Climate Change and Forests

Northeast U.S.

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Climate Change Response Framework
www.forestadaptation.org
Vulnerability Assessment & Synthesis

- Series of reports for **natural resource professionals**
- Focus on **tree species and forest ecosystems**
- Examine a **range** of future climates
- Evaluate **key ecosystem vulnerabilities** to climate change
- Does **not make recommendations** or assess vulnerability to changes in mgmt., land use, policy

Reports, Summaries and StoryMaps: [www.forestadaptation.org/vulnerability-assessment](http://www.forestadaptation.org/vulnerability-assessment)
Vulnerability Assessment & Synthesis

- Synthesize state/regional assessments and scientific literature
  - Identify areas of agreement regarding ecosystems and species at greatest risk
  - Describe state-of-knowledge for anticipated changes in climate and response of forest ecosystems

- Incorporate new results from forest impact models: *Climate Change Tree Atlas*, *LINKAGES*, *LANDIS*

- Draw on local expertise of scientists and land managers

34 authors – General Technical Report – 234 pages
A Warmer Climate

HOTTEST YEARS ON RECORD GLOBALLY
LAST 5 = Hcottest 5

Source: NASA GISS & NOAA NCEI global temperature anomalies (°F) averaged and adjusted to early industrial baseline (1881-1910). Data as of 2/6/2019

www.ClimateCentral.com
A Warmer Climate - NY

Ten coldest years = all before 1980

Ten warmest years = all since 1940

New York, Average Temperature, January-December

- Avg Temperature
- 1901-2000 Mean: 44.5°F
- 1895-2018 Trend +1.8°F/Century

NOAA Climate-at-a-Glance Tool
Increase = 4.4” per century!
Not Just Warmer Temperatures

- More days with extreme heat
- Precipitation increased >5 inches
- Extreme rain events
- Extreme storms
- Coastal flooding
This presentation...

I’ll talk about...

- Shifting seasonality
- Disturbance
- Sea-level rise
- Extreme Events
- Wildfire Risk
- Forest pests and disease
- Invasive Plants
- Interacting stressors
- Altered precipitation
- Tree species changes

You think about...

What’s at risk in YOUR forest?
All models project increased temperatures.

All models project warming during all months.

Temperature (°F) change 2081-2100 from 1961-2000 (higher emissions, A2)
All models project increased temperatures.

All models project warming during all months.

Temperature (°F) change 2081-2100 from 1961-2000 (higher emissions, A2)

Each line = one climate model projection (16 total); Red = mean; Blue = median

Lorenz et al.
Models project seasonal changes in precipitation.

Models consistently project wetter conditions during the colder months.

Precipitation (in/month) change 2081-2100 compared to 1961-2000 =

Each line = one climate model projection (9 total); Red = mean; Blue = median
Models project seasonal changes in precipitation.

Models project relatively unchanged precipitation during the growing season.

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Hayhoe et al. 2007, Lorenz et al. 2015, Lynch et al. 2016, National Climate Assessment, and more...
Shorter Winter (Less Snow)

Projected decreases in snow fall, cover, and depth

- 30-70% decreases in snowfall
- Greatest loss in December/January

Area with some snow on ground for 30 days per year

Red = historic
White = high emissions

Notaro et al. 2014, Figure: Frumhoff et al. 2007
Projected decreases in snow fall, cover, and depth
- 30-70% decreases in snowfall
- Greatest loss in December/January

Decreased snowpack
- Increased soil freeze-thaw cycles can damage roots and alter soil processes

What may be at risk: The ability to do winter timber harvest when it is preferred to prevent damage to forest soils and residual forest; tree species sensitive to soil freeze-thaw
Shorter Winter (Less Snow, More Rain)

More rain
- Warmer temperatures
- Increased precipitation
- Extreme rain events

Earlier peak stream flows
- Flashiness and episodic high flows may increase

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What may be at risk: Increased erosion/sedimentation on susceptible sites; culvert washouts and road damage from extreme events; aquatic habitats and species
Warmer temps result in longer growing seasons

- Evidence of phenological shifts
- Projected to increase 3-7+ more weeks

Longer period for plant growth

Melillo et al. 2014, Nelson Center 2014
Longer Growing Season

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

Longer period for plant growth

Phenological changes/mismatches
- Early bud break and frost damage from late spring freezing.

