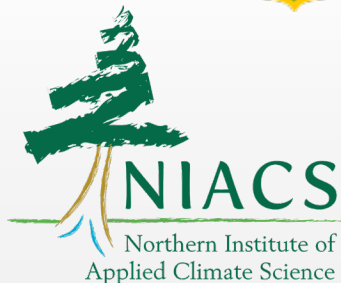
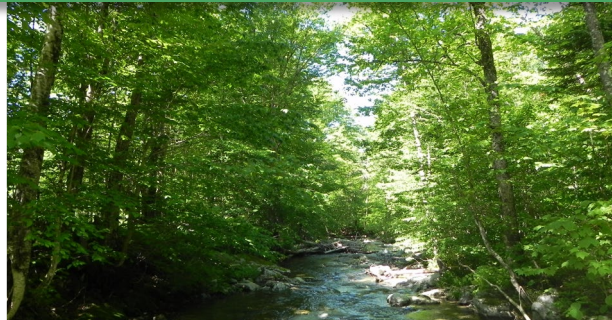


Climate Change and Forests Northeast U.S.

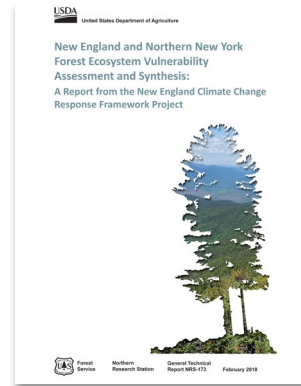
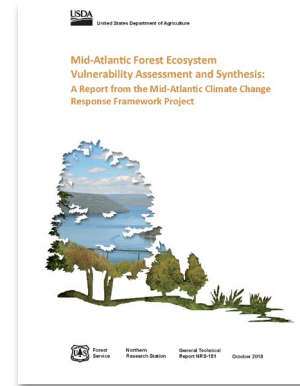
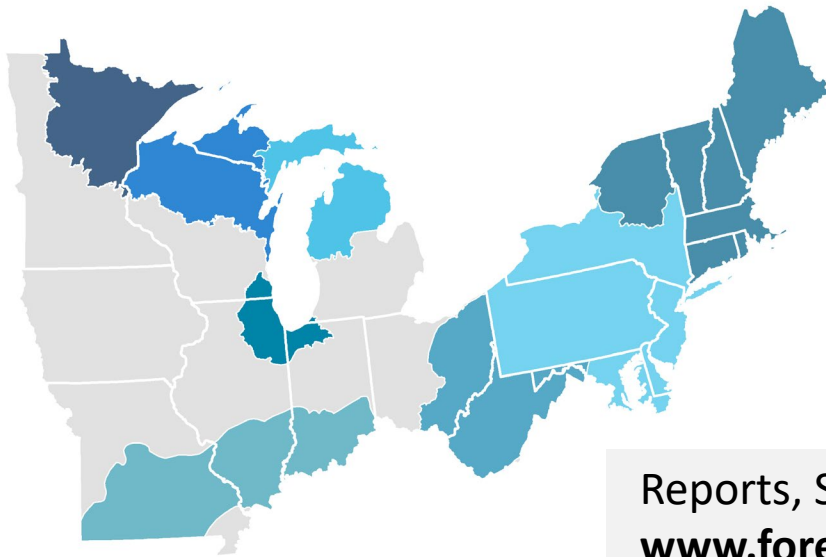


Maria Janowiak maria.janowiak@usda.gov
Northern Institute of Applied Climate Science
USDA Forest Service

Climate Change Response Framework
www.forestadaptation.org

Vulnerability Assessment & Synthesis

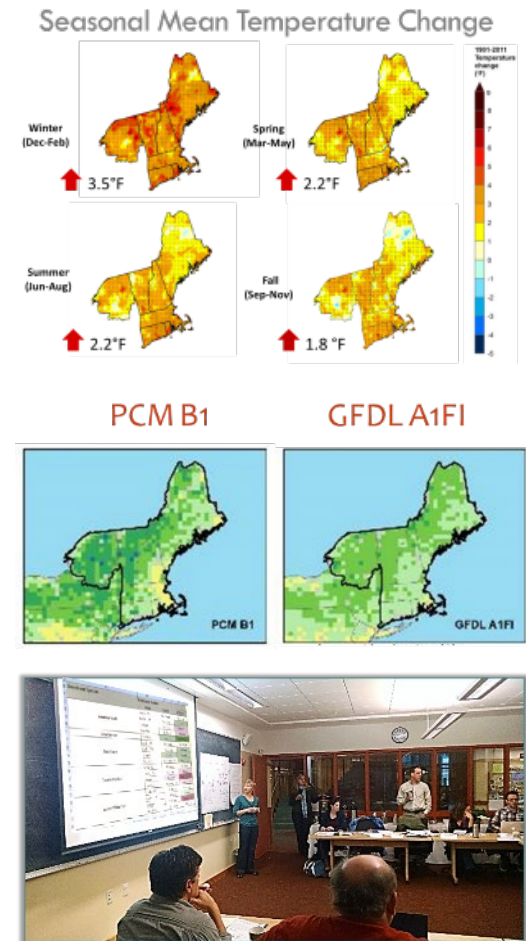
- Series of reports for **natural resource professionals**
- Focus on **tree species and forest ecosystems**
- Examine a **range** of future climates
- Evaluate **key ecosystem vulnerabilities** to climate change
- Does **not make recommendations** or assess vulnerability to changes in mgmt., land use,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



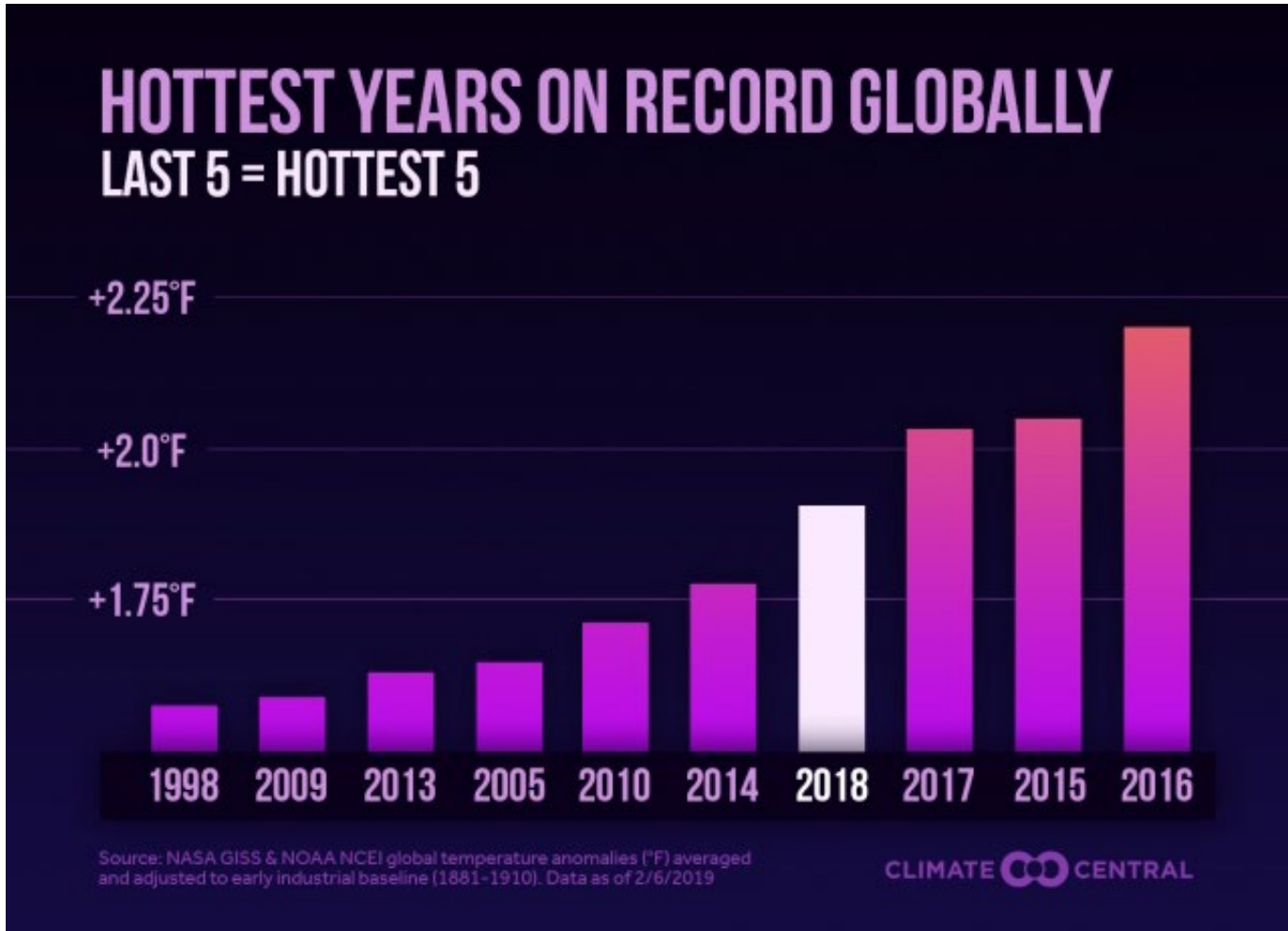
Reports, Summaries and StoryMaps:
www.forestadaptation.org/vulnerability-assessment

