Climate Change & Oak Forests

in Southern New England

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Some Major Factors Influencing Oak Forests

Factors drawn from: McEwan et al. 2011
Drought History Across Eastern Oak Forest Since 1500

McEwan et al. 2011
Observed Changes in Climate (CT)

Temperatures have risen 3.2°F since turn of last century.

Annual precipitation has increased about 2.6 inches (~4%).

Connecticut, Average Temperature, January-December

Connecticut, Precipitation, January-December

Ten coldest years = 1940 and earlier

Ten warmest years = 1990 and later

NOAA Climate-at-a-Glance Tool
3.6-4.9°F more warming (all seasons)

9-12.9°F more warming (all seasons)

Map: USDA Forest Service
Other studies project same trends: Lorenz et al., Lynch et al.
4-5.9" more precipitation
Wetter in winter/spring
Little change summer/fall

6-7.9" more precipitation
Wetter in winter/spring
Little change summer/fall

Map: USDA Forest Service
Other studies project same
trends: Lorenz et al., Lynch et al.
Wetter Winters & Springs?

- Water loss from soils (evaporation)
- Water loss from trees (transpiration)

Increased precipitation:
- More rain.
- Less snow.
- And more extreme events.

Increased Runoff
Drier Summers?

Greater evaporative demand & water loss

Water loss from soils (evaporation)

Water loss from trees (transpiration)

Same or less precipitation
And more extreme events.

Runoff

Groundwater recharge
Drought?

Palmer Drought Severity Index (PDSI) for the Northeast under two greenhouse gas emissions scenarios

End of Century Projections. Asbjornsen et al. 2019
Insects and Diseases

Increased damage from forest insects & diseases

**Indirect:** Stress from other impacts increases susceptibility

**Direct:**
- Pests migrating northward
- Decreased probability of cold lethal temperatures
- Accelerated lifecycles

Projected southern pine beetle expansion into ranges of forest types with suitable dominant pine species (Lesk et al. 2017)

Extreme Events

Extreme events may become more frequent or severe

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

October 2020 News:

New England Sees First 'Derecho' Storm In Quarter-Century
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

Deer Herbivory

Here to stay.

Deer populations likely to be maintained or increase:

- More overwinter survival & better condition due to warmer conditions
- Potential increase in some diseases affecting deer?
- Effect much greater near northern edge of range.

Weiskopf et al. 2019, Image: Norcross Wildlife Foundation
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

Clark et al. 2014, Guyette et al. 2014
Wildfire

Potential Increase in Fire Weather

Percentage change in days with HI ≥5. The Haines Index (HI) is a measure of how conducive the atmosphere is to potential extreme or erratic fire behavior based on atmospheric stability and moisture.

Tang et al. 2015
Heilman et al. 2015
Changes in Forest Composition

Habitat based on:
- Temperature
- Precipitation
- Elevation
- Latitude
- Soils
- Slope & Aspect
- Land use
- Competition
- Management

Iverson et al. 2008; Atlas website: www.fs.fed.us/nrs/atlas/
# Tree Atlas Projections – end of century (CT)

