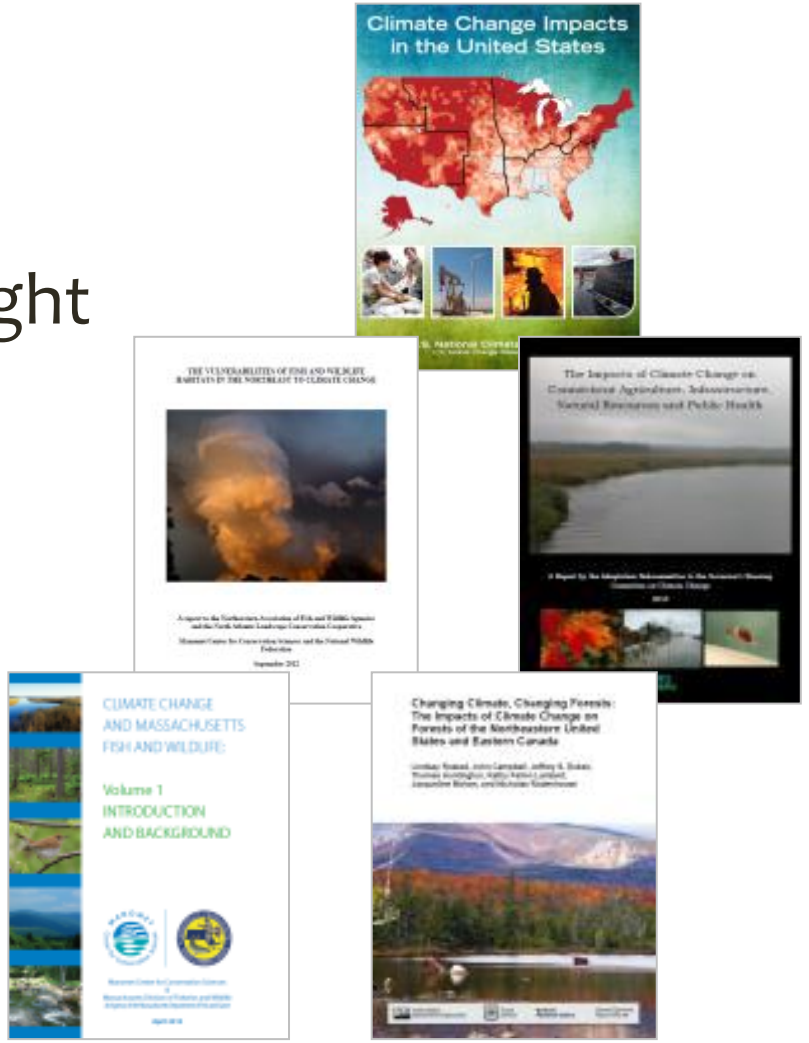
9 WAYS THAT CLIMATE CHANGE WILL AFFECT FORESTS

A Synthesis of Anticipated Impacts

Climate Change Impacts

1) Longer Growing Season
2) Shorter Winters
3) Potential for Summer Drought
4) CO_2 Fertilization
5) Changes in Suitable Habitat
6) Extreme Events
7) Wildfire Risk
8) Forest Pests and Diseases
9) Invasive Plants



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Eric Aldrich/The Nature Conservancy

1: *Longer Growing Season*

Warmer temps result in longer growing seasons

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

Longer period for plant growth

Melillo et al. 2014, Nelson Center 2014

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Potential risks:

- Early bud break/loss of cold hardening
- Frost damage during spring freezing

Melillo et al. 2014, Nelson Center 2014

2: *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

2: *Shorter Winter (Less Snow)*

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- Greatest loss in December/January

Decreased snowpack

- Increased soil frost and root damage in cold temps
- Warmer soil temperatures and altered processes