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**

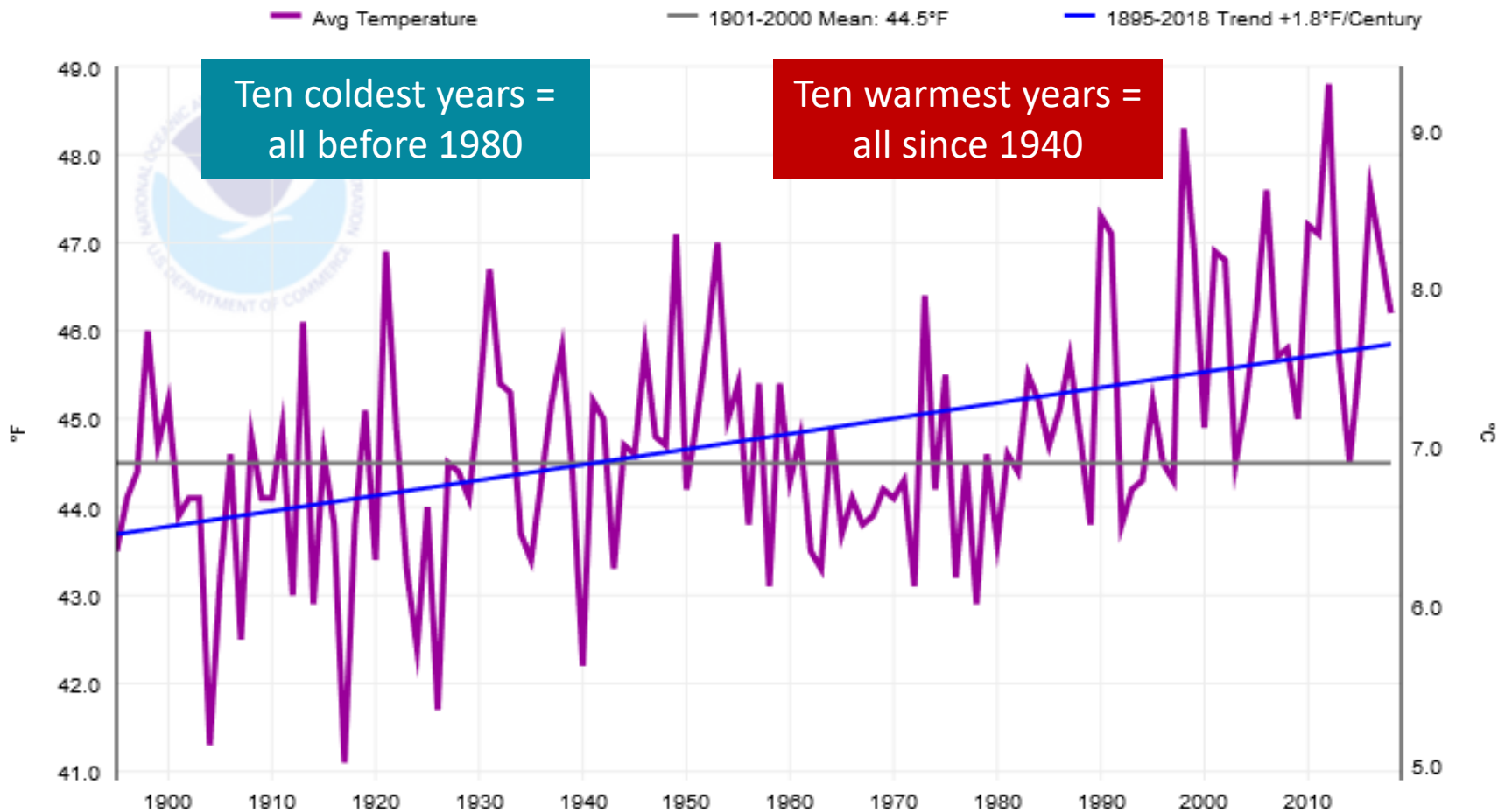


A Warmer Climate



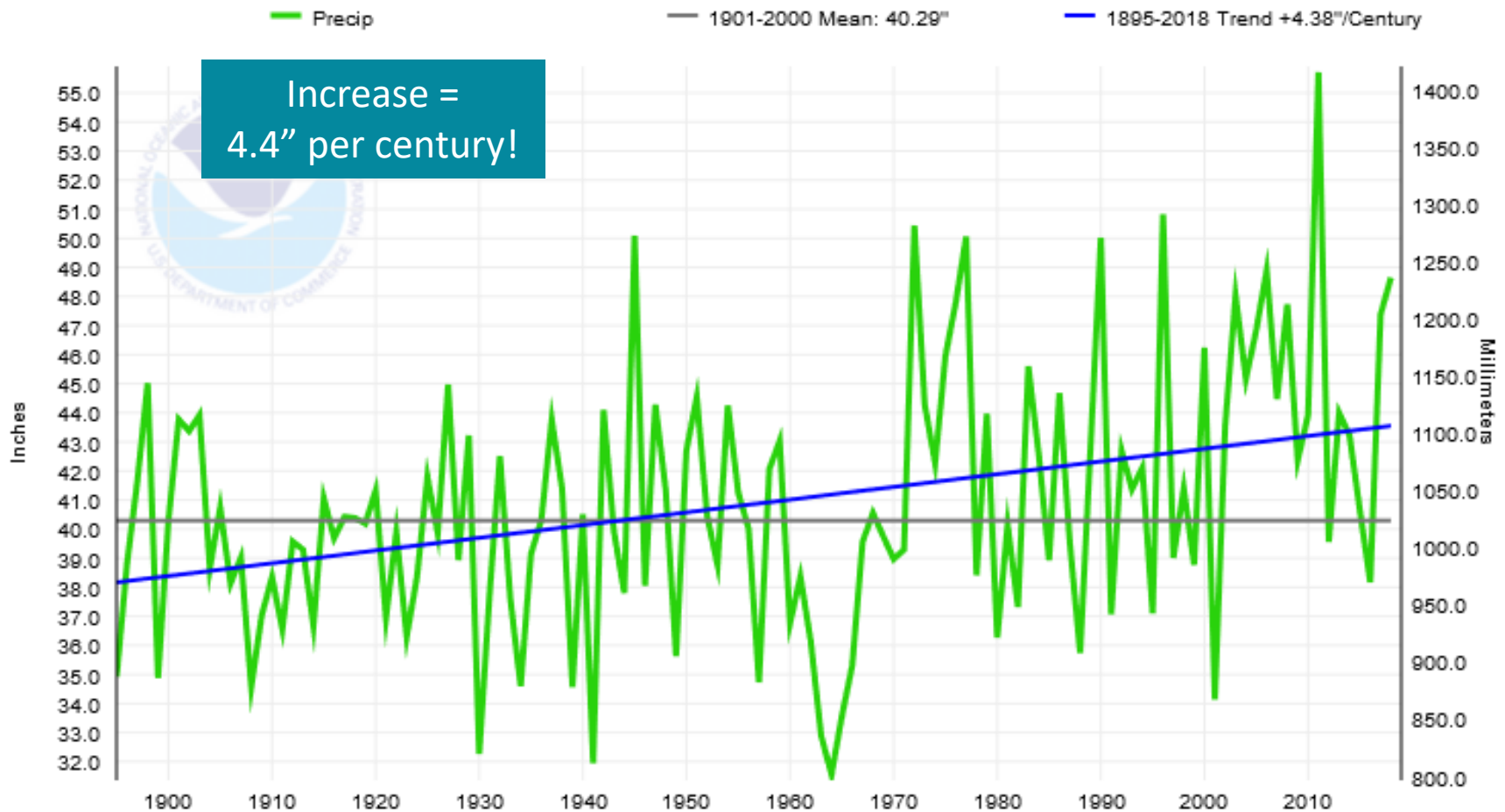
A Warmer Climate - NY

New York, Average Temperature, January-December



A Warmer Climate - NY

New York, Precipitation, January-December



Not Just Warmer Temperatures

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

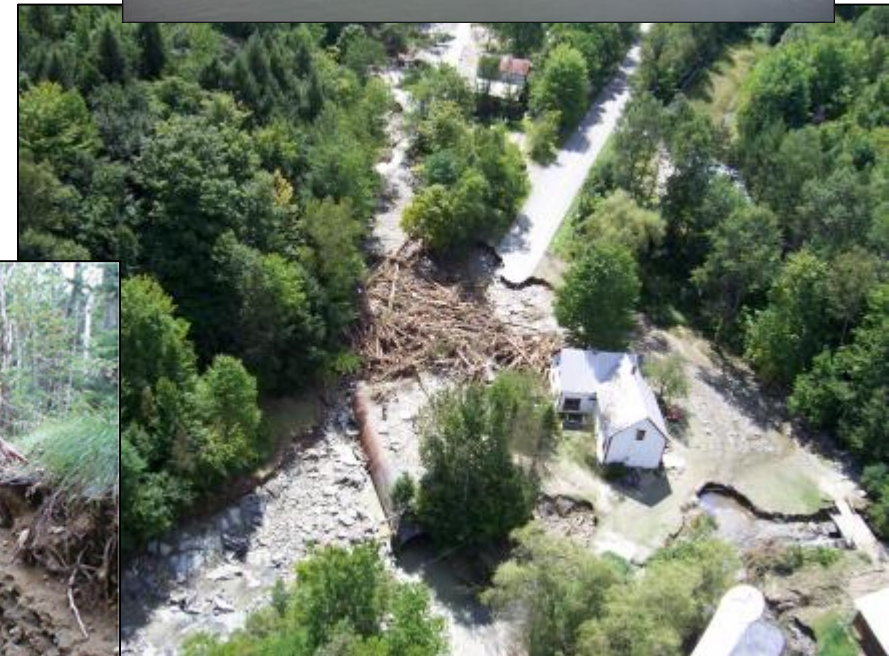
