Climate Change & Our Forests

Guidance for Foresters and Land Managers

Forests are a defining feature of the landscape in "the MassConn Woods" of northeastern Connecticut and south central Massachusetts. These natural systems, so crucial to our history and current quality of life, provide many environmental, economic, and social benefits to the region.

These forests, primarily in private family or individual ownership, will increasingly be affected by a changing climate. Understanding these potential impacts is an important first step to sustaining healthy forests in the face of changing conditions.

THE CLIMATE HAS CHANGED

The Earth's climate is changing. Many trends have been tracked across the globe, some reaching back hundreds of thousands of years. Although the climate has always changed, the changes that have occurred over the past century are more profound than anything that has happened since the start of human civilization and have important effects on our current environment.

The average annual temperature in the area has risen more than 2°F since the late 1800s.[1,2] Temperatures warmed in all seasons, with winter warming by more than 3°F. Temperature records show that warming has accelerated in recent decades.

Winter temperatures increased by more than 3°F since the turn of the last century, and heavy rainfall events have become more common.

Precipitation also increased during this period, ranging from increases of approximately 3 inches across most of Connecticut to more than 5.5 inches in central Massachusetts.[1] The greatest increase in precipitation has been in the fall, with smaller increases during spring and summer. Extreme precipitation events have increased substantially, particularly over the past several decades[2].

CHANGES WILL CONTINUE

It's impossible to predict exactly what will happen in the future, so global climate models can help us understand how the climate may react under various scenarios. There are many different models available and they provide an opportunity to understand the *range* of potential changes that may occur depending on the carbon-intensity of future energy sources.

Temperatures will increase

Climate models agree that temperatures will increase across all seasons in the region over the next century. The projected increase in annual temperature ranges from 3 to 10°F by the end of the century, depending upon future scenarios.[3,4] Growing seasons will continue to get longer as a result of warmer temperatures.

Precipitation will change

It is harder to predict how future precipitation will change, but total annual precipitation is generally expected to increase through the end of the century.[5] The greatest precipitation increases are expected to occur during the winter, when warmer temperatures will result in more winter precipitation falling as rain instead of snow. There is greater uncertainty whether precipitation will increase or decrease during the growing season. Even with moderate precipitation increases, there may be greater moisture stress in summer or fall because higher temperatures will lead to greater water loss from evaporation and transpiration.[6]

Forests will change, too

Forests will experience both direct and indirect impacts from a changing climate. Although it is hard to anticipate all of the ways that forests may change in the future, there is a growing amount of information about how forests in southern New England are likely to change.[7] This information can be combined with professional expertise to better understand how a particular forest may respond to changing environmental conditions, including climate, land use, management, and biological invasions.

Soil moisture patterns will change, with drier soil conditions later in the growing season. Seasonal changes in precipitation are expected across the MassConn region, and the trend toward more frequent heavy rainfall events is expected to continue. Warmer winters may lead to earlier snowmelt in the spring, and longer growing seasons combined with warmer temperatures may lead to more frequent moisture stress in summer and fall.

Northern species will face increasing stress from climate change. Northern tree species such as eastern white pine, northern white-cedar, quaking aspen, and paper birch will have reduced suitable habitat across the MassConn region at the end of the century.[8,9] These species may be less able to take advantage of longer growing seasons and warmer temperatures than temperate forest species, especially if temperatures increase substantially. Although habitat suitability is expected to decrease over time, trees that are already established may respond favorably to slightly warmer and more favorable conditions during the next several decades.

Southern species will be favored by climate change. Temperate or southern tree species are generally expected to have increased suitable habitat and biomass in this area.[8,9] This includes many oak and hickory species that are currently present, or are more common slightly farther south. Several other minor species and species currently found in places like New Jersey, Pennsylvania, and Maryland are projected to increase, but fragmentation may limit natural migration of these species.

Species and forest types that are more tolerant of disturbance have less risk of declining across the landscape. Climate change is generally expected to increase disturbances over the next century.[10] As hurricanes, storms, floods, pest outbreaks, or other events become more frequent or damaging, tree species and forest types that are better able to tolerate these disturbances may be favored. This idea holds true only to a point, because it still may be possible for disturbance-adapted systems to undergo too much disruption.