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

2: *Shorter Winter (Less Snow, More Rain)*

Precipitation is projected to increase = more rain

Dale et al 2001, Huntingon 2004, Parmesan 2006

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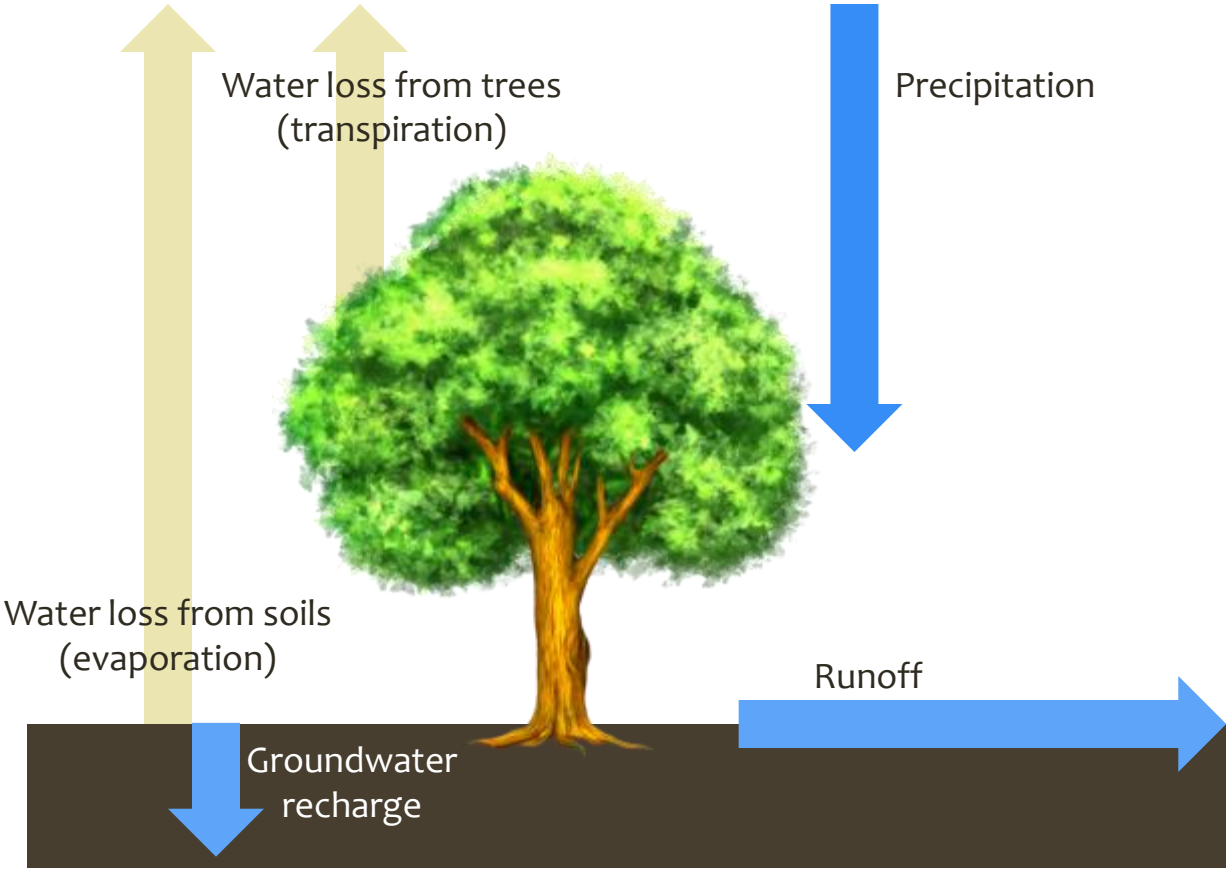
Altered streamflow timing and amount

- Earlier spring peak flows
- Potential increases in flashiness and episodic high flows
- Potential declines in summer seasonal stream flow