NOAA



Dan Turner, Cambridge Fire Dept.



NY DEC



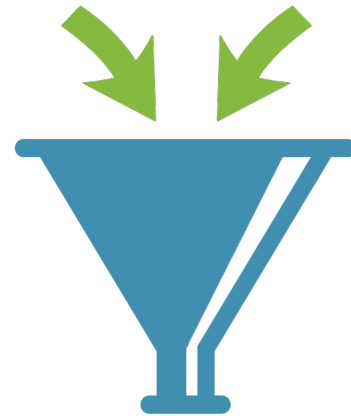
VTRANS/VT ANR

This presentation...

I'll talk about...

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

You think about...



**What's at risk in
YOUR forest?**

All models project increased temperatures.

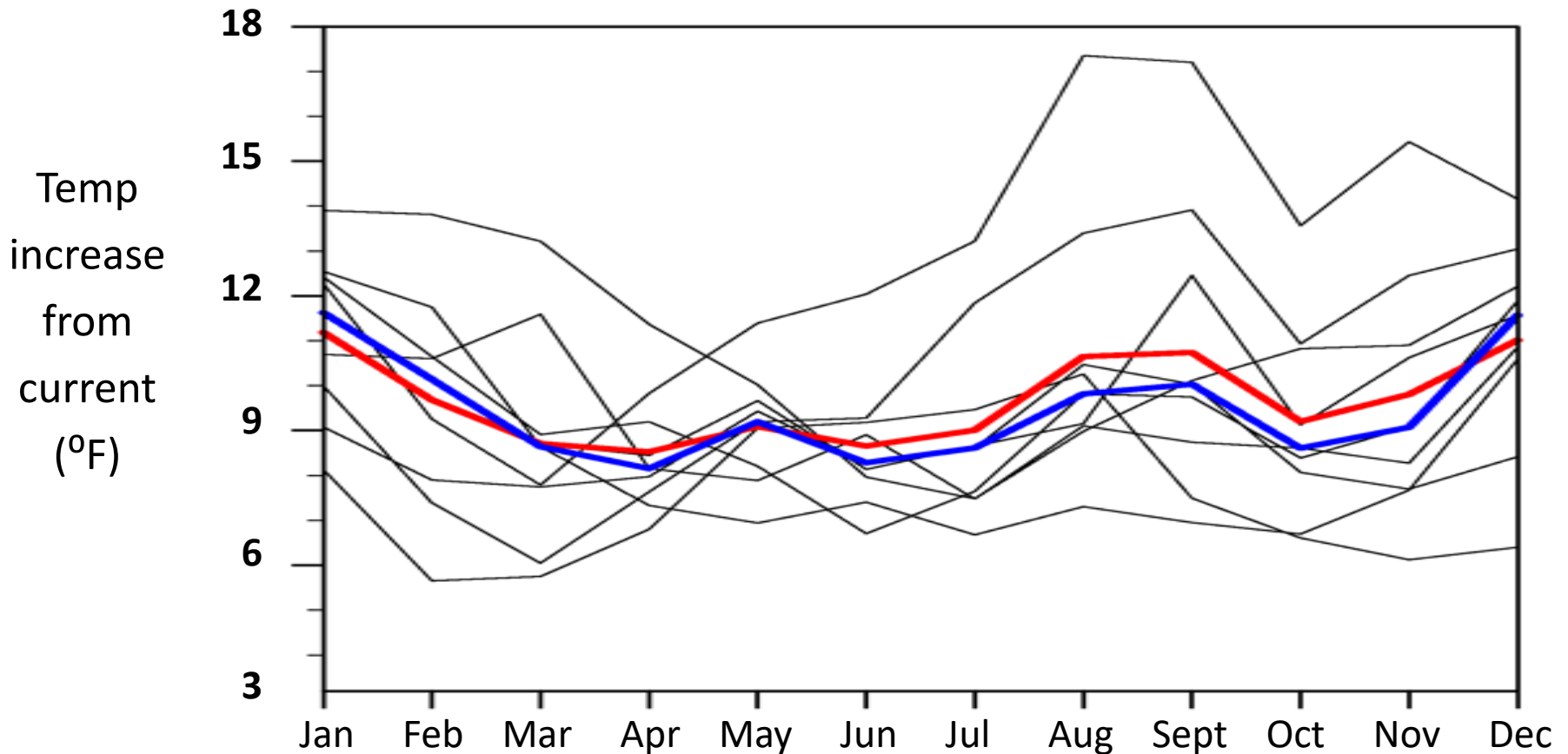
All models project warming during all months.

