Climate Change Impacts on Kentucky Forests

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Climate Change Response Framework
www.forestadaptation.org
How is the climate changing?
Shifting rates of change

www.climatecentral.org/news/the-heat-is-on/

www.climatecentral.org/climate-matters/earth-day-warming-rankings
Future changes

Model mean global mean temperature change for low emission scenario RCP4.5

Model mean global mean temperature change for high emission scenario RCP8.5

Projected Changes in Annual Temperature

Low emissions
CCSM4 – RCP 4.5
+4°F

High emissions
HadGEM2-ES – RCP 8.5
+10.6°F

Data source: NASA Earth Exchange Downscaled Climate Projections
Projected Changes in Growing Season Temperature

Low emissions
CCSM4 – RCP 4.5

+4°F

High emissions
HadGEM2-ES – RCP 8.5

+12.7°F

Data source: NASA Earth Exchange Downscaled Climate Projections
Projected Changes in Coldest Month Temperature

Low emissions
CCSM4 – RCP 4.5

+3.2°F

High emissions
HadGEM2-ES – RCP 8.5

+5°F

Data source: NASA Earth Exchange Downscaled Climate Projections
Projected Changes in Warmest Month Temperature

Low emissions
CCSM4 – RCP 4.5
+3.1°F

High emissions
HadGEM2-ES – RCP 8.5
+11°F

Data source: NASA Earth Exchange Downscaled Climate Projections
Projected Changes in Annual Total Precipitation

Low emissions
CCSM4 – RCP 4.5
+4.5 inches

High emissions
HadGEM2-ES – RCP 8.5
+1.9 inches

Data source: NASA Earth Exchange Downscaled Climate Projections
Projected Changes in Growing Season Precipitation

Low emissions
CCSM4 – RCP 4.5
0.8 inches

High emissions
HadGEM2-ES – RCP 8.5
-3.1 inches

Data source: NASA Earth Exchange Downscaled Climate Projections
Extreme Temperatures

https://science2017.globalchange.gov/chapter/6/
Extreme Temperatures

Projected Change in Number of Days Above 90°F
Mid 21st Century, Higher Scenario (RCP8.5)

Projected Change in Number of Days Below 32°F
Mid 21st Century, Higher Scenario (RCP8.5)

https://science2017.globalchange.gov/chapter/6/
7 WAYS THAT CLIMATE CHANGE WILL AFFECT FORESTS

A Synthesis of Anticipated Impacts in Kentucky and the broader Central Hardwoods/Central Appalachians Regions
Climate Change Impacts

1) Longer Growing Season
2) Increased Risk of Moisture Stress
3) Increased Risk of Fire
4) CO$_2$ Fertilization
5) Changes in Suitable Habitat
6) Extreme Events
7) Invasive Plants
Climate Change Impacts

1) Longer Growing Season
2) Increased Risk of Moisture Stress
3) Increased Risk of Fire
4) CO₂ Fertilization
5) Changes in Suitable Habitat
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Warmer temps result in longer growing seasons
- Evidence of phenological shifts
- Projected to increase 3 to 7+ more weeks

Longer period for plant growth
1) Longer Growing Season

Warmer temps result in longer growing seasons
- Evidence of phenological shifts
- Projected to increase 3 to 7+ more weeks

Longer period for plant growth

Phenological changes
- Early bud break and frost damage

Melillo et al. 2014, Nelson Center 2014
2) Increased Risk of Moisture Stress

Longer and warmer growing seasons may lead to drier conditions during the growing season.
2) Increased Risk of Moisture Stress

Longer and warmer growing seasons may lead to drier conditions during the growing season.

Earlier spring runoff and increased runoff during extreme rain events
2) Increased Risk of Moisture Stress

Longer and warmer growing seasons may lead to drier conditions during the growing season.

Warmer temperatures drive greater water loss from soils and plants.
Warmer temperatures = \( \uparrow \) vapor pressure deficit (VPD)
- More evaporation from soils & open water
- More transpiration from plants

Image: NCA4 – Midwest Regional chapter: https://nca2018.globalchange.gov/chapter/21/
2) Increased Risk of Moisture Stress

Longer and warmer growing seasons may lead to drier conditions during the growing season.

Risk may be greatest:

- Sites with drought-prone or shallow soils
- South-facing ridges
- Mesic species on drier sites (marginal sites or off-site)
- Crowded stands that compete for water
3) Increased Risk of Wildfire

Projected changes (%) in annual fire probability from baseline (1971-2000) to late century (2070-2099) based on Greenhouse Gas Emissions Scenario RCP 8.5.
3) Increased Risk of Wildfire

Future climate conditions suggest increased risk of fire.