Dale et al 2001, Huntingon 2004, Parmesan 2006

3: *Potential for Summer Drought*

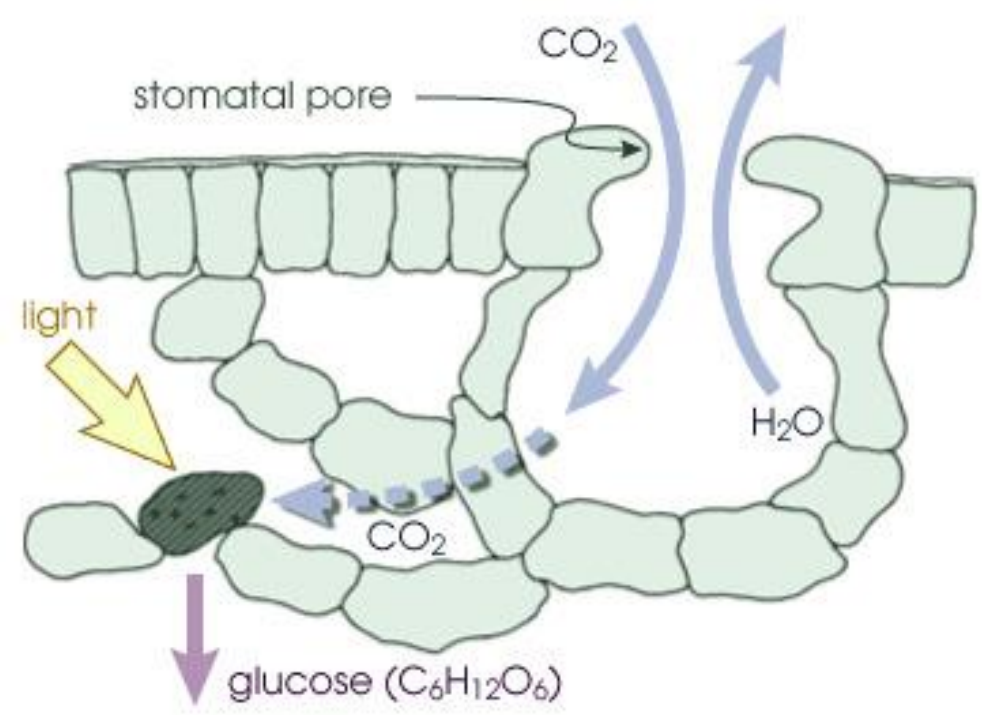
Greater uncertainty about future precipitation, but increased risk of summer moisture stress