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

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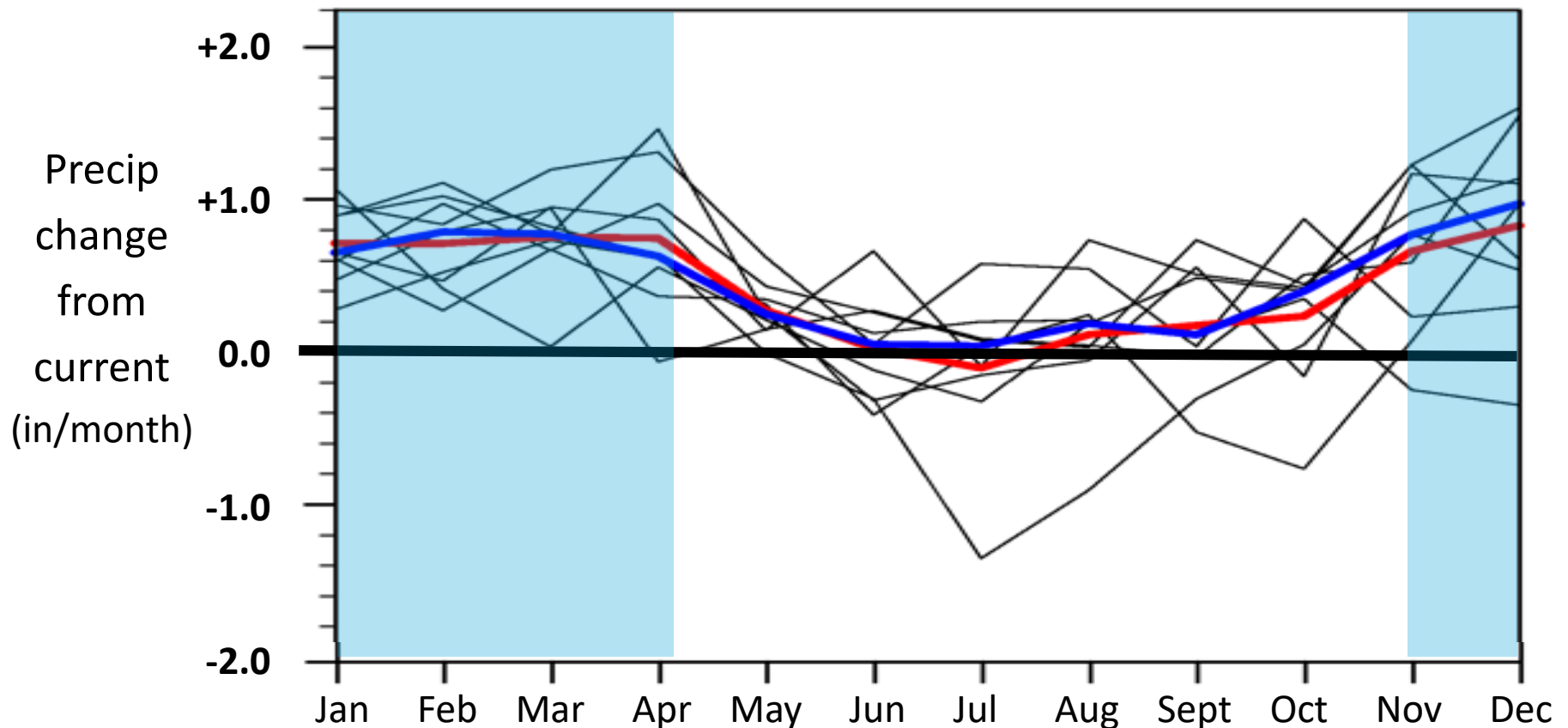
Each line = one climate model projection (16 total); Red = mean; Blue = median

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 =



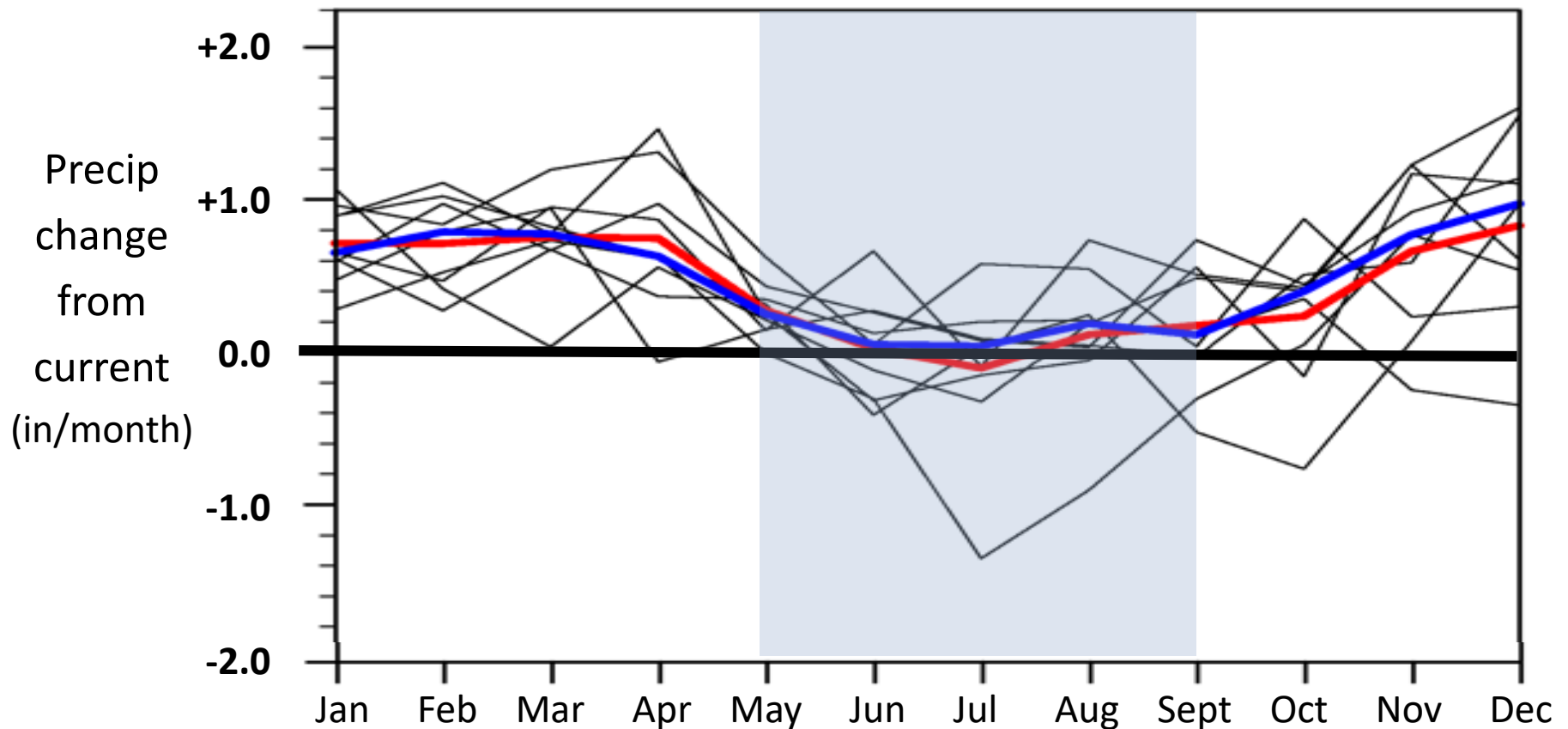
Each line = one climate model projection (9 total); Red = mean; Blue = median

Lorenz et al.

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Models project relatively unchanged precipitation during the growing season.

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Lorenz et al.

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Models project relatively unchanged precipitation during the growing season.

