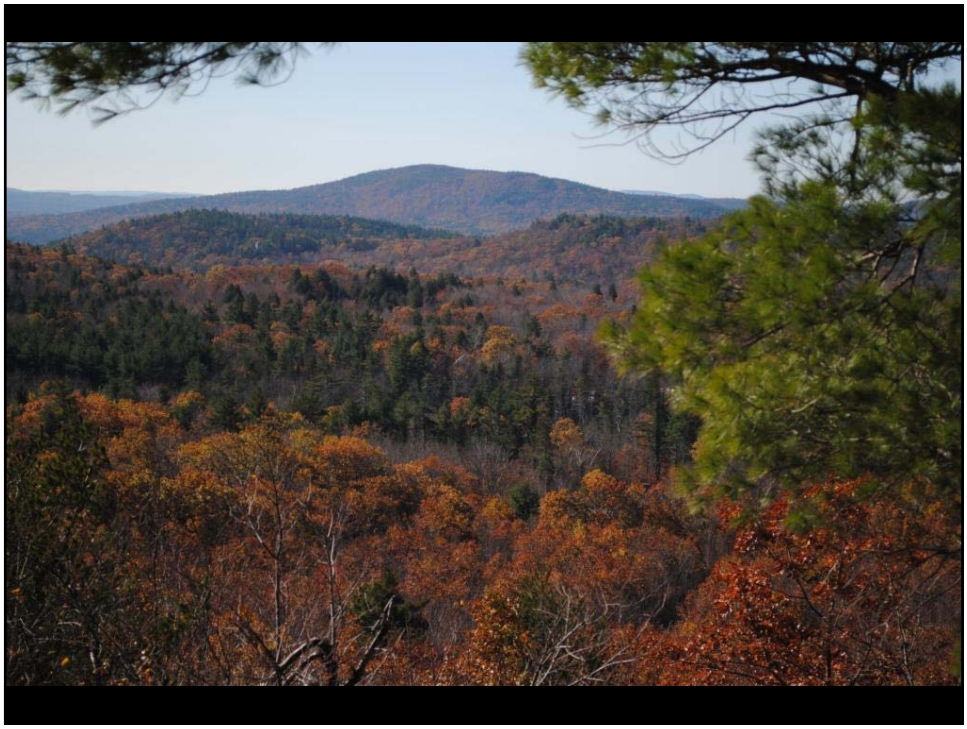


Pine-Oak-Hemlock in the Northeast

Silvics, Dynamics, Climate Change, Restoration

Tom Lee
Department of Natural Resources and the Environment
University of New Hampshire

Topics

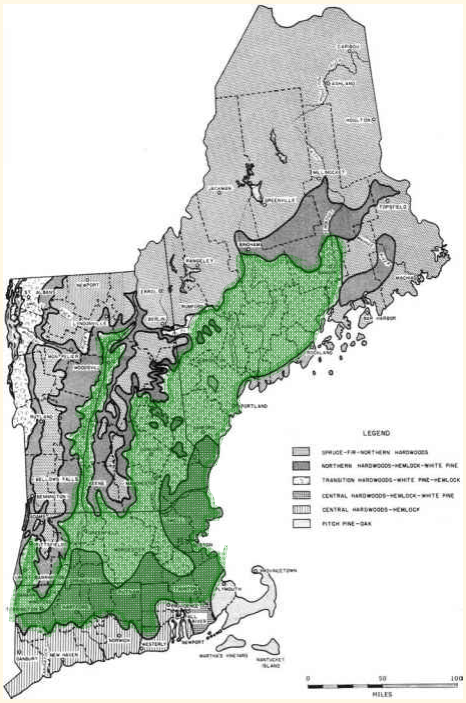
- Where is pine-oak-hemlock forest?
- Silvics of individual species
- Succession and stand dynamics, including the effects of land use history
- Climate change adaptation and restoration

Forest Types of New England

(Westveld et al. 1956)

"Transition hardwoods – white pine – hemlock"

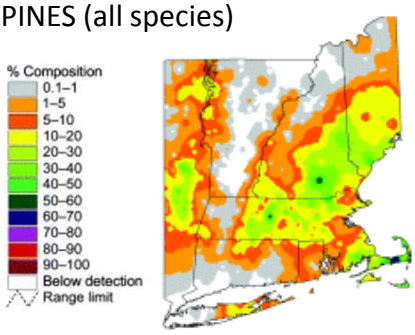
"Central hardwoods – hemlock – white pine"



Pine

HISTORIC

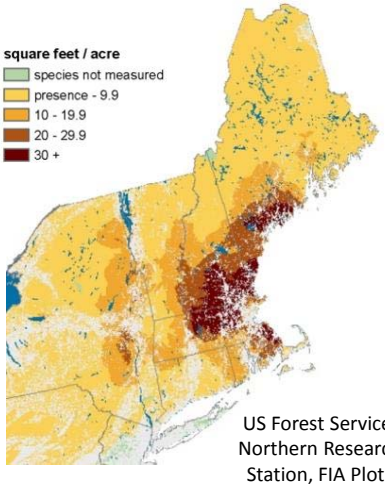
PINES (all species)



At the time of first surveys
from witness trees
(Cogbill et al. 2002, J. Biogeography)

PRESENT

EASTERN WHITE PINE

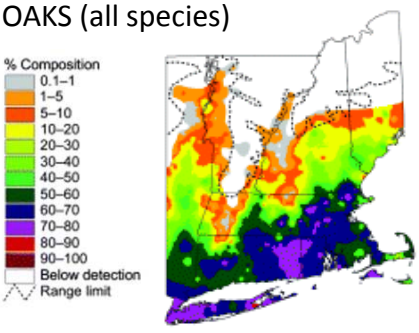


US Forest Service,
Northern Research
Station, FIA Plots

Oak

HISTORIC

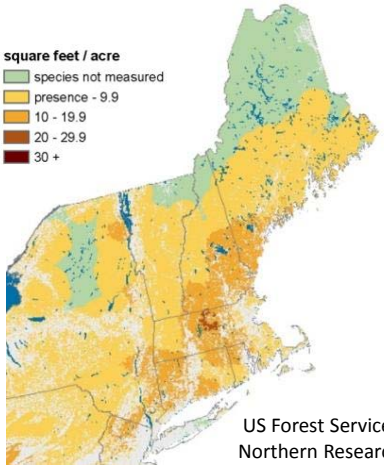
OAKS (all species)



At the time of first surveys
from witness trees
(Cogbill et al. 2002, J. Biogeography)

PRESENT

NORTHERN RED OAK

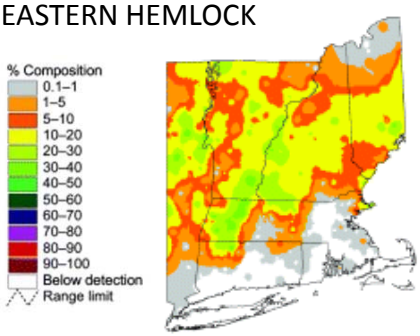


US Forest Service,
Northern Research
Station, FIA Plots

Hemlock

HISTORIC

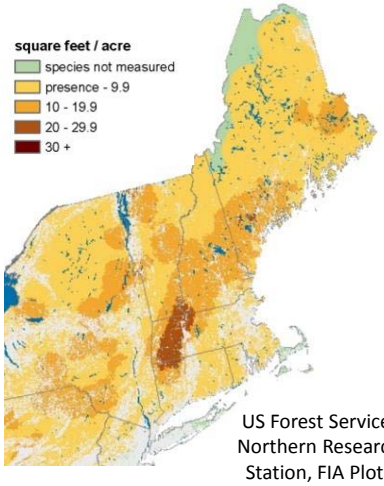
EASTERN HEMLOCK



At the time of first surveys
from witness trees
(Cogbill et al. 2002, J. Biogeography)

PRESENT

EASTERN HEMLOCK



US Forest Service,
Northern Research
Station, FIA Plots

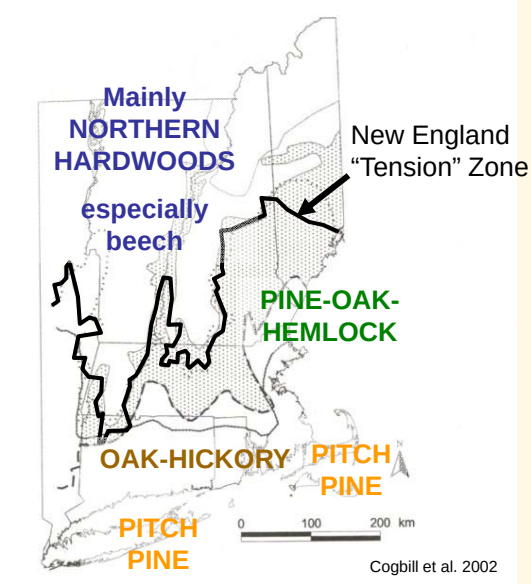
Most frequent occurrence of pine - oak - hemlock

Why here?

Pre-European Vegetation in New England

Based on "witness trees" listed in early land surveys

(Cogbill et al. 2002)

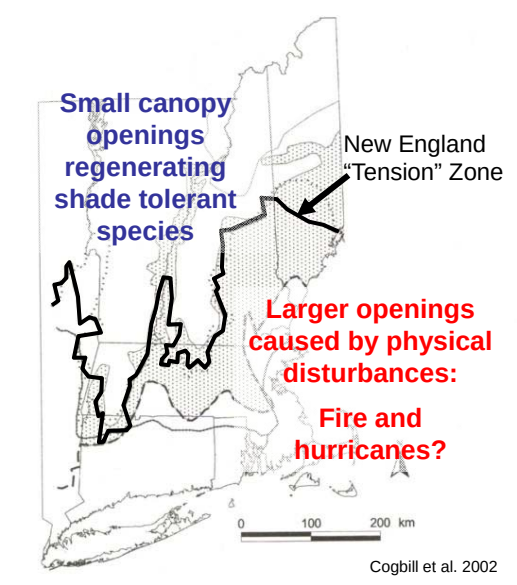


Pre-European Vegetation in New England

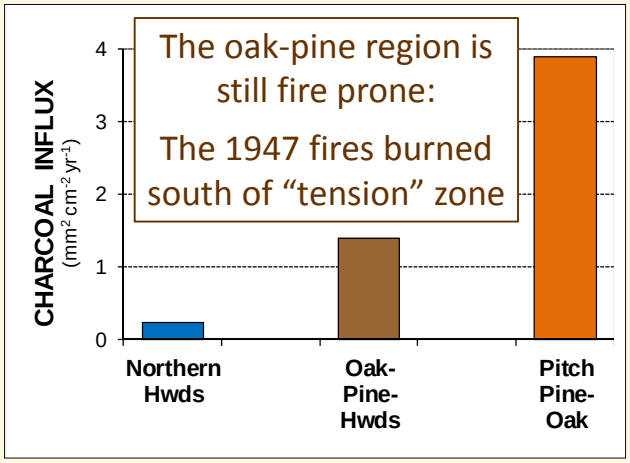
Why the pattern?

Climate?

Disturbance regime?

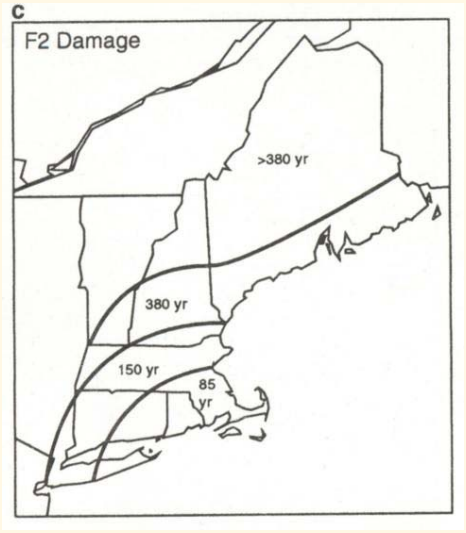


Fire: Charcoal in lake sediments



Calculated from Parshall and Foster (2002)

Hurricane damage

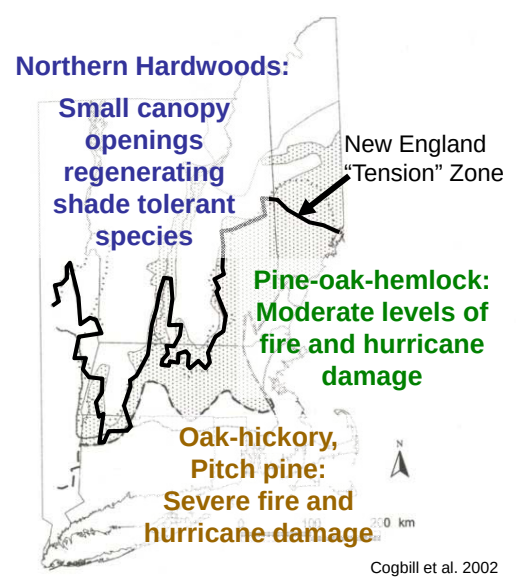


F2 damage: Large trees snapped or uprooted

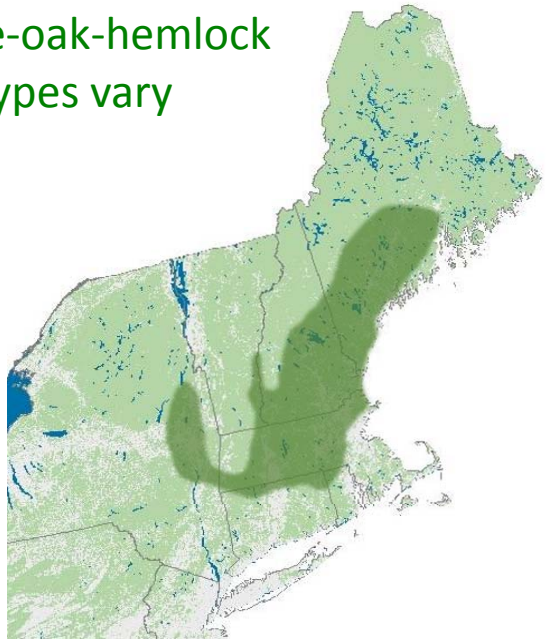
Boose et al. (2001)

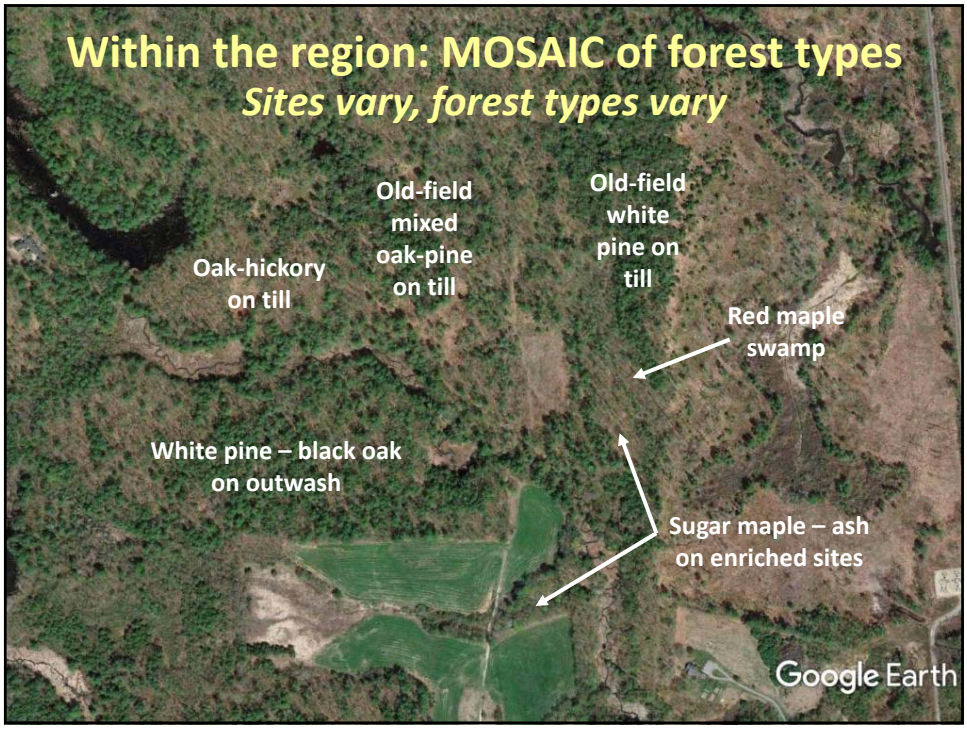
Pre-European Vegetation in New England

Summary of possible controlling factors



Within the pine-oak-hemlock region, forest types vary



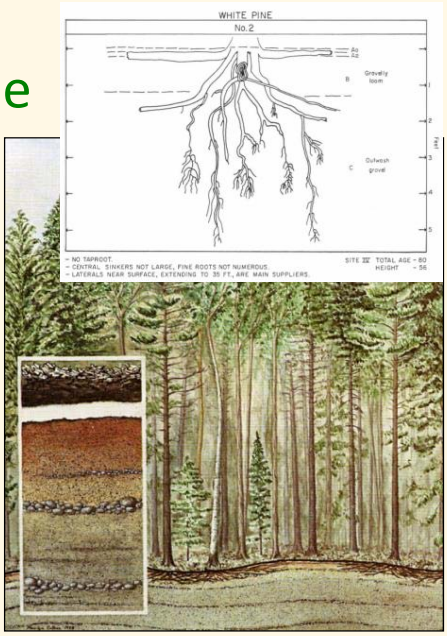


Topics

- Where is pine-oak-hemlock forest?
- Silvics of individual species
  - *Site affinity*
  - *Life history characteristics*
- Succession and stand dynamics, including the effects of land use history
- Climate change adaptation and restoration

Eastern White Pine

- Naturally occurs on excessively drained soils
  - *Coarse texture (sands, sandy loams)*
  - *Glacial outwash*
  - *Dry, nutrient poor*
- Pine is drought tolerant
  - *Not as much as oaks*
  - *Produces "sinker roots" in deep coarse soils (up to 15' deep)*



Leak and Riddle (1979)

Eastern White Pine

- More common on poorer soils…
- BUT – *growth* is better on moist, fertile soils
- Limited to poorer soils by vigorous competition on better sites

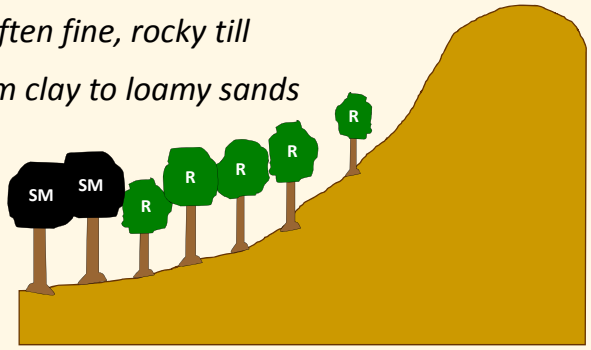
Eastern Hemlock

- Associated with shallow soils
  - *Shallow to bedrock or hard pan*
  - *Rocky, often just loose rock*
- Soils can be wet
- Sometimes on sandy soils
- BUT: as in pine, *growth* is better on moist, fertile soils

Northern Red Oak

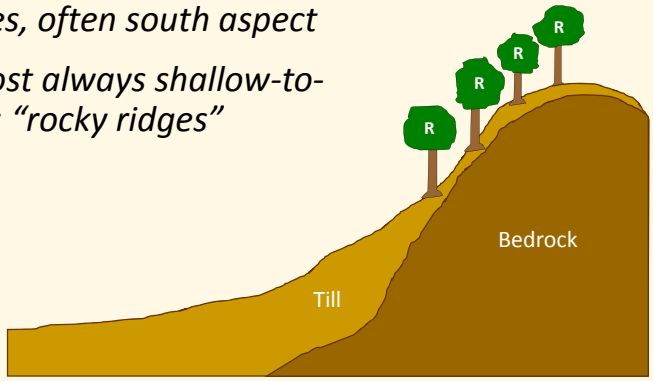
- In southern, central parts of region:
  - *Often on middle and lower slopes*
  - *Substrate: Often fine, rocky till*
  - *Texture: From clay to loamy sands*

Competition from other mesic hardwoods



Northern Red Oak

- Northern edge of region
  - *Mid- and upper-slopes, ridges, often south aspect*
  - *Almost always shallow-to-rock: "rocky ridges"*

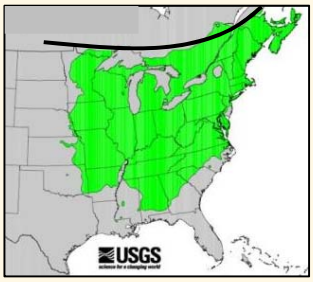