4: CO_2 Fertilization

Benefits

- Increased photosynthesis
- Increased water use efficiency

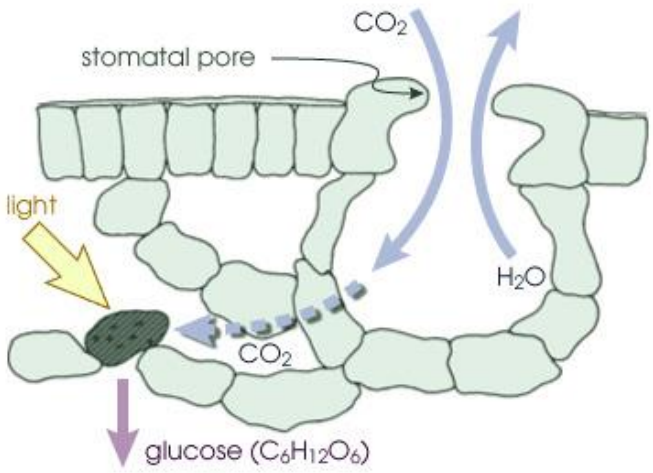


Ainsworth and Long 2005, Ainsworth and Rogers 2007, Norby and Zak 2011

4: CO_2 *Fertilization*

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



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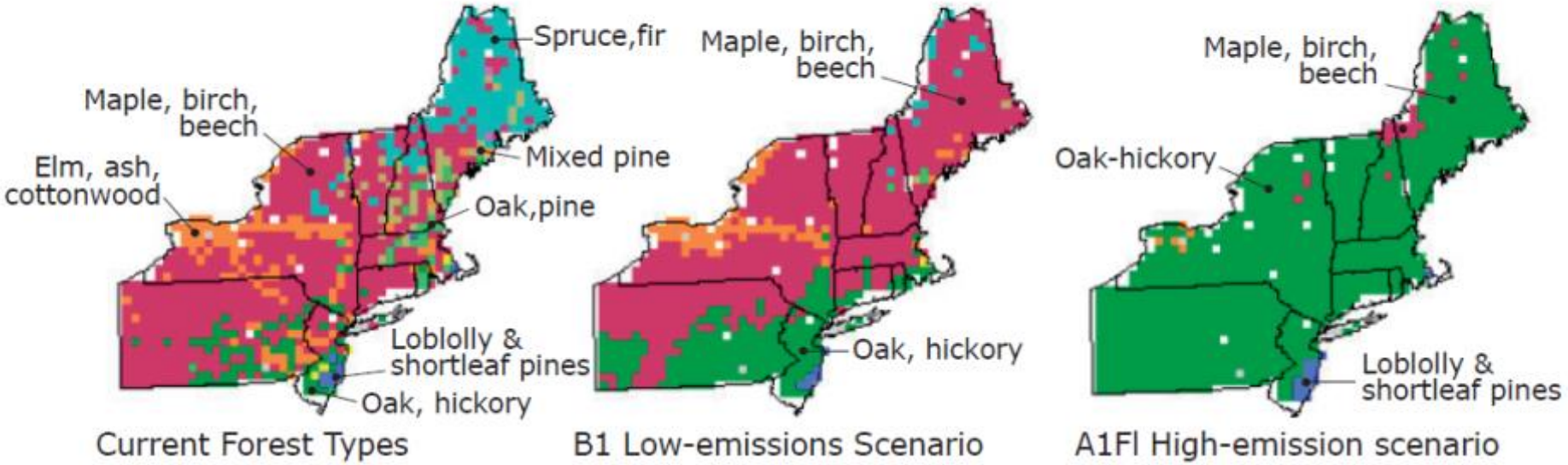
5: *Changes in Suitable Habitat*



Iverson et al. 2007, Rustad et al. 2012

5: *Changes in Suitable Habitat*

Habitat based on:

- Temperature
- Precipitation
- Elevation
- Latitude
- Soils
- Slope & Aspect
- Land use
- Competition
- Past management

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Climate Change Atlas:
What happens to tree and bird habitat when climate changes?

- 134 Trees
- 147 Birds

www.fs.fed.us/nrs/atlas/

Iverson et al. 2008; Atlas website: **www.fs.fed.us/nrs/atlas/**

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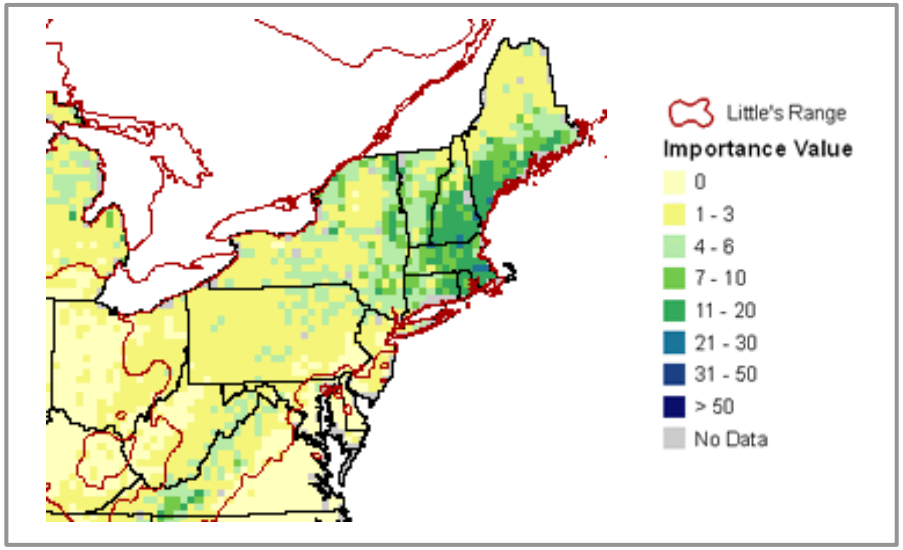
White Pine: Current Habitat (modeled)