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

Shorter Winter (Less Snow)

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



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



What may be at risk: Increased erosion/sedimentation on susceptible sites; culvert washouts and road damage from extreme events; aquatic habitats and species

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



Longer Growing Season

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Longer period for plant growth

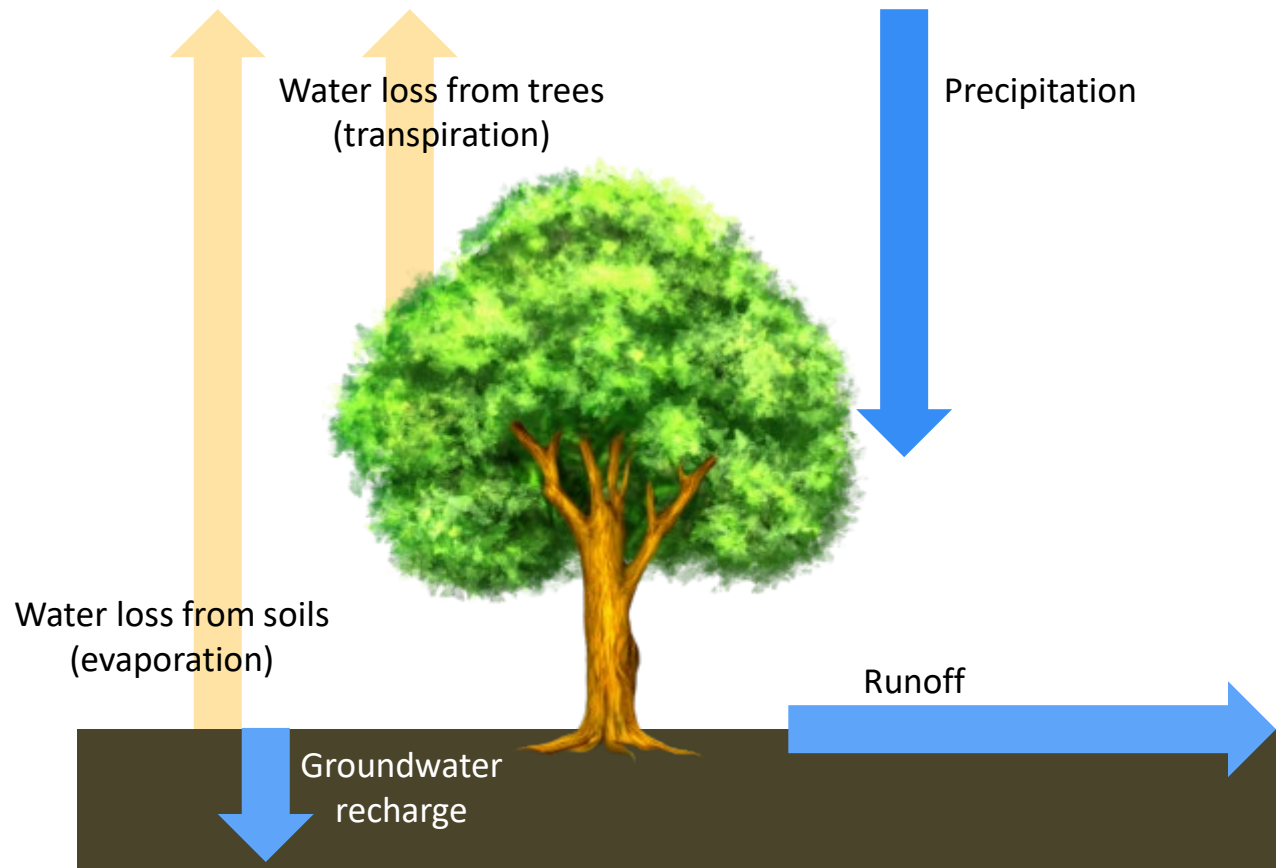
Phenological changes/mismatches

- Early bud break and frost damage from late spring freezing.



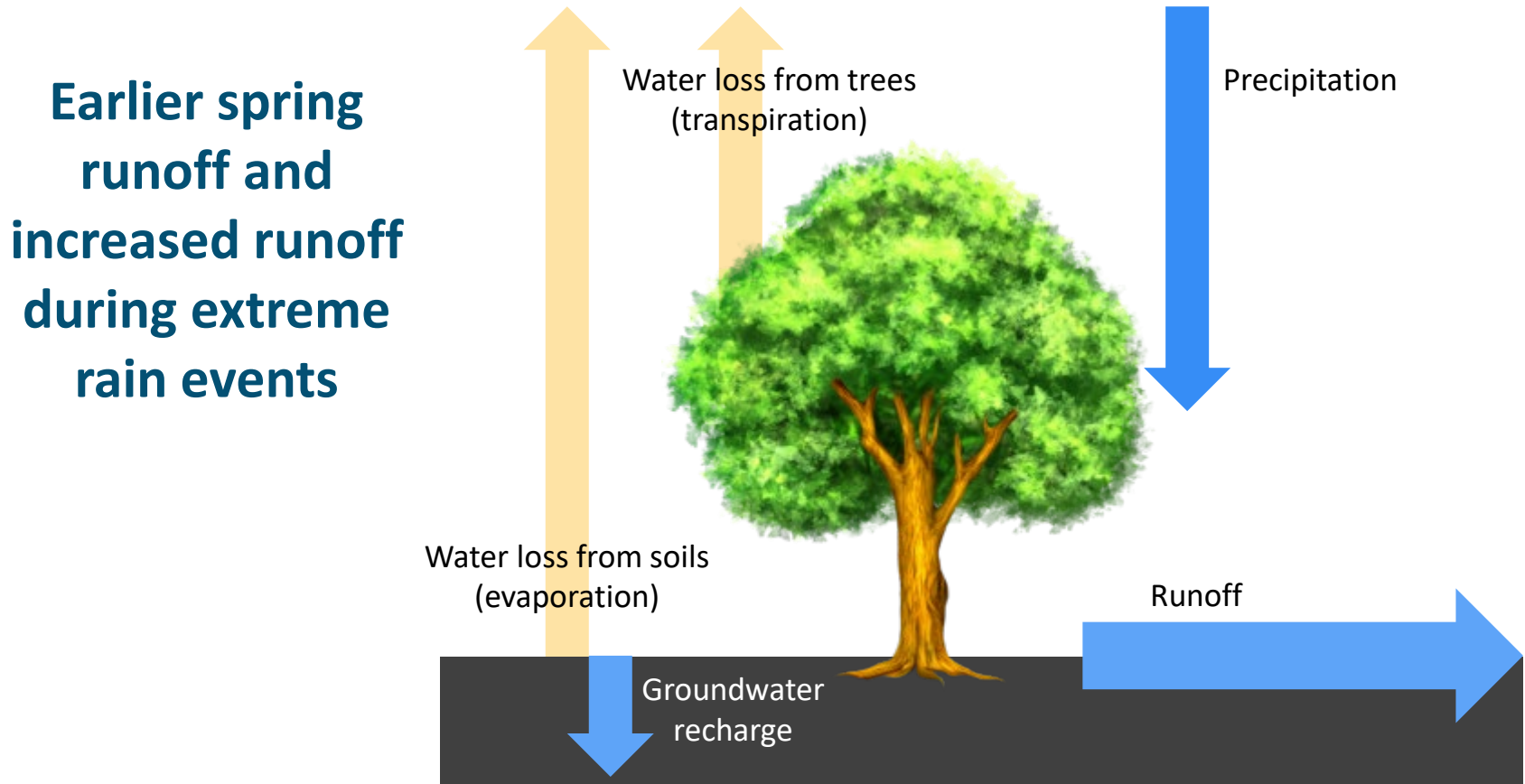
Increased Risk of Moisture Stress

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



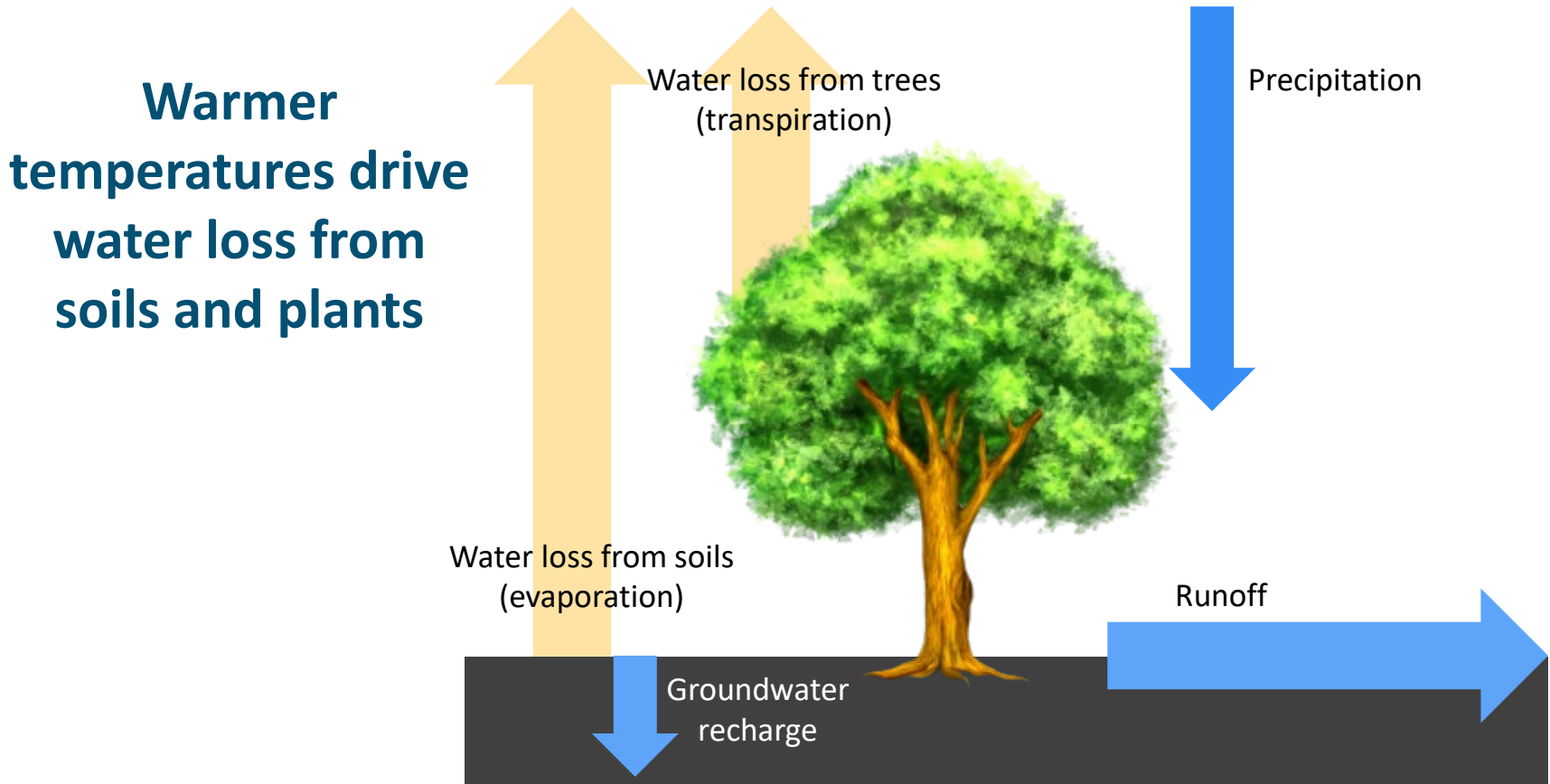
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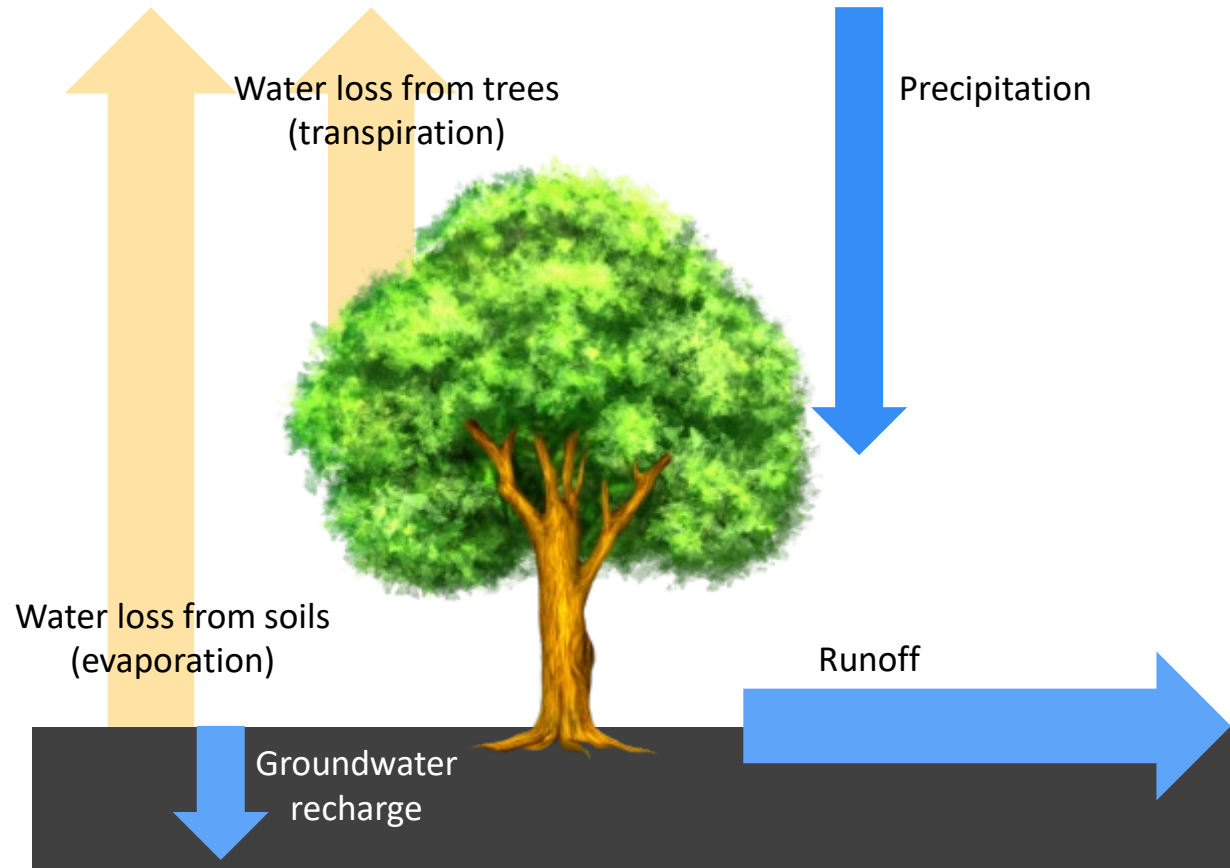


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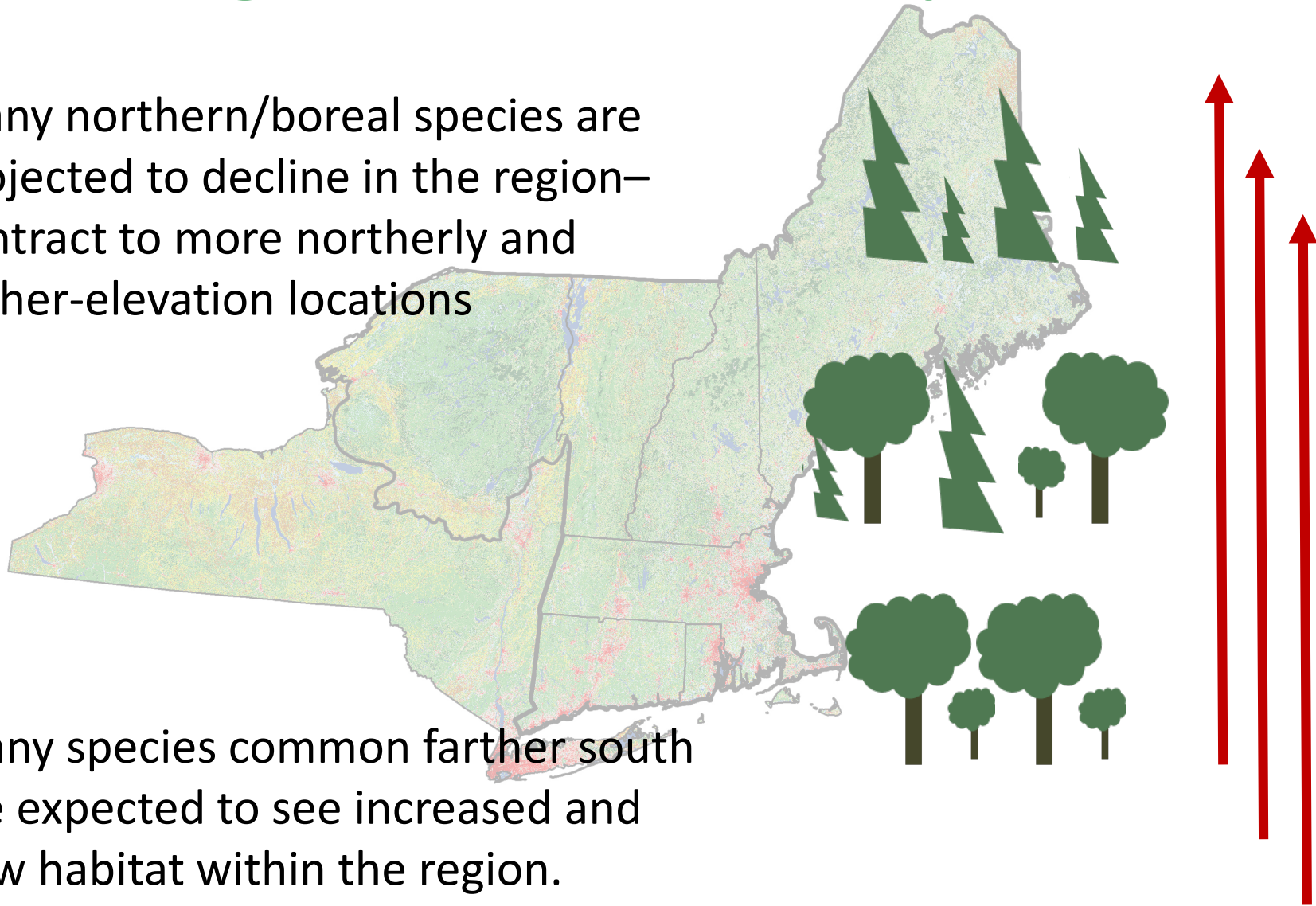
Risk may be greatest:

- 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

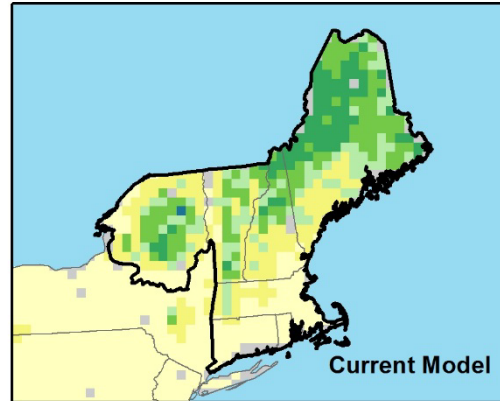


Many species common farther south are expected to see increased and new habitat within the region.

Changes in Forest Composition

Current Distribution

**Suitable Habitat:
Red Spruce
(Climate Change Atlas)**

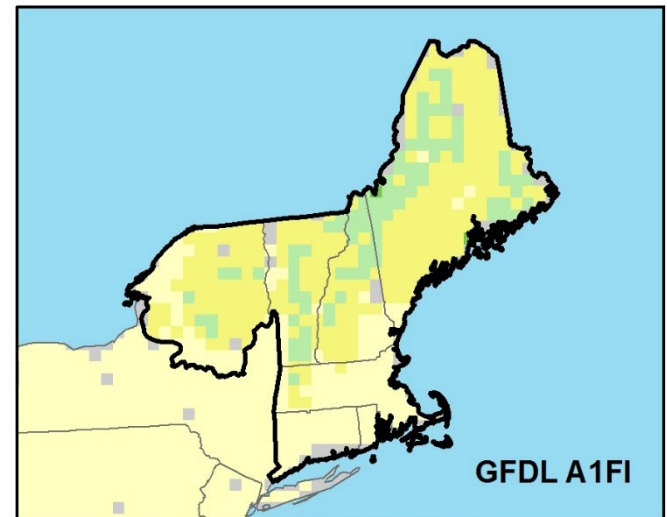
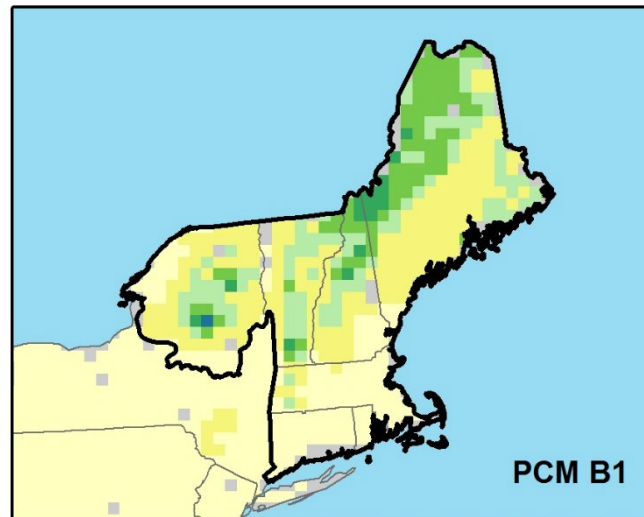


Importance Value
Low

High

2070-2100 Low

2070-2100 High

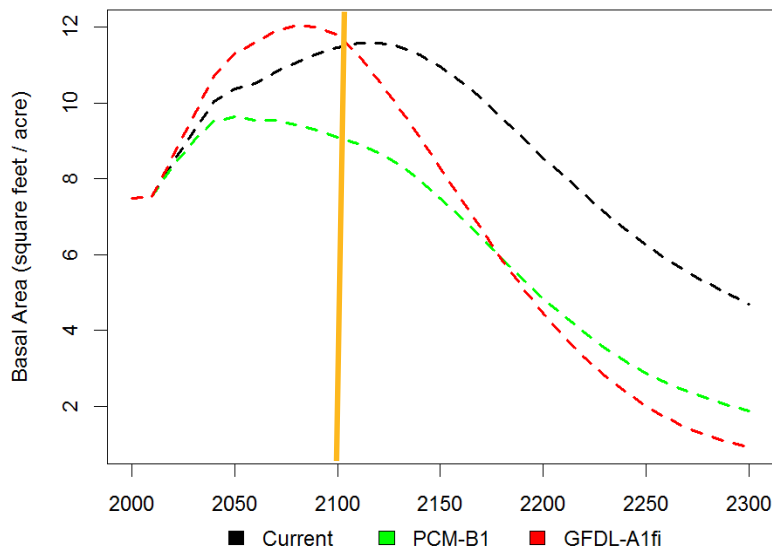


Changes in Forest Composition

Red Spruce

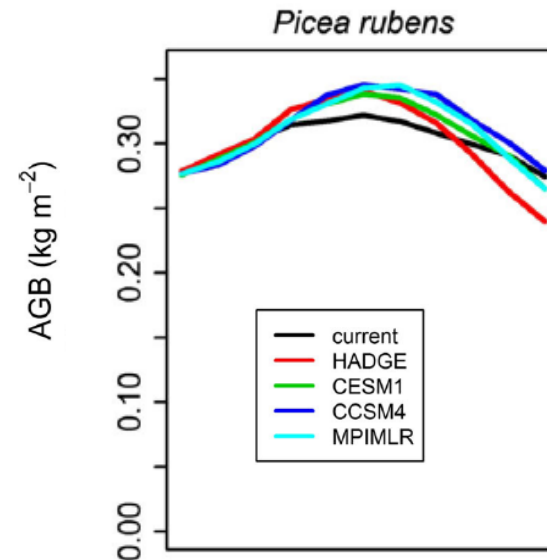
Basal Area

LANDIS-PRO



Aboveground Biomass

LANDIS-II; Duveneck et al. 2017



Changes in Forest Composition

Likely to decline

- Balsam fir
- Black, red, & white spruce
- Northern white-cedar
- Eastern hemlock
- Black ash
- Paper birch
- Quaking aspen
- Tamarack

Mixed model results

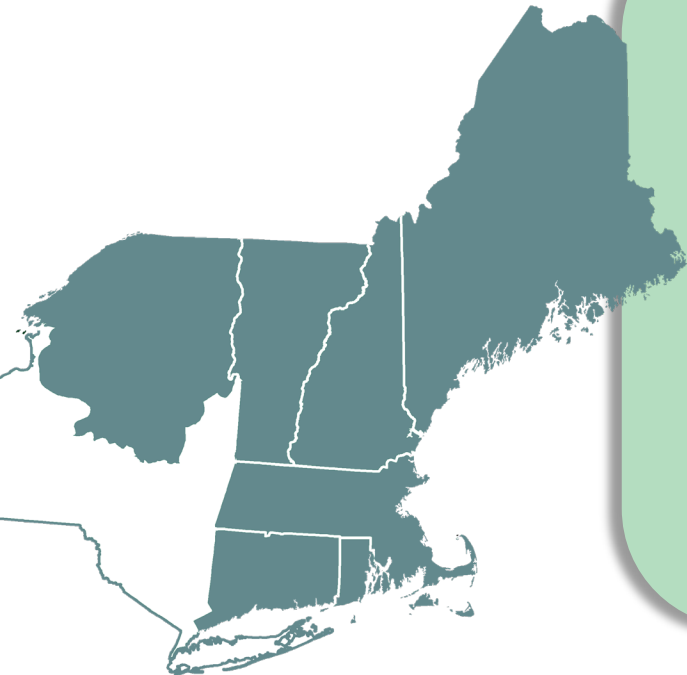
- American beech
- Sugar & red maple
- Yellow birch
- White pine

Potential “winners”

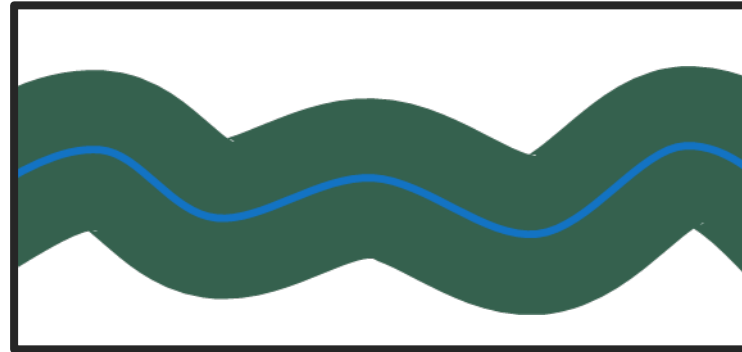
- American elm
- American basswood
- Black cherry
- Eastern hophornbeam
- Gray birch
- Northern red oak
- Serviceberry
- Silver maple
- Sweet birch
- White oak

New habitat (esp. south)

- Black hickory
- Chinkapin oak
- Common persimmon
- Hackberry
- Loblolly pine
- Osage-orange
- Shortleaf pine
- Southern red oak
- Sweetgum
- Virginia pine

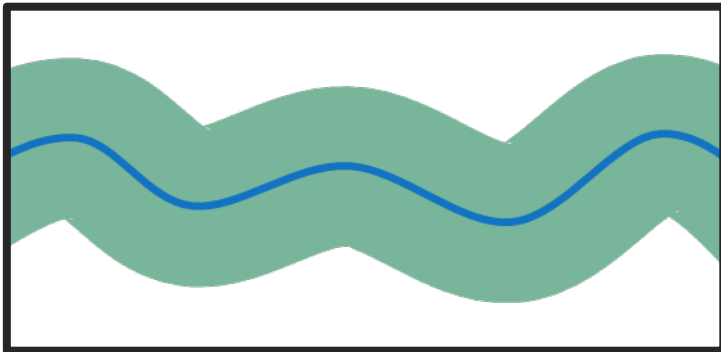


Changes in Forest Composition

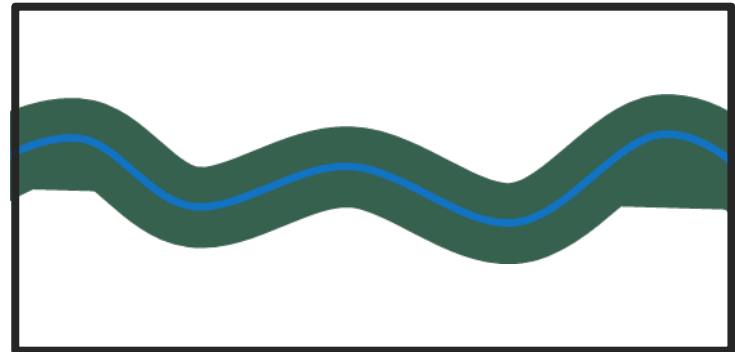


 = species X
suitable habitat

50% Reduction in Habitat:



Habitat reduced equally



Best habitats remain

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

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.

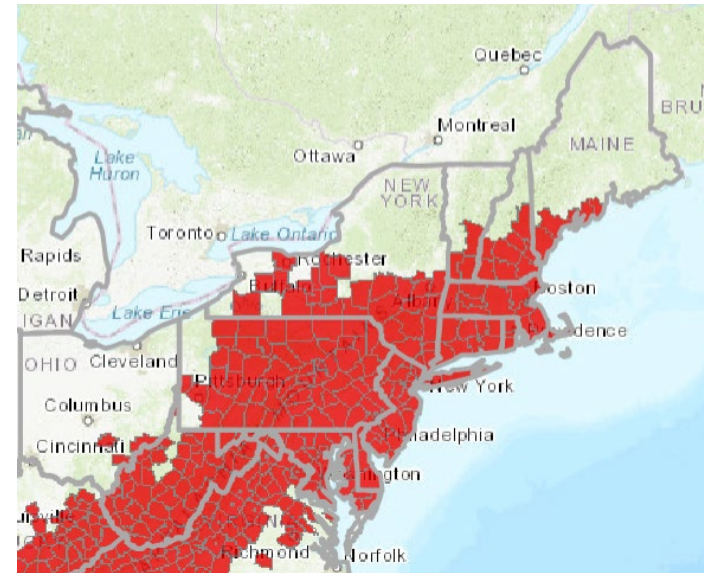
Interactions: Insects and Disease

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



Hemlock woolly adelgid incidence ~2015

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

Ayres and Lombardero 2000,
Parmesan 2006, Dukes et al. 2009,
Weed et al. 2013, Sturrock et al. 2011

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

Dukes et al. 2009, Hellman et al. 2008; Images: Invasives Plants Atlas of New England (www.eddmaps.org)

Vulnerability: *Forest Communities*

Forest communities will be affected differently

Forest system	Potential impacts	Adaptive capacity	Vulnerability
Central hardwood-pine	Neutral-Positive	Moderate-High	Low
Low-elevation spruce-fir	Neutral-Negative	Moderate	Moderate-High
Lowland/riparian hardwood	Positive and Negative	Moderate-High	Moderate
Lowland mixed conifer	Neutral-Negative	Low-Moderate	Moderate-High
Montane spruce-fir	Neutral-Negative	Moderate	Moderate-High
Northern hardwood	Positive and Negative	Moderate-High	Low-Moderate
Pitch pine-scrub oak	Neutral-Positive	Moderate	Low
Transition hardwood	Positive and Negative	Moderate-High	Low-Moderate

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.