Low-diversity systems are at greater risk. Studies have consistently shown that more diverse systems are more resilient to disturbance, and low-diversity systems have fewer options to respond to change. There are many aspects to forest diversity – species, structural characteristics, and genetics – and each of these can generally help reduce risk and increase adaptability.

Tree species change

One tool used to estimate changes in suitable habitat for tree species is called the Climate Change Tree Atlas (www.fs.fed.us/nrs/atlas). The Tree Atlas uses climate models to assess future habitat suitability for individual species.[9] Whether or not tree species will follow these patterns is a different question because human choices and other pressures also exert significant influence on forest distribution. Exotic pests and diseases will likely be game-changers for some species, but the Tree Atlas doesn't include these kinds of variables. However, the Tree Atlas is useful for understanding the general trends for a species in a particular region.

No change represents less than a 20% change in future suitable habitat. Large decreases refer to greater than 40% decreases in suitable habitat, and large increases indicate more than a doubling (200% increase) in suitable habitat at the end of the century. Symbols (-) and (+) indicate that this species has particularly low or high modification factors according to Tree Atlas, which are biological traits that might make them less or more adaptable to future change. Data for Southern and Coastal New England summarized from www.fs.fed.us/nrs/atlas/products/#ra.

Projected changes in suitable habitat for the most common tree species in coastal and southern New England under a low and high climate change scenario.

Common Name	Low Change	High Change
American beech	No Change	Decrease
American elm	Increase	Large Increase
Balsam fir (–)	Large Decrease	Large Decrease
Black cherry (–)	No Change	No Change
Black oak	Increase	Increase
Eastern hemlock (–)	No Change	Large Decrease
Eastern white pine	Decrease	Large Decrease
Gray birch	No Change	Decrease
Northern red oak (+)	No Change	Decrease
Paper birch	Large Decrease	Large Decrease
Pignut hickory	Increase	Large Increase
Pitch pine	Increase	No Change
Quaking aspen	Decrease	Large Decrease
Red maple (+)	No Change	Large Decrease
Scarlet oak	Increase	Increase
Sugar maple (+)	No Change	No Change
Sweet birch (–)	Increase	Decrease
White ash (–)	No Change	No Change
White oak (+)	Increase	Large Increase
Yellow birch	No Change	Decrease

Forest Vulnerability

Climate change will not affect all forest species, communities, and parts of the landscape in the same way. Tree species tend to grow with common associations called forest types, forest systems, or natural communities. As the climate changes, forest composition, structure, and function will evolve. There will not likely be a simple direct relationship between climate and forest condition because climate is not the only set of factors influencing forests, and climate will affect different forests in different ways.

There is little evidence of tree species migrating due to climate change to date. Tree species with aggressive dispersal strategies will likely occupy new habitat more quickly than other tree species. Highly fragmented landscapes will be a barrier to natural tree species migration. Planting programs may assist migration of future-adapted species, but would likely be very costly across a large area.

Vulnerability by Forest System

Recent assessments have looked at the vulnerability of regional forest systems to climate change.[11-13]

Central hardwood-pine forests have relatively low vulnerability to climate change. This ecosystem supports a high number of tree species and occurs over a wide range of habitats. Many species are tolerant of dry soil conditions and fire, although young trees may be sensitive to severe drought and fire. Several oak and hickory species are likely to benefit from projected changes in climate.

Transition hardwood forests, which include a diverse mix of species such as sugar maple, red maple, yellow birch, black cherry, and red oak, are moderately vulnerable to climate change. Because these forests vary widely, there is a wide variety of potential outcomes depending upon the interaction of climate impacts and local conditions. Over the next several decades, change in these forests is expected to be driven primarily by a number of current stressors, such as insect pests and invasive species, more than climate change.

Lowland and riparian hardwood forests are also moderately vulnerable to climate change. Climate change is expected to alter the hydrologic regimes in riparian and lowland systems, and may amplify the effects of insect pests and invasive species. High diversity and the presence of southern species raise the adaptability of these forests. There is high uncertainty regarding future precipitation patterns and associated hydrologic change that will affect these forests, and many impacts will be strongly influenced by local conditions.

WHAT CAN MANAGERS DO?