Melillo et al. 2014, Nelson Center 2014
Longer and warmer growing seasons may lead to drier conditions during the growing season.

Water loss from soils (evaporation)
Water loss from trees (transpiration)
Groundwater recharge
Precipitation
Runoff
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

- Water loss from soils (evaporation)
- Water loss from trees (transpiration)
- Precipitation
- Groundwater recharge
- Runoff
Increased Risk of Moisture Stress

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

Warmer temperatures drive water loss from soils and plants.

- Water loss from soils (evaporation)
- Water loss from trees (transpiration)
- Groundwater recharge
- Precipitation
- Runoff
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)
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.
Changes in Forest Composition

Suitable Habitat:
Red Spruce
(Climate Change Atlas)
Changes in Forest Composition

Red Spruce

**Basal Area**
LANDIS-PRO

**Aboveground Biomass**
LANDIS-II; Duveneck et al. 2017

![Graph showing changes in Basal Area and Aboveground Biomass for Red Spruce](chart.png)
Changes in Forest Composition

**Likely to decline**
- Balsam fir
- Black, red, & white spruce
- Northern white-cedar
- Eastern hemlock

**Mixed model results**
- Black ash
- Paper birch
- Quaking aspen
- Tamarack

**Potential “winners”**
- American elm
- American basswood
- Black cherry
- Eastern hophornbeam
- Gray birch
- Northern red oak
- Serviceberry
- Silver maple
- Sweet birch
- White oak

**New habitat (esp. south)**
- Black hickory
- Chinkapin oak
- Common persimmon
- Hackberry
- Loblolly pine
- Osage-orange
- Shortleaf pine
- Southern red oak
- Sweetgum
- Sweetgum
- Virginia pine

www.forestadaptation.org/ne-species
Changes in Forest Composition

50% Reduction in Habitat:

- Habitat reduced equally
- Best habitats remain

= species X suitable 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
- Something is “missing” from the ecosystem
- Other factors cause additional stress
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: Joe Klementovich, HBRF
Interactions: 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.

Clark et al. 2014, Guyette et al. 2014
Interactions: Insects and Disease

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

Risk may be greatest: Presence of host species; pest is nearby; other factors reduce forest vigor

Hemlock woolly adelgid incidence ~2015

Interactions: 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

Vulnerability: *Forest Communities*

Forest communities will be affected differently

<table>
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<tr>
<th>Forest system</th>
<th>Potential impacts</th>
<th>Adaptive capacity</th>
<th>Vulnerability</th>
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<td>Central hardwood-pine</td>
<td>Neutral-Positive</td>
<td>Moderate-High</td>
<td>Low</td>
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<tr>
<td>Low-elevation spruce-fir</td>
<td>Neutral-Negative</td>
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<td>Lowland/riparian hardwood</td>
<td>Positive and Negative</td>
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<td>Lowland mixed conifer</td>
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<td>Montane spruce-fir</td>
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<td>Northern hardwood</td>
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<td>Pitch pine-scrub oak</td>
<td>Neutral-Positive</td>
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<td>Transition hardwood</td>
<td>Positive and Negative</td>
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</table>
Vulnerability: Spruce-fir and Lowland Conifer

**Impacts:**
- Warm temperatures
- Declines in boreal tree species
- Extreme storms

**Adaptive Capacity:**
- Generally slow to adjust to change
- Constrained by elevation/latitude
- Isolated mountaintops

Generally rated as **most vulnerable forest communities**, especially at southern extent of range.
Vulnerability: *Hardwood Forests*

**Impacts:**
- Extreme storms
- Several diseases, pests, invasives
- Several northern species projected to decline

**Adaptive Capacity:**
- Mixed species forests
- Several southern species projected to increase
- Extensive type, exists farther south

Vulnerability rated as **low** *(central hardwoods)* or **low-moderate** *(northern, transition hardwoods)*, or **moderate** *(lowland and riparian)* based on species composition and location.
Vulnerability: *Pitch Pine-Scrub Oak*

**Impacts:**
- Less affected by warm temperatures, drought, or wildfire
- Pitch pine habitat suitability not projected to change much

**Adaptive Capacity:**
- Limited to sandy, nutrient-poor soils
- Affected by development, fragmentation, fire suppression

Generally rated as **lower-moderate vulnerability**.
Research and assessments describe **broad trends** but **local conditions** and **management** make the difference.