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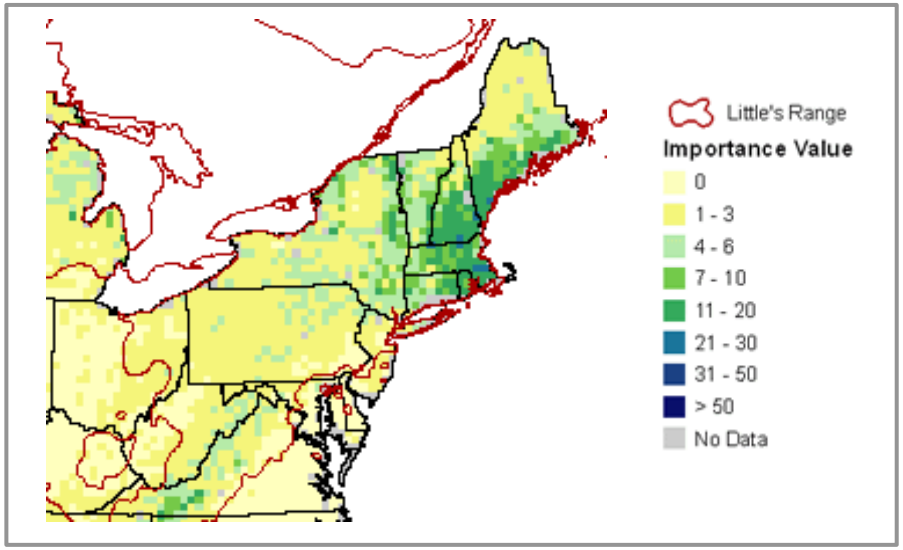
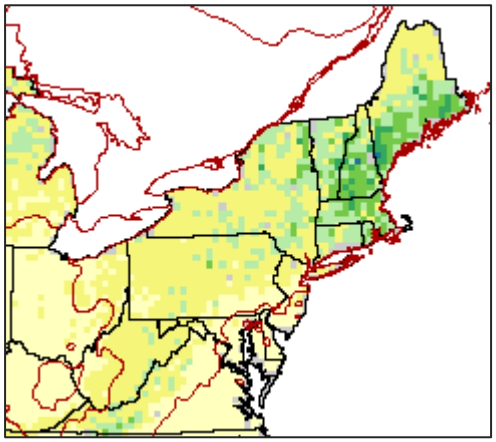


PCM B1 (Less Change)



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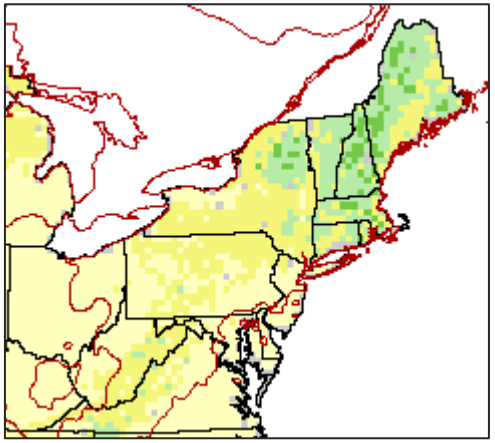