**Wildfire may increase:**
- Warmer/drier summers
- Increased stress or mortality from less suitable conditions
- Shift toward fire-associated species like oaks and pines

**Wildfire may not change:**
- Spring/early summer moisture
- Current regeneration of more mesic species
- Spatial patterns of land use and fragmentation
- Fire suppression

**What may be at risk:**
Fire-dependent forests or areas of tree mortality when fire is not suppressed.
4) CO2 Fertilization

Benefits

• Increased photosynthesis
• Increased water use efficiency

Limits to CO$_2$ fertilization

- Varies by species and site
- Nutrient deficiencies (especially N)
- Sensitive to ozone pollution
- Limited sink strength
- Limited evidence of long-term sequestration
- Any productivity increases may be offset by reductions from increased drought stress or disturbance

5) Changes in Suitable Habitat

**Good Capability**
- American elm
- Black oak
- Blackgum
- Blackjack oak
- Eastern redcedar
- Hackberry
- Loblolly pine
- Mockernut hickory
- Northern red oak
- Post oak
- Red maple
- Shortleaf pine
- Southern red oak
- Sugar maple
- Sugarberry
- Sweetgum
- Water oak
- White oak
- Winged elm
- Yellow-poplar
- ....and more!

**Poor Capability**
- American basswood
- American beech
- American holly
- Bald cypress
- Black ash
- Bur oak
- Cherrybark oak
- Eastern hemlock
- Eastern white pine
- Pignut hickory
- Pitch pine
- Scarlet oak
- Shingle oak
- Swamp tupelo
- Sweet birch
- Virginia pine
- White ash
- Yellow birch
- ....and more!

**New Habitat with Migration Potential**
- Black hickory
- Laurel oak
- Longleaf pine
- Slash pine
- Striped maple

https://www.fs.fed.us/nrs/atlas/
5) Changes in Forest Composition

Many northern/boreal species are projected to decline in the region—contract to more northerly and higher-elevation locations.

Many species common farther south are expected to see increased and new habitat within the region.
5) Changes in Forest Composition

- Many common tree species are projected to have reduced suitability in the future
- Changes will occur slowly—not instant dieback
- Mature and established trees should fare better
- Immense lags to occupy habitats
- Critical factors: competition, management, & disturbance

Risk may be greatest:
- Location is relatively near the southern extent of species range
- Trees are projected to decline and located on a marginal site
- Forest is composed of few species, esp. those projected to decline
- Something is “missing” from the ecosystem
- Other factors cause additional stress
6) Extreme Events

*Extreme events may become more frequent or severe*

- Heavy precipitation
- Ice storms
- Heat waves/droughts
- Wind storms
- Hurricanes
- “Events” are not well modeled

**What may be at risk:** Depends greatly on site conditions and susceptibility to different types of disturbance

Photo: Route 72 in Preston County
7) Invasive Plants

*Increased habitat for many noxious plants*

**Indirect:**
- Stress or disturbance from other impacts can affect the potential for invasion or success

**Direct:**
- Expanded ranges under warmer conditions
- Increased competitiveness from ability of some plants to take advantage of elevated CO2

**Risk may be greatest:** Presence of invasive species nearby; other factors that reduce forest/understory vigor
Climate change is a “threat multiplier”

- Chronic stress
- Disturbances
- Insect pests
- Forest diseases
- Invasive species

Interactions make all the difference.

Drawing: Bartlett Tree Experts
Vulnerability Assessment Process

Place-based, model-informed, expert driven, transparent

Modified from Swanston and Janowiak 2012
Vulnerability

Modified from Swanston and Janowiak 2012
### Vulnerability Ratings

<table>
<thead>
<tr>
<th>Forest Ecosystem</th>
<th>Potential Impacts</th>
<th>Adaptive Capacity</th>
<th>Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appalachian (Hemlock)- Northern</td>
<td>Negative</td>
<td>Low-Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Hardwood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry Calcareous</td>
<td>Neutral-Negative</td>
<td>Low-Moderate</td>
<td>Moderate-High</td>
</tr>
<tr>
<td>Dry Oak &amp; Pine-Oak</td>
<td>Positive</td>
<td>Moderate-High</td>
<td>Low</td>
</tr>
<tr>
<td>Dry/Mesic Oak</td>
<td>Positive-Neutral</td>
<td>High</td>
<td>Low-Moderate</td>
</tr>
<tr>
<td>Large Stream Floodplain and</td>
<td>Negative</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Riparian</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed Mesophytic and Cove</td>
<td>Neutral-Negative</td>
<td>Moderate-High</td>
<td>Moderate</td>
</tr>
<tr>
<td>North-Central Interior Maple-Beech</td>
<td>Neutral</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Small Stream Riparian</td>
<td>Negative</td>
<td>Moderate</td>
<td>Moderate-High</td>
</tr>
<tr>
<td>Spruce-Fir</td>
<td>Negative</td>
<td>Moderate</td>
<td>High</td>
</tr>
</tbody>
</table>
Vulnerability: Dry-Mesic Oak Forest

Low-Moderate Vulnerability

Drivers:
Dry to mesic soils, gap-phase dynamics, fire was historically important

Dominant Species:
Pignut hickory, white oak, mockernut hickory, shagbark hickory, chestnut oak, scarlet oak, black oak

Stressors:
Increased drought, pests and diseases, Ailanthus and other invasive plants

Adaptive Capacity:
Past shift to mesic species (sugar maple, beech, etc. wide distribution, variety of habitat conditions, increased fire could help oak regen.
Location, Location, Location

Research and assessments describe broad trends but local conditions and management make the difference.
Thank you!

More information and resources at:

Forestadaptation.org

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