Confronting the challenge of climate change presents opportunities for land managers to plan ahead, assess risk, and ensure that the benefits forests provide are sustained into the future. Foresters and forest owners will naturally have different perspectives on how to judge climate change risks and opportunities. They will also have different constraints and opportunities when it comes to taking action. **Even so, it is prudent for foresters to consider what they can do in order to help forests adapt to climate change. In many cases, preparing for climate change offers "win-win" opportunities because many adaptation actions are already fundamental practices of good forestry.** Also, many adaptation actions can address forest stressors that foresters are already used to considering, such as invasive species and forest pests.

A set of adaptation strategies and approaches for forest management can be used to help consider what actions might help forests adapt to changing conditions while meeting landowner objectives.[14] The following set of strategies and approaches can generate ideas and drive the selection of on-the-ground practices. **This list is proposed as a "menu" of possible actions – the idea is to pick and choose the approaches that are most suitable to a particular management goal and forest type.** Not all items on the menu will work together, although they can be applied in various combinations across a landscape or project area. Also, foresters may generate additional ideas that can be added to the menu.

If desired, these adaptation strategies and approaches can be used as part of a larger process to develop adaptation plans and identify actions to implement. An Adaptation Workbook (www.adaptationworkbook.org) provides a structured process to consider the potential effects of climate change on forest ecosystems and to design forest management and conservation actions that can help prepare for changing conditions. The process is completely flexible to accommodate a wide variety of geographic locations, scales, forest types, management goals, and ownership types.[14]

The Workbook consists of 5 basic steps.

1. *Define goals and objectives*
2. *Assess climate impacts and vulnerabilities*
3. *Evaluate objectives considering climate impacts*
4. *Identify adaptation approaches and tactics for implementation*
5. *Monitor effectiveness of implemented actions*

Forest Adaptation Strategies and Approaches

Strategy 1: Sustain fundamental ecological functions.

1.1. Reduce impacts to soils and nutrient cycling.
1.2. Maintain or restore hydrology.
1.3. Maintain or restore riparian areas.
1.4. Reduce competition for moisture, nutrients, and light.
1.5. Restore or maintain fire in fire-adapted ecosystems.

Strategy 2: Reduce the impact of biological stressors.

2.1. Maintain or improve the ability of forests to resist pests and pathogens.
2.2. Prevent the introduction and establishment of invasive plant species and remove existing invasive species.
2.3. Manage herbivory to promote regeneration of desired species.

Strategy 3: Reduce the risk and long-term impacts of severe disturbances.

3.1. Alter forest structure or composition to reduce risk or severity of wildfire.
3.2. Establish fuelbreaks to slow the spread of catastrophic fire.
3.3. Alter forest structure to reduce severity or extent of wind and ice damage.
3.4. Promptly revegetate sites after disturbance.

Strategy 4: Maintain or create refugia.

4.1. Prioritize and maintain unique sites.
4.2. Prioritize and maintain sensitive or at-risk species or communities.
4.3. Establish artificial reserves for at-risk and displaced species.

Strategy 5: Maintain and enhance species and structural diversity.

5.1. Promote diverse age classes.
5.2. Maintain and restore diversity of native species.
5.3. Retain biological legacies.
5.4. Establish reserves to maintain ecosystem diversity.

Strategy 6: Increase ecosystem redundancy across the landscape.

6.1. Manage habitats over a range of sites and conditions.
6.2. Expand the boundaries of reserves to increase diversity.

Strategy 7: Promote landscape connectivity.

7.1. Reduce landscape fragmentation.
7.2. Maintain and create habitat corridors through reforestation or restoration.

Strategy 8: Maintain and enhance genetic diversity.

8.1. Use seeds, germplasm, and other genetic material from across a greater geographic range.
8.2. Favor existing genotypes that are better adapted to future conditions.

Strategy 9: Facilitate community adjustments through species transitions.

9.1. Favor or restore native species that are expected to be adapted to future conditions.
9.2. Establish or encourage new mixes of native species.
9.3. Guide changes in species composition at early stages of stand development.
9.4. Protect future-adapted seedlings and saplings.
9.5. Disfavor species that are distinctly maladapted.
9.6. Manage for species and genotypes with wide moisture and temperature tolerances.
9.7. Introduce species that are expected to be adapted to future conditions.
9.8. Move at-risk species to locations that are expected to provide habitat.

Strategy 10: Realign ecosystems after disturbance.

10.1 Promptly revegetate sites after disturbance.
10.2. Allow for areas of natural regeneration to test for future-adapted species.
10.3. Realign significantly disrupted ecosystems to meet expected future conditions.

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