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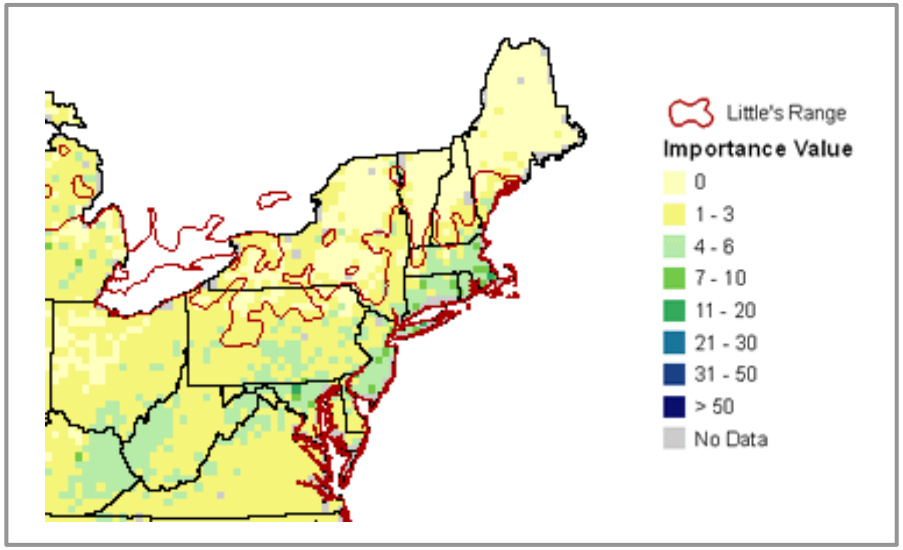
Black Oak: Current Habitat (modeled)



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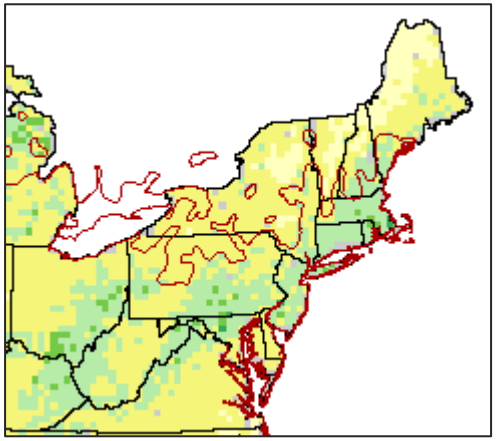

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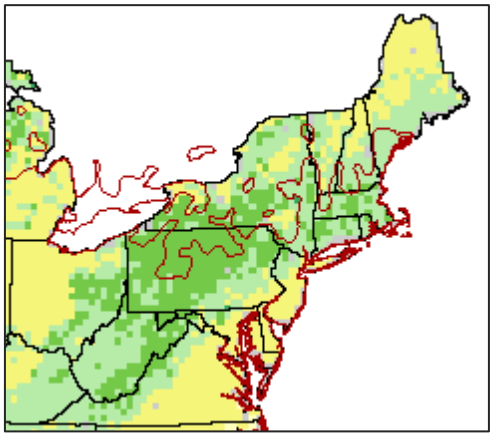

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5: *Changes in Suitable Habitat*

- Immense lag times
  - Range shifts ≠ instant catastrophic dieback
- Factors causing change will increase over time
  - Temperature
  - Moisture
  - Competition
- Mature and established trees should fare better
  - Developed root system
  - Greater carbohydrate reserves
- Game changers: Disturbance, Land use, …

Dale et al. 2001, Iverson et al. 2008

6: *Extreme Events*

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

Dan Turner, Cambridge Fire Dept.

NY DEC

VTRANS/VT ANR

7: *Wildfire Risk*

Fire may increase:

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

Prescribed fire – MASS DCR

Fire may not change:

- Spring/early summer moisture
- Current regeneration of more mesic species
- Spatial patterns of land use and fragmentation
- Fire suppression