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Adaptability</th>
<th>Abundance</th>
<th>Habitat Suitability (RCP 4.5)</th>
<th>Capability (RCP 4.5)</th>
<th>Habitat Suitability (RCP 8.5)</th>
<th>Capability (RCP 8.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>American beech</td>
<td>Fagus grandifolia</td>
<td>Medium</td>
<td>Common</td>
<td>Sm. inc.</td>
<td>Good</td>
<td>Sm. inc.</td>
<td>Good</td>
</tr>
<tr>
<td>bitternut hickory*</td>
<td>Carya cordiformis</td>
<td>High</td>
<td>Rare</td>
<td>No change</td>
<td>Fair</td>
<td>No change</td>
<td>Fair</td>
</tr>
<tr>
<td>black oak</td>
<td>Quercus velutina</td>
<td>Medium</td>
<td>Abundant</td>
<td>Sm. inc.</td>
<td>Very Good</td>
<td>Sm. inc.</td>
<td>Very Good</td>
</tr>
<tr>
<td>eastern hemlock</td>
<td>Tsuga canadensis</td>
<td>Low</td>
<td>Abundant</td>
<td>Sm. dec.</td>
<td>Fair</td>
<td>Lg. dec.</td>
<td>Poor</td>
</tr>
<tr>
<td>eastern white pine</td>
<td>Pinus strobus</td>
<td>Low</td>
<td>Abundant</td>
<td>Sm. dec.</td>
<td>Fair</td>
<td>Sm. dec.</td>
<td>Fair</td>
</tr>
<tr>
<td>gray birch*</td>
<td>Betula populifolia</td>
<td>Medium</td>
<td>Rare</td>
<td>Sm. dec.</td>
<td>Very Poor</td>
<td>No change</td>
<td>Poor</td>
</tr>
<tr>
<td>mockernut hickory</td>
<td>Carya alba</td>
<td>High</td>
<td>Common</td>
<td>Lg. inc.</td>
<td>Very Good</td>
<td>Lg. inc.</td>
<td>Very Good</td>
</tr>
<tr>
<td>northern red oak</td>
<td>Quercus rubra</td>
<td>High</td>
<td>Abundant</td>
<td>No change</td>
<td>Very Good</td>
<td>Sm. dec.</td>
<td>Good</td>
</tr>
<tr>
<td>pignut hickory</td>
<td>Carya glabra</td>
<td>Medium</td>
<td>Common</td>
<td>Sm. inc.</td>
<td>Good</td>
<td>Sm. inc.</td>
<td>Good</td>
</tr>
<tr>
<td>pitch pine</td>
<td>Pinus rigida</td>
<td>Medium</td>
<td>Rare</td>
<td>Sm. dec.</td>
<td>Very Poor</td>
<td>Sm. dec.</td>
<td>Very Poor</td>
</tr>
<tr>
<td>red maple</td>
<td>Acer rubrum</td>
<td>High</td>
<td>Abundant</td>
<td>Sm. dec.</td>
<td>Good</td>
<td>Sm. dec.</td>
<td>Good</td>
</tr>
<tr>
<td>shagbark hickory</td>
<td>Carya ovata</td>
<td>Medium</td>
<td>Common</td>
<td>No change</td>
<td>Fair</td>
<td>No change</td>
<td>Fair</td>
</tr>
<tr>
<td>shellbark hickory*</td>
<td>Carya laciniosa</td>
<td>Medium</td>
<td>Rare</td>
<td>Very Lg. dec.</td>
<td>Lost</td>
<td>Very Lg. dec.</td>
<td>Lost</td>
</tr>
<tr>
<td>sugar maple</td>
<td>Acer saccharum</td>
<td>High</td>
<td>Abundant</td>
<td>Sm. inc.</td>
<td>Very Good</td>
<td>No change</td>
<td>Very Good</td>
</tr>
<tr>
<td>sweet birch</td>
<td>Betula lenta</td>
<td>Low</td>
<td>Abundant</td>
<td>Sm. dec.</td>
<td>Fair</td>
<td>Sm. dec.</td>
<td>Fair</td>
</tr>
<tr>
<td>white ash</td>
<td>Fraxinus americana</td>
<td>Low</td>
<td>Abundant</td>
<td>No change</td>
<td>Fair</td>
<td>No change</td>
<td>Fair</td>
</tr>
<tr>
<td>white oak</td>
<td>Quercus alba</td>
<td>High</td>
<td>Abundant</td>
<td>Sm. inc.</td>
<td>Very Good</td>
<td>Sm. inc.</td>
<td>Very Good</td>
</tr>
<tr>
<td>yellow birch</td>
<td>Betula alleghaniensis</td>
<td>Medium</td>
<td>Common</td>
<td>Sm. inc.</td>
<td>Good</td>
<td>Sm. inc.</td>
<td>Good</td>
</tr>
</tbody>
</table>

*species where the habitat suitability model has low model reliability

Iverson et al. 2020
Changes in Forest Composition

50% Reduction in Habitat:

Habitat reduced equally

Best habitats remain

= species X quality habitat
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
- Other factors reduce system function or add stress
## Summary of Impacts

<table>
<thead>
<tr>
<th>Anticipated Change in Climate</th>
<th>Ecosystem Impact?</th>
</tr>
</thead>
<tbody>
<tr>
<td>More variable precipitation and soil moisture – potentially both wetter and drier</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>Drought stress</strong> potentially increased during the growing season</td>
<td>Supportive</td>
</tr>
<tr>
<td><strong>Fire weather</strong> potentially increased during some parts of the year</td>
<td>Supportive</td>
</tr>
<tr>
<td><strong>White-tailed deer</strong> populations and impacts unchanged or increase</td>
<td>Disruptive</td>
</tr>
<tr>
<td><strong>Invasive plant species</strong> increase (enhanced disturbance and non-climate impacts)</td>
<td>Disruptive</td>
</tr>
<tr>
<td><strong>Insect pests and pathogens</strong> become more problematic in general</td>
<td>Disruptive</td>
</tr>
<tr>
<td><strong>Southern pine beetle</strong> expands northward</td>
<td>Disruptive?</td>
</tr>
<tr>
<td><strong>Gypsy moth (and fungus)</strong> change uncertain</td>
<td>Uncertain</td>
</tr>
<tr>
<td><strong>Extreme disturbance events</strong> becoming more frequent and severe</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>Tree species composition</strong> favoring oak and associate species</td>
<td>Supportive</td>
</tr>
<tr>
<td><strong>Interactions</strong> among all the above</td>
<td>Complex!</td>
</tr>
</tbody>
</table>
Activity A: Climate Change Considerations for Forest Management

What new or different considerations do we need to think about when managing forests in the face of a changing climate?

Google Jamboard!
Field Tour Logistics

• Meet on Devotion Road at 1:00 p.m.
• Please wear a face covering and do your best to maintain a distance of 6 ft.
• Virtual discussion at 2:00 p.m.
• Check-out the StoryMap
Homework for Tomorrow

Think about the climate change impacts that are likely to affect the site, and what management challenges and opportunities this creates.