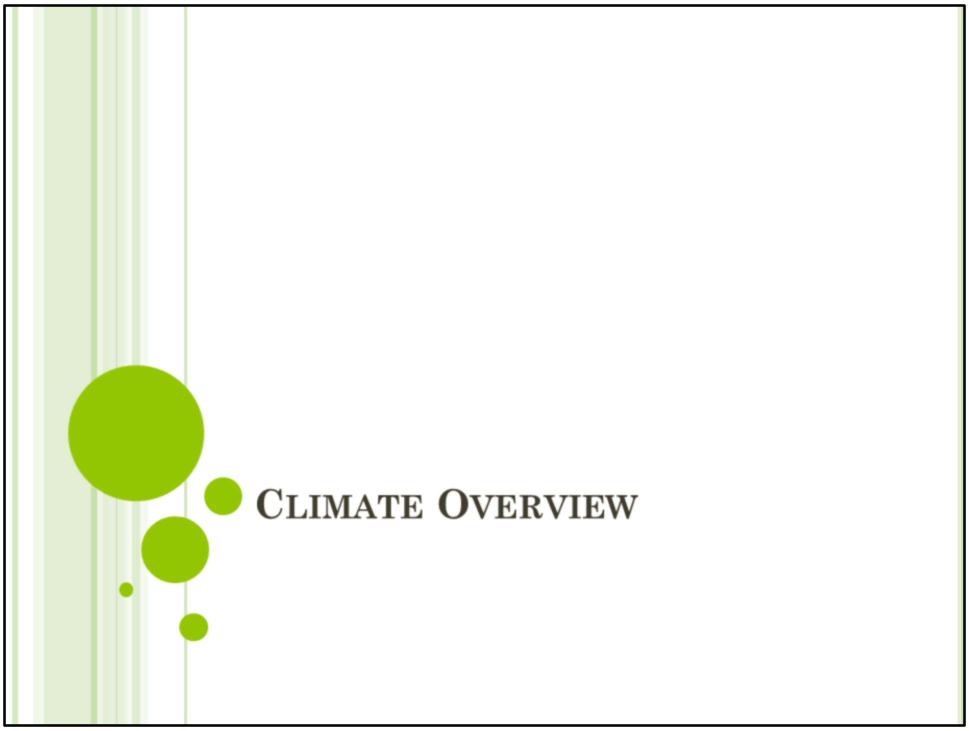
*Hold up each toolkit component as you introduce them on these slides



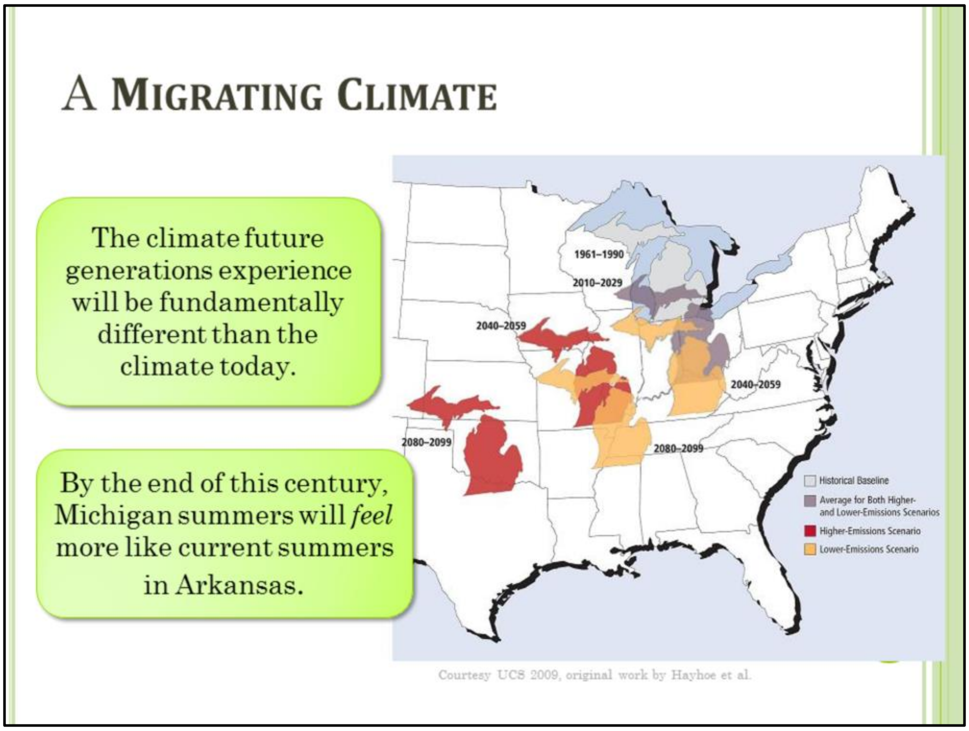
Several additional resources allow you to dive deeper

- Historical Climatology reports for Ann Arbor & Southeast Lower Michigan – showing trends in existing precipitation and temperature records.
- Climate Change Impacts on Natural Resources fact sheet – summarizing how climate change can impact natural resources in more broadly.
- Annotated resource list: Further reading regarding resiliency-based management options

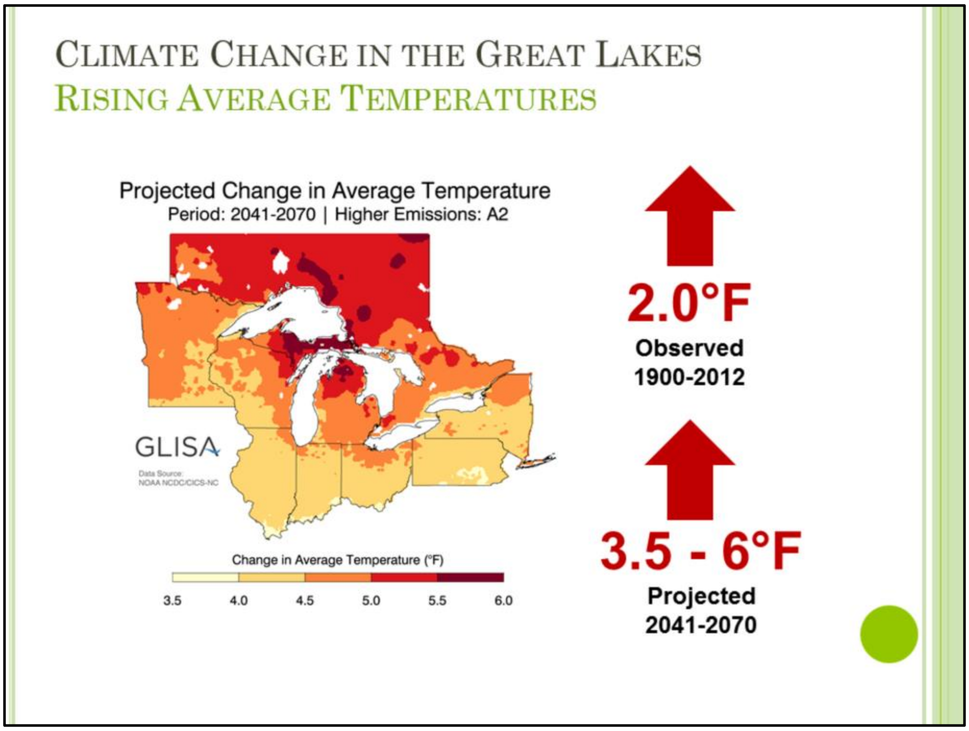
*Hold up each toolkit component as you introduce them on these slides



We will begin with a summary of climate data for our region.

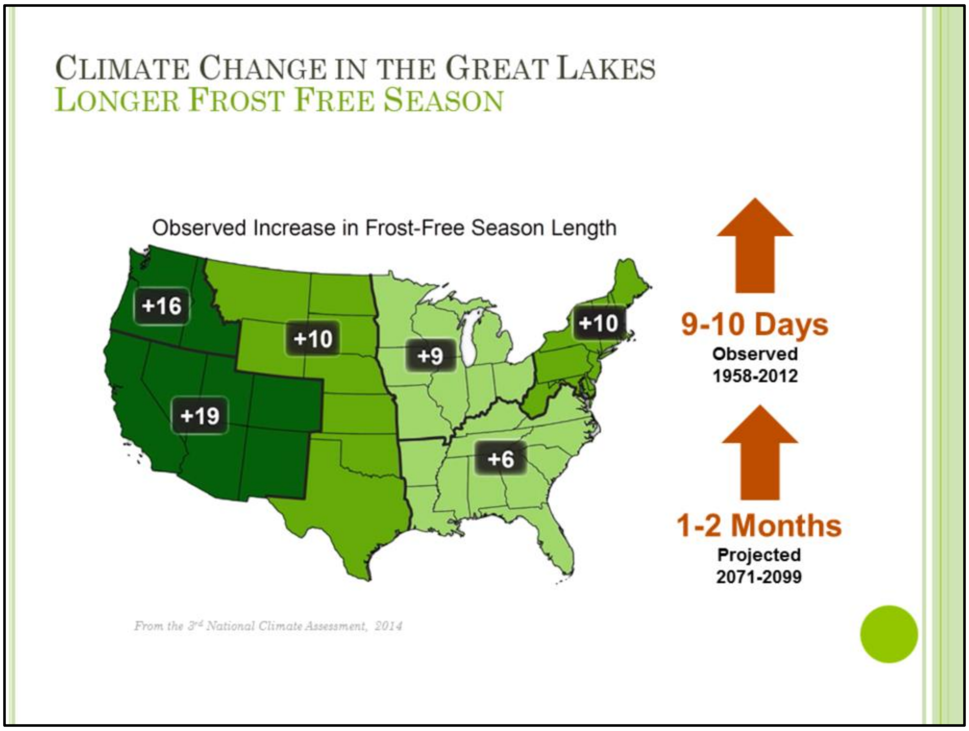


This is a useful graphic to illustrate the consequences of climate change on ecosystems. Oklahoma and Arkansas support different ecosystems made up of different species than we see in our lower Michigan forests.



The next few slides look at observed change and projected change for the Great Lakes region for several climate factors.

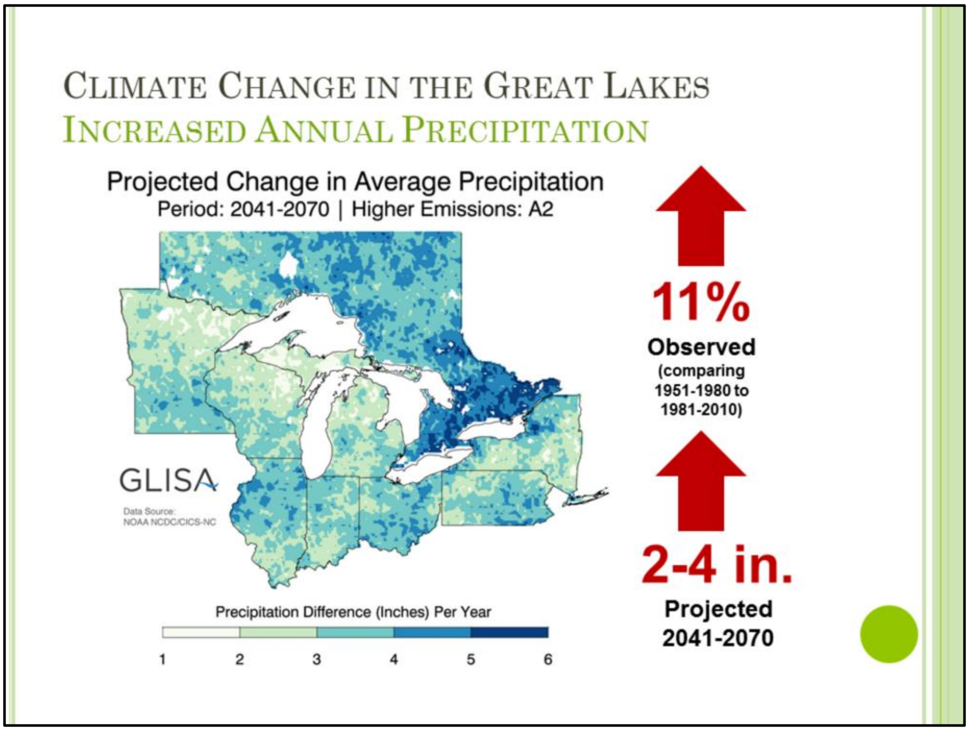
Temperature has increase about 2 degrees F and is projected to increase by 3.5 to 6 degrees F by 2070.



The Growing Season, or the frost-free season, has gotten longer. We're seeing generally shorter winters and longer summers.

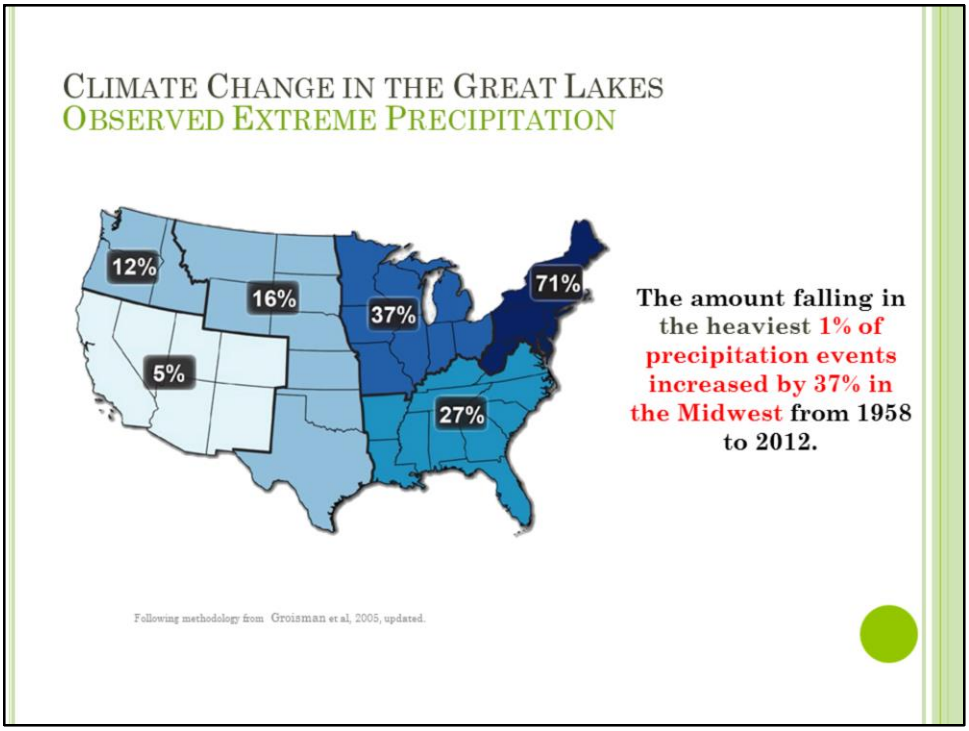
In the Midwest, we've seen the frost-free season lengthen by 9 days. This trend is expected to continue or accelerate. Under a high emissions scenario, it's possible the region could see the frost-free season grow longer by 1-2 months, a potentially dramatic change from the current climate with a cascade of implications for our native ecosystems.

(Based on data from the National Climatic Data Center for the cooperative observer network and updated from Kunkel et al. (2004) and the 3rd National Climate Assessment.)



Projections of precipitation are highly variable by location, individual model, the timeframe considered. Total annual precipitation is generally projected to increase across the region, but may remain nearly stable or decrease in parts of the Upper Peninsula of Michigan, Northern Wisconsin, and Northern Minnesota.

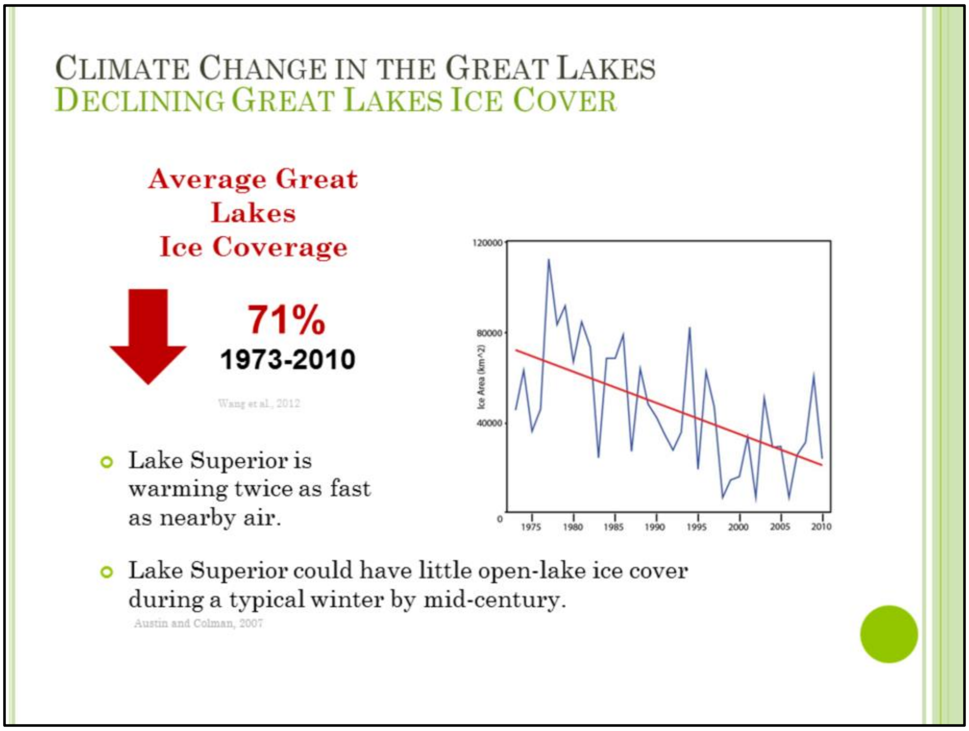
In southeast Michigan we have seen an 11% increase in annual precipitation. Projections predict anywhere from an additional 2-4 inches of rainfall annually in this area.



Changes in average annual precipitation are only a part of the picture.

The strongest storms have become more intense and more frequent. The amount of precipitation falling in the heaviest 1% of precipitation events increased by 37% in the Midwest.

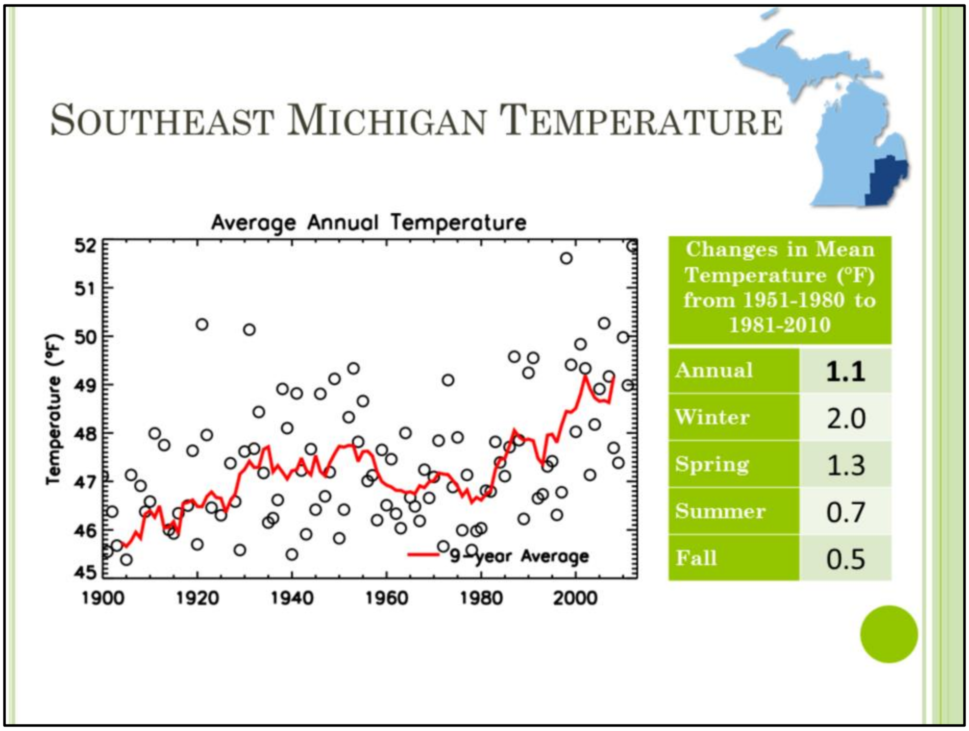
There are clear trends toward more very heavy precipitation for the nation as a whole, and particularly in the regions that span the Great Lakes and Northeast. The magnitude of this change experienced is a distinctly unique issue for our region.



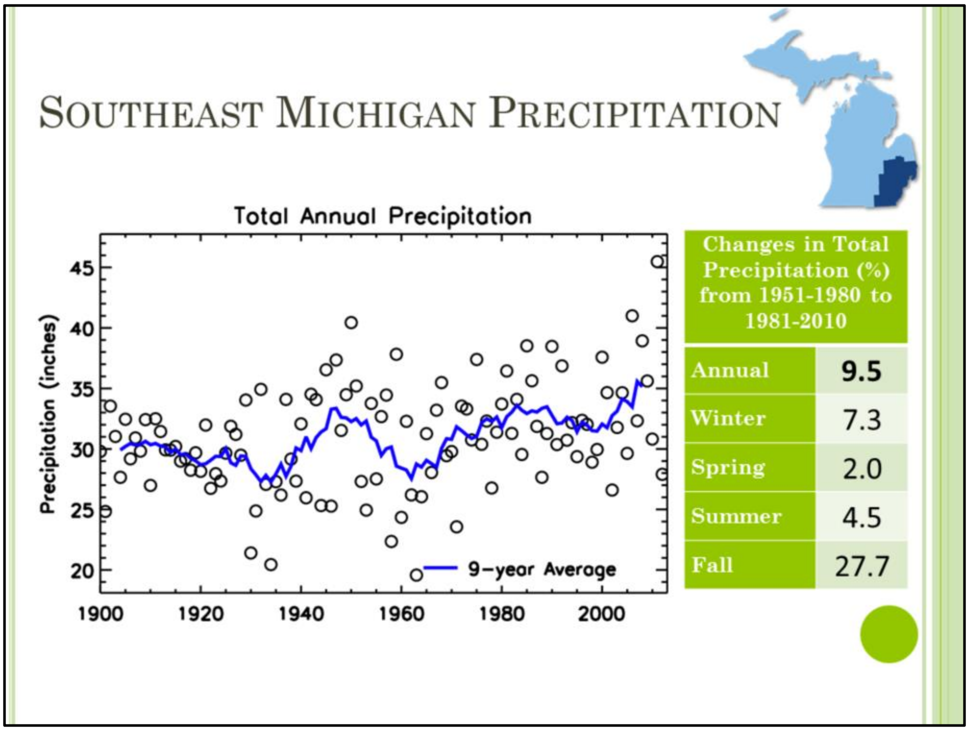
One of the most startling observed trends in the Great Lakes is the decline of lake ice cover.

Average annual ice coverage on the Great Lakes declines by 71% between 1973 and 2010 (though we expect that trend will be reduced slightly because of several recent severe winters).

This is significant because the Great Lakes are a major driving force behind Michigan's weather patterns. Changes to the lakes mean changes to our local climate unique to the Great Lakes region.

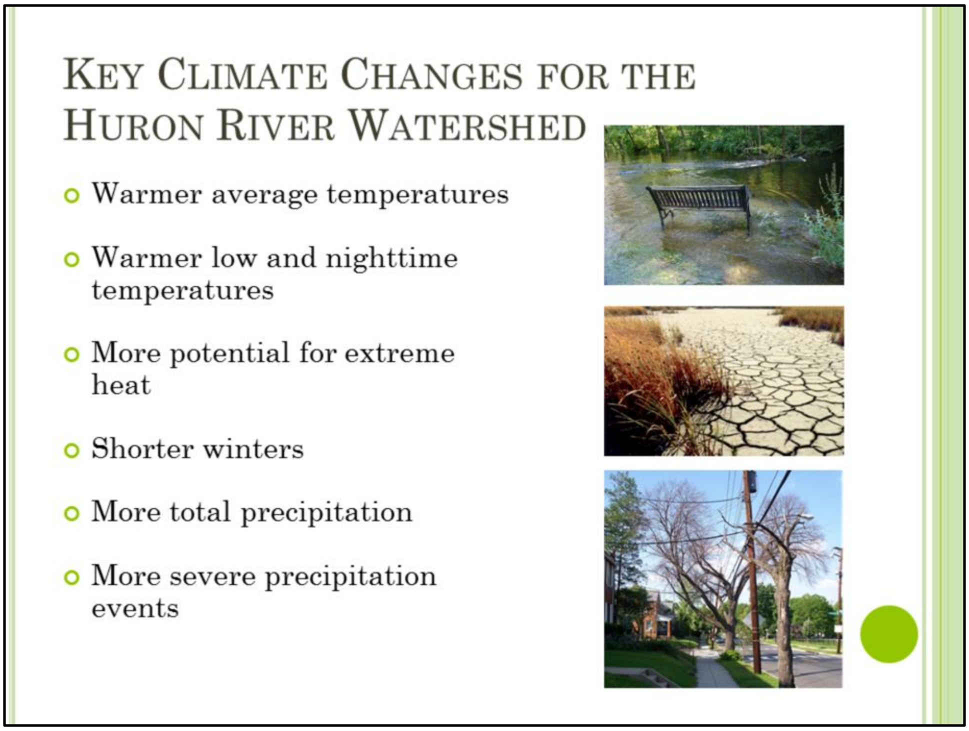


For southeast Michigan, temperature records reveal we have experienced an average annual temperature increase of 1.1 degrees F with increases varying by season and winter seeing the greatest increase in average temperature.



Similarly, precipitation records reveal we have experienced an increase in annual precipitation of 9.5% with increases varying by season and autumn seeing the greatest increase in precipitation.

The story that this does not tell is that we are also expecting greater likelihood of drought in the heat of summer.



In summary, for our area we are expecting and have begun experiencing:

Warmer average temperatures

Warmer low and nighttime temperatures

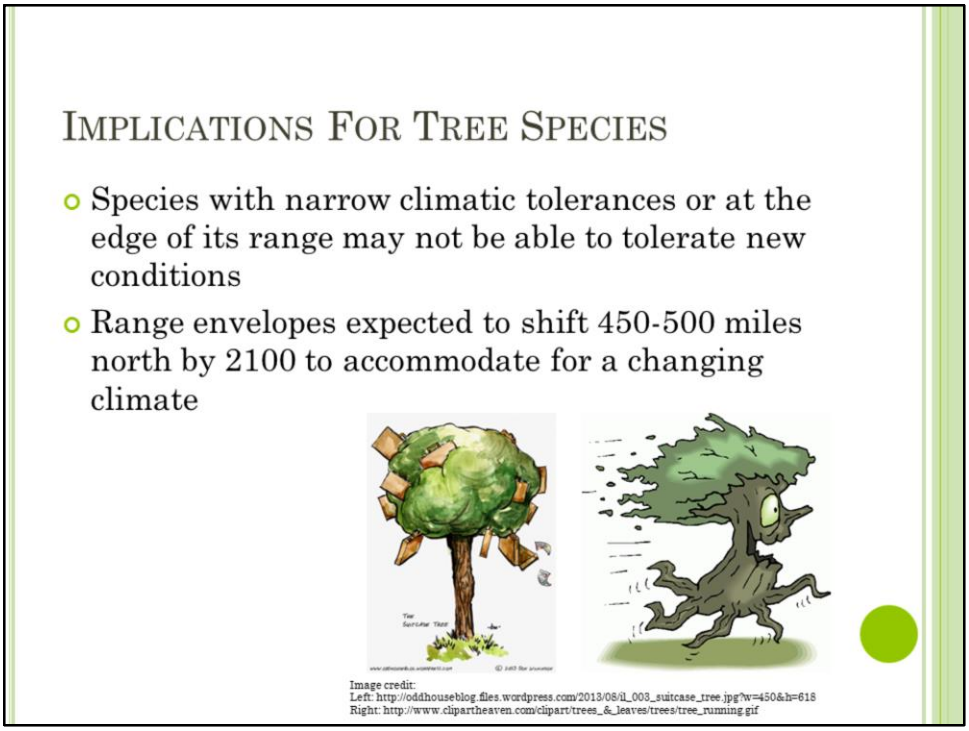
More potential for extreme heat

Shorter winters

More total precipitation

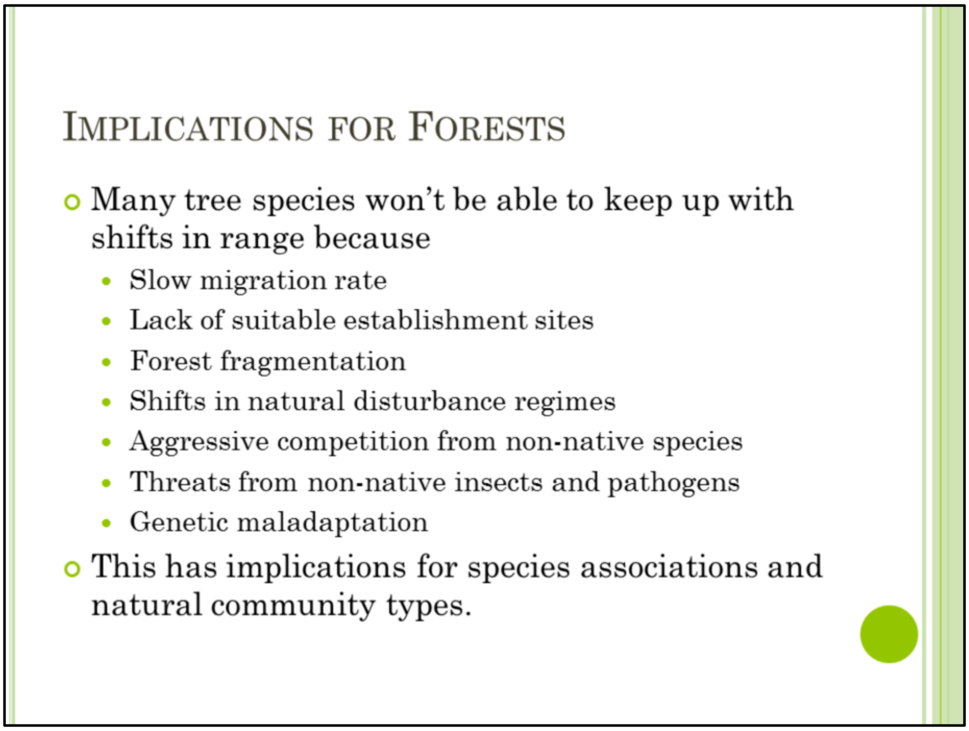
More severe precipitation events

Now lets shift to considering what this means for our forests and native tree species.



Native species evolved to thrive within a set range of climatic conditions. Species with limited tolerances (e.g. drought intolerant, requires winter hardening, wetland obligates) may find the climate of tomorrow increasingly inhospitable.

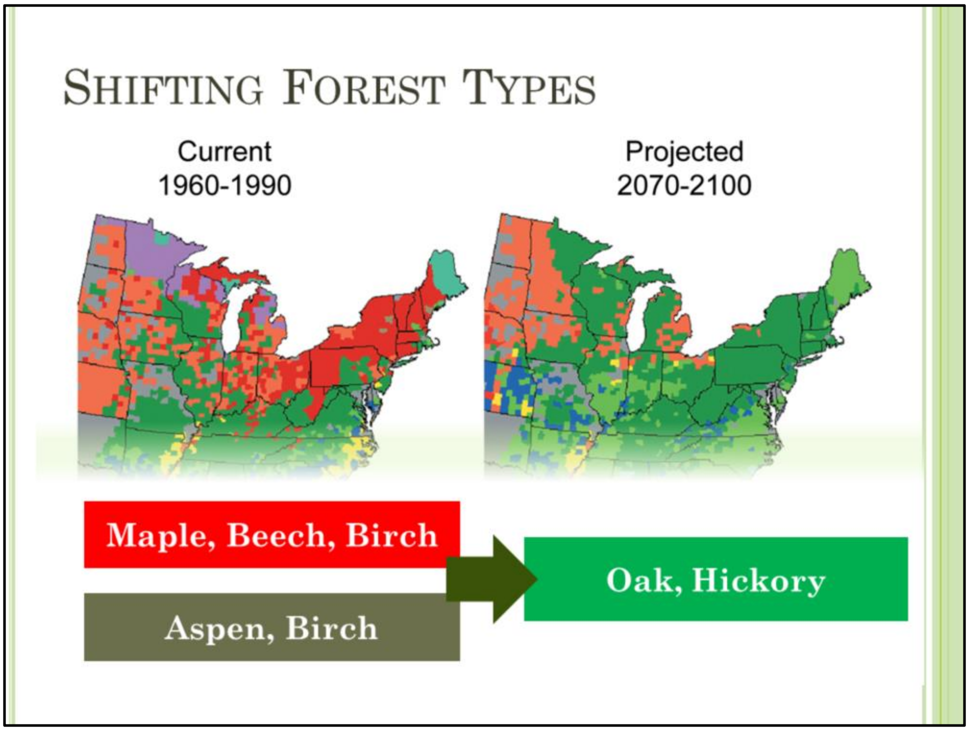
Models predict that by the end of the century, range envelopes for species are expected to shift northward and likely eastward by 450-500 miles. That is approximately the distance from the Huron River, Michigan to Ottawa, Ontario.



Many tree species won't be able to keep up with shifts in range because of one or many of these factors:

- Slow migration rate
- Lack of suitable establishment sites
- Forest fragmentation
- Shifts in natural disturbance regimes
- Aggressive competition from non-native species
- Threats from non-native insects and pathogens
- Genetic maladaptation

This has implications for species associations and natural community types. It is not realistic to expect all species to march north in a coordinated manner. We will see ecosystems change, species composition change, dominance and abundances change. And we have no crystal ball to tell us what the systems of the future will look like. This brings unique challenges to natural resource protection, management and restoration.



This set of maps show current forest types in our area and how these are expected to shift over time.

This gives a course view of the issue. However, not all species associated with these forest types will fare the same. We do not know how individual species will respond. Some species will successfully migrate. New species may expand from more southern extents. Some species may have limitations that will not allow them to follow more favorable conditions. Introduced pests or pathogens may wipe out some species. Phenology changes are anticipated which could lead to compromised species fitness (e.g. trees flowering before pollinators arrive). These are just a few examples.

The implications of this shift are many. One implication is to fall foliage. The Fall color associated with beech maple forests is considerably different than those of Oak Hickory forests.

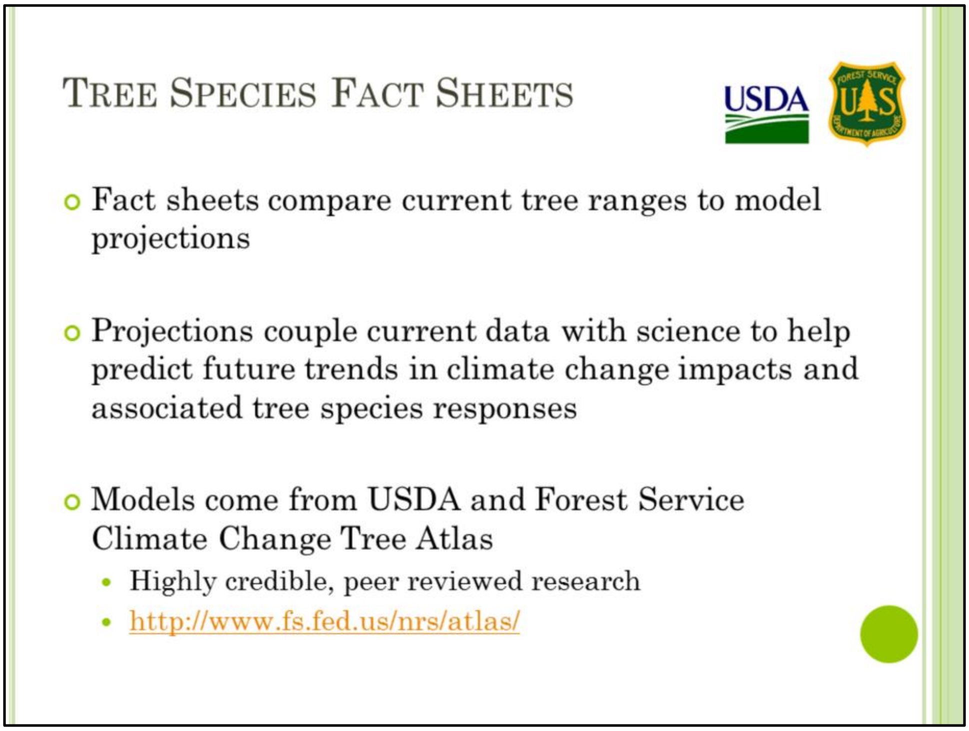
Additional Implications

Changing Climate makes systems vulnerable to:

- Disease
- Invasive species
- Pest Infestations
- Wildfire
- Floods

Distribution of kudzu in the United States. Image credit: EDDMapS. 2011. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org/; last accessed December 08, 2011.

In addition to range shifts climate change will make ecosystems more vulnerable to disease, invasive species, pest infestations, wildfire and floods.

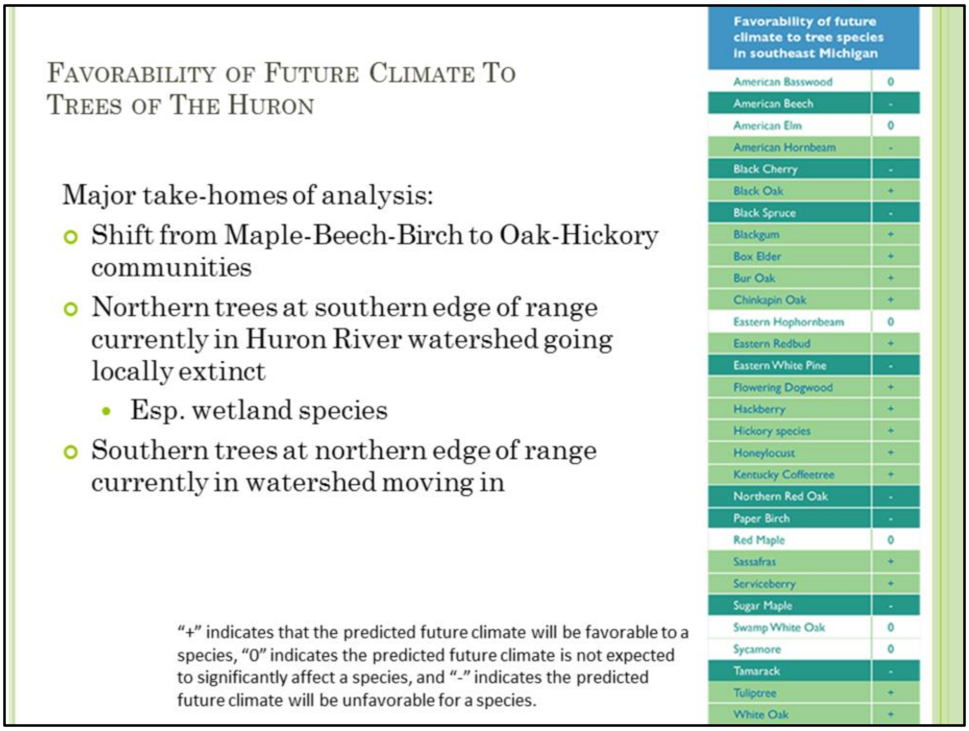


To become more informed on how climate change will affect our tree resources, a series of tree species fact sheets were developed that summarize specific anticipated climate change impacts on 30 important native trees.

The Forest Service's Climate Change Tree Atlas provided maps of current distribution and importance of tree species and several predictive models showing how species distribution and importance are expected to change under various climate scenarios.

Model projections are approximations of the future built utilizing the best science. While uncertainty exists within any predictive model, this does not mean models cannot provide credible information that can help inform how we respond to climate change in our planning and management decisions.

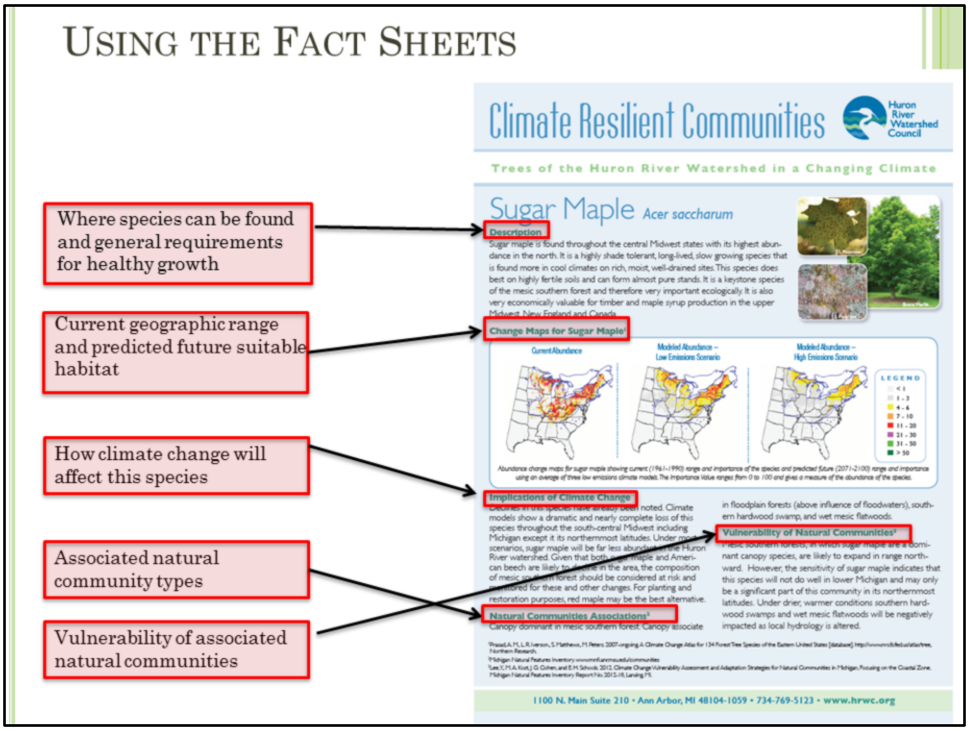
The models are based on work by expert climate scientist within United States Forest Service and results have been peer reviewed.



The summary from those fact sheets are presented here in this Favorability Table.

Some themes emerging from the analysis are that we expect to see:

- a shift from Maple-Beech-Birch to Oak-Hickory communities
- Northern trees at southern edge of range currently in Huron River watershed going locally extinct, especially wetland species.
- Southern trees at northern edge of range currently in watershed are moving in



This is a look at one of the 30 tree species fact sheets. First you will find a description of the species focused on its preferred growing conditions and its role in ecosystems. The change maps are from the Forest Service Tree Atlas and show the current range and abundance of the species and the projected importance (a proxy for abundance) of the species at the end of the century under low and high greenhouse gas emission scenarios (current global emissions align with the high emission scenario). Next you will find a summary of the likely implications of climate change for the species. The fact sheet also captures the Michigan Natural Features Inventory (MNFI) Natural Communities that the species is a significant component of and a brief description of vulnerabilities of those natural communities according to an MNFI led vulnerability assessment.

Switching gears now, the following section of the presentation will focus on the outcomes of a literature review of the challenges climate change poses to land acquisition, management, restoration and urban forestry and the emerging strategies that may help forest systems adapt.

The following slides summarize two reports in the Tree Resilience Toolkit:
A Review of Management Options for Improving Climate Resiliency in the Huron River Watershed's Forest and Tree Resources, and the
Annotated Resource List of suggested reading regarding resiliency-based management options

There are multiple costs associated with climate impacts to our forest and tree resources. We face ecological, economic, infrastructure and cultural costs.

Ecological costs include:

Forest and tree resources at risk of being fundamentally altered

Loss of biodiversity and ecosystem services

Economic costs include:

High numbers of planted trees lost and requiring replacement

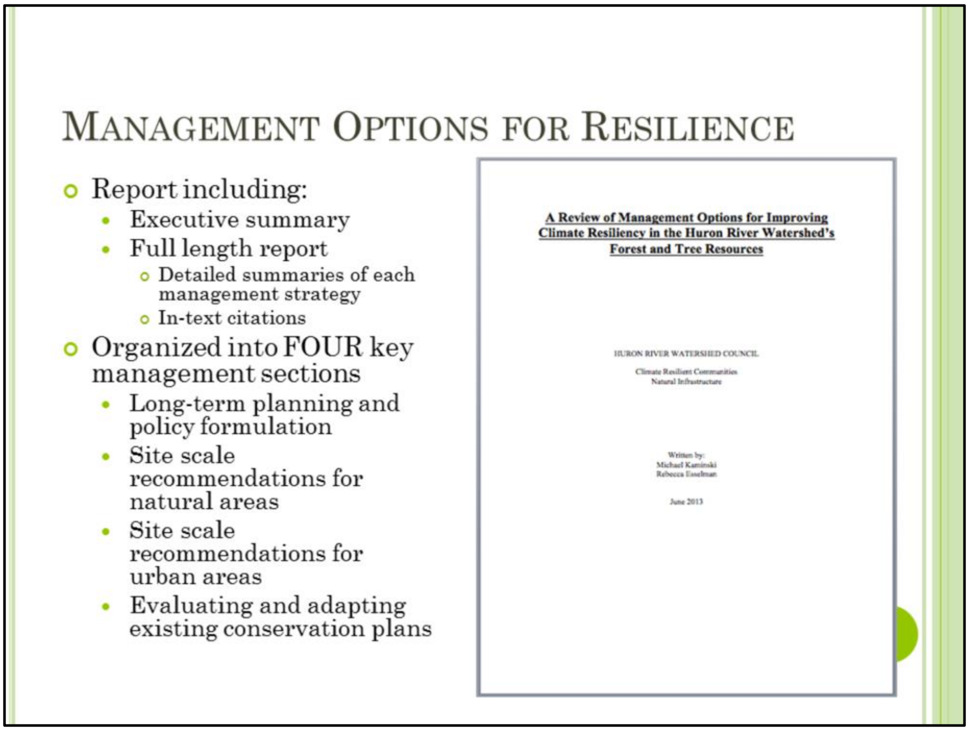
Infrastructure costs include:

Loss of municipal services such as stormwater infiltration, clean air, urban heat island mitigation

Cultural costs include:

Impacts on recreational amenities such as parks and natural areas

To lessen the impacts of climate change and associated costs, we can work to build resilience in our forests and urban canopy helping to ensure these resources provide the services they have historically provided even in the face of change.



We reviewed management options for improving the resilience of forests and urban forests and summarized the findings in this report. The report has a brief executive summary and a full length report that summarizes resiliency strategies in four sections:

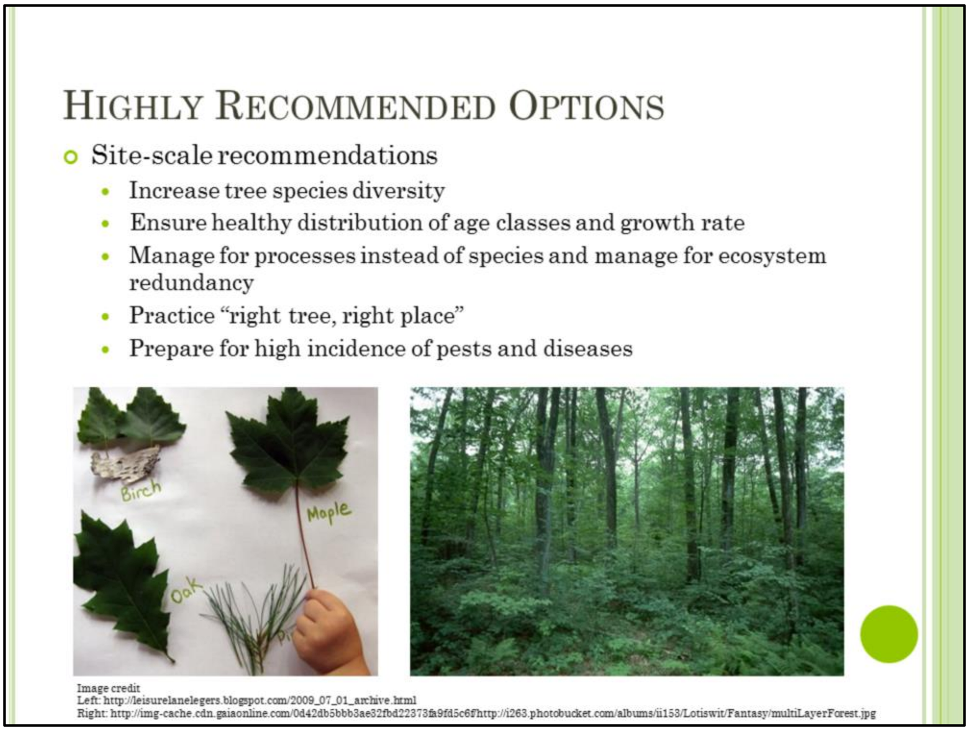
- Long term planning and policy
- Site scale recommendations for natural areas
- Site scale recommendations for urban areas, and
- Evaluating and adapting existing conservation plans

This next series of slides capture those strategies that currently have the most support as credible, effective means for addressing climate change in forest and urban forest management.

For long term planning and policy activities, consider:

- Reserve planning - ecologically informed acquisition of land for conservation management.
- Improving landscape connectivity -Creating and maintaining habitat linkages between natural areas to reduce the negative impacts of fragmentation.
- Inventory urban forest resources -The inventory and mapping of urban trees by a municipality to allow for more informed management practices of their tree resources.
- Development ordinances promoting resiliency – ordinances could include a climate resilient tree species list for new plantings, minimum tree canopy standards in new developments, protection of natural areas, etc.
- Be wary of relying on historical tree species ranges in planning efforts – This does not allow one to account for climate change and associated changes in weather.

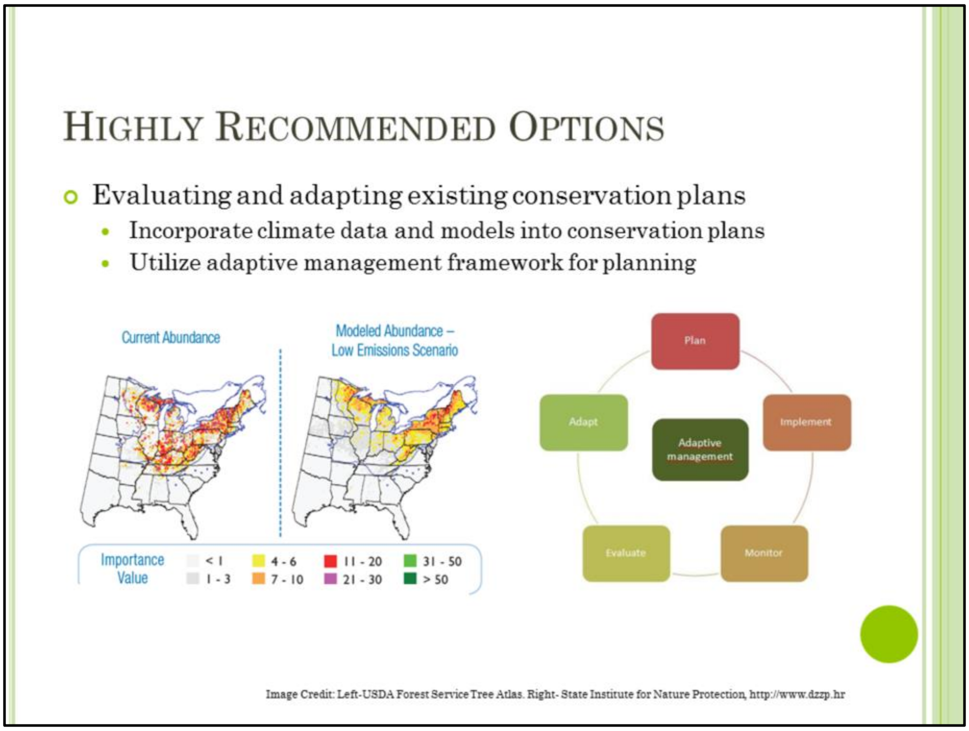
- Improving stakeholder communication and community engagement -Good communication is important for insuring that all stakeholders are operating with common goals and objectives, while also increasing support for climate resilient forestry programs.



At the site scale, consider:

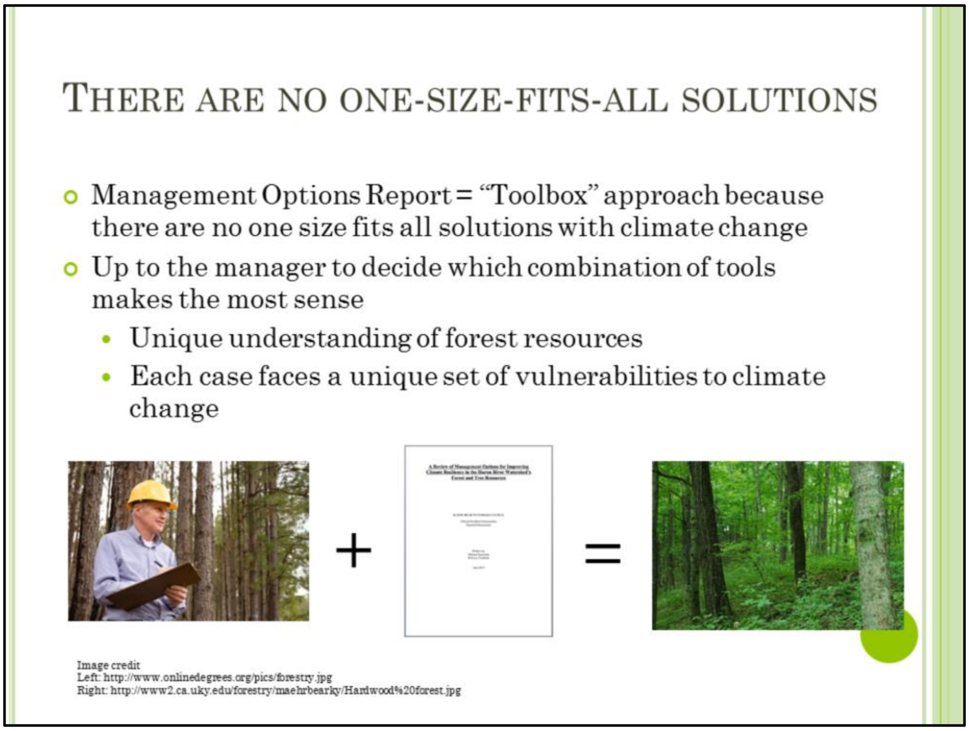
- **Increase tree species diversity** - This can help maintain resilience to mortality and reduction in growth rates of trees in response to diseases and other climate change impacts like drought stress.
- **Ensure healthy distribution of age classes and growth rate** - A multi-aged forest management program can buffer against stressors that might affect trees differently based on size and age. This also balances a higher carbon stores in retained mature trees with higher sequestration rates in younger trees.
- **Manage for processes instead of species and manage for ecosystem redundancy** - Management goals and approaches should not focus on the health of specific tree species, but instead on the role that species plays and the services the ecosystem provides
- Practice "right tree, right place"- Matching tree type to the appropriate urban planting site based on site specific conditions.
- **Prepare for high incidence of pests and diseases** - Proactive measures and monitoring can help mitigate the impacts of climate change and associated increases in pest insect populations and

added stress on trees that makes them more susceptible to pathogens.



For existing conservation plans, consider:

- Incorporate climate data and models into conservation plans -This allows for better understanding of the types and ranges of climate change impacts predicted for an area. It helps identify ranges of potential management options to reduce vulnerability risk from uncertainty.
- Utilize adaptive management framework for planning -A systematic and iterative approach for improving resource management by emphasizing learning from management outcomes.



Given the nature of climate change and environmental variability, the inevitability of novelty and surprise, and the range of management objectives and situations, it is important to remember that no single approach will fit all solutions. A toolbox approach recognizes this and arms managers with a range of options. It is up to the manager to decide which combination of these options makes the most sense based on their unique understanding of their forest resources and the associated vulnerabilities to climate change. The range of options outlined in this literature review will provide environmental leaders throughout the Huron River Watershed with the tools they need to start planning for climate resiliency in the area's forests.

Examples of Management Options

- The situation:
  - High numbers of street trees needing replacement
- Management options:
  - Inventory urban forest resources
  - Incorporate tree range models in planning
  - Development ordinances that promote resiliency
    - Update planting lists
  - Protect existing trees
  - Increase tree species diversity
  - Ensure healthy distribution of ages classes and growth rates
  - Plant drought resistant species
  - Management plan audits to update for climate resiliency

The next two slides provide hypothetical examples of an impact from climate change and some of the options that can be employed to address the situation and build the resilience of the system.

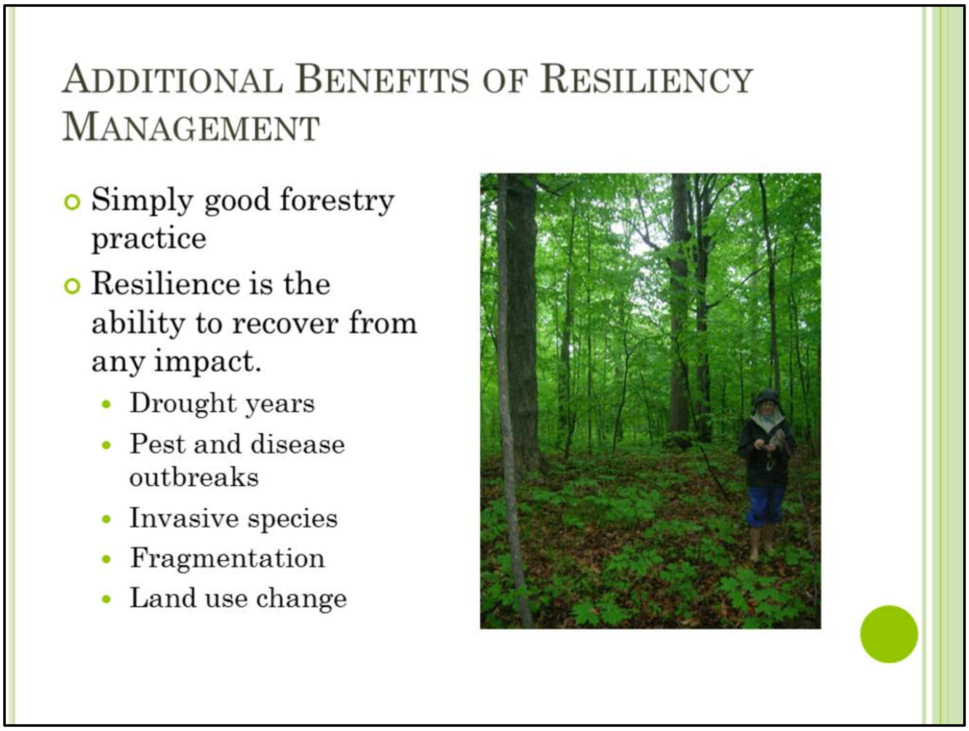
The first is an urban forestry scenario.
For each of the bullets, more detail is available in the report.

Examples of Management Options

- The situation:
  - Tree stand
  - Dominated by a two or three different tree types
  - Dominant species showing signs of declining health
- Management options:
  - Incorporate tree range models in planning
  - Increase stand diversity
  - Natural regeneration
  - Enrichment planting
  - Thinning the stand
  - Triage approach

Image credit:
http://buroaklandmanagement.com/img/large/PA240009.jpg

This scenario is set in a natural community.

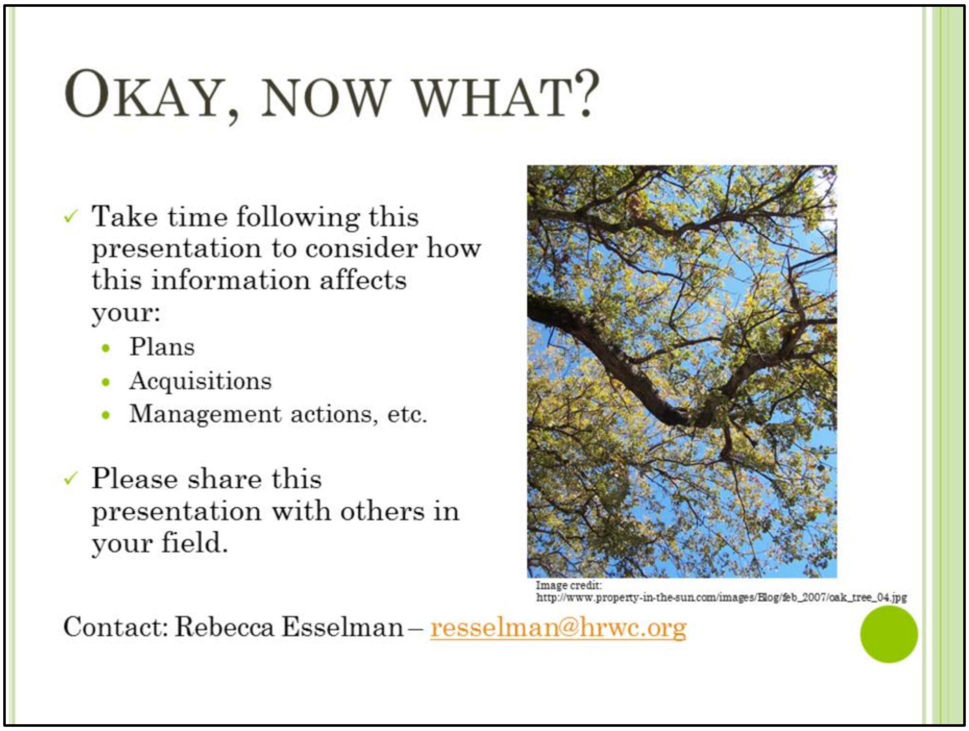


Many of the emerging strategies are also just good stewardship. Many have multiple benefits of which building climate resilience is one. These strategies are often referred to as “no regrets” strategies because they are beneficial whether or not, or to what degree the climate changes. Strategies that are a little more extreme, such as relocation or introductions of non native species may not be your first line of defense but may become a priority action depending on the severity of the situation.

The report introduces the array of possible approaches being discussed in the literature to improve the resilience of forests impacted by climate change. The paper does not attempt to recommend particular strategies as most lack significant supporting evidence due to the long-term nature of climate change as a stressor and each setting is unique requiring customized approaches to natural resource management.

This presentation has introduced you to the data on local climate change, what the implications of these changes are for our native forest and tree resources and emerging adaptation strategies that can help natural resource managers prepare for or respond to the impacts.

The materials presented today and more are available at www.hrwc.org/tree-toolkit



Exercise: 1 discuss how this information affects your work. This exercise is scalable. It can be 30 minutes on your own, or be the precursor to a working session with colleagues. Ask:
How do management plans change?
Does this change how parcels are prioritized for acquisition?
Does this affect current management practices?
Can the monitoring program be modified to provide early warning signs of climate impacts?

Exercise 2:
Write out a list of affiliates/partners you could share this with and possibly present to
Are there newsletters or other outlets for sharing this toolkit?

Questions, ideas, thoughts can be directed to Rebecca Esselman at the Huron River Watershed Council, resselman@hrwc.org.

The Huron River Watershed Council would like to thank the contributors to the development of this toolkit: Daniel Brown, GLISA; James Lloyd, Six Rivers Land Conservancy; Jeff Plakke and Paul Bairley, University of Michigan; Kerry Gray, City of Ann Arbor; Susan Shink, ALPAC, and Susan Lackey, Legacy Land Conservancy. Support for this project came from: GLISA, the Mott Foundation, Friedman Family Foundation, *Washtenaw Water Resources Commissioners Office, Upton Foundation and the Porter Family Foundation.*