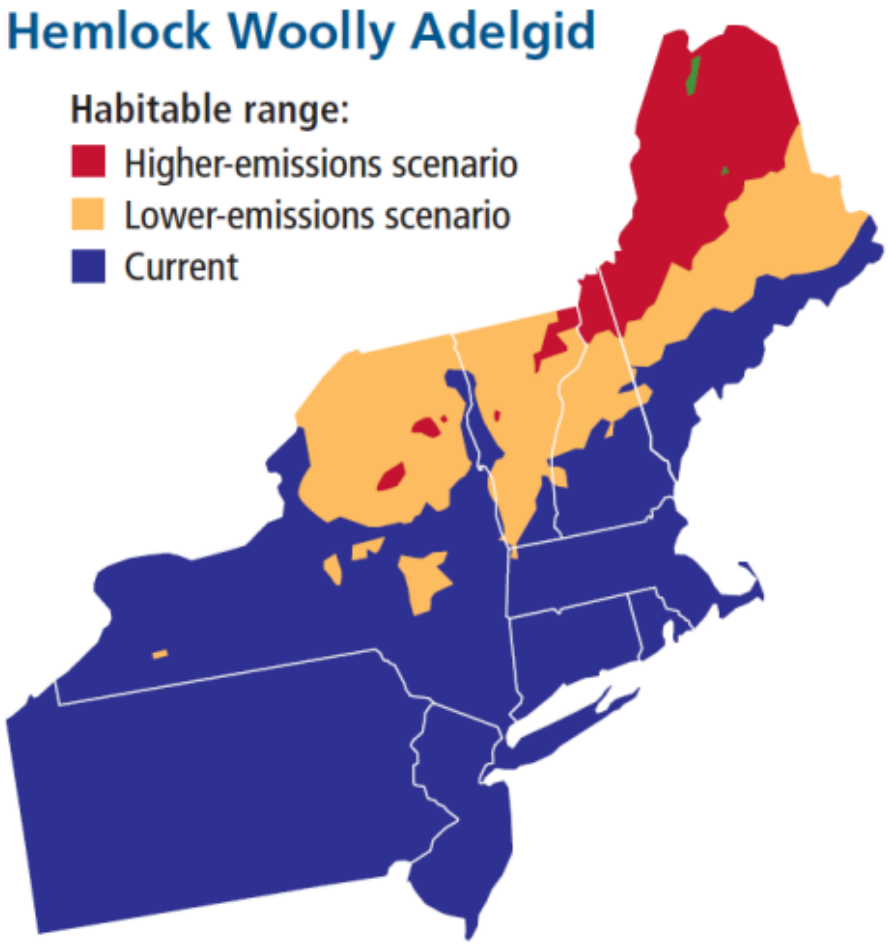
Clark et al. 2014

8: *Forest Pests and Diseases*

Indirect: Stress from other impacts increases susceptibility

Direct:

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



HWA lethal temp: -20 to -30°F

Ayres and Lombardero 2000, Woods et al. 2005, Parmesan 2006, Dukes et al. 2009 Image: Frumhoff et al. 2007

9: *Invasive 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 CO_2




Invasives Plants Atlas of New England (www.eddmaps.org)

Dukes et al. 2009, Rustad et al. 2011

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What conclusions can we draw from all this?

Vulnerability: *Forest Communities*

Forest communities will be affected differently

May have greater risk:

- Low diversity
- Static
- Threatened, rare, or endangered
- Already in decline
- Fragmented

May have less risk:

- More diversity (species, genetics, …)
- Adapted to disturbance
- Wider ecological range of tolerances
- Currently increasing
- Larger, contiguous blocks

Vulnerability: *Spruce-fir*

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 community, especially at southern extent of range.

Connecticut Climate Change 2010, Manomet and Mass. Dept. of Fish and Wildlife 2010, Manomet and NWF 2012

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 moderate (northern hardwoods) based on species and location.

Connecticut Climate Change 2010, Manomet and Mass. Dept. of Fish and Wildlife 2010, Manomet and NWF 2012

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.

Eric Aldrich/The Nature Conservancy

Connecticut Climate Change 2010, Manomet and Mass. Dept. of Fish and Wildlife 2010, Manomet and NWF 2012

Vulnerability: *Local Considerations*

Research and assessments describe **broad trends** but **local conditions** make the difference.

Summary

- **Uncertainty is guaranteed**
  - Consider a **range** of future conditions
  - Uncertainty varies across scales
- **Expect a new mixture of stresses**
  - Mostly familiar stresses, but new combos, timing, etc.
- **Severity is affected by local conditions**
  - Consider broad projections, adjust to local reality
- **Changes occur gradually**
  - Small changes now can have big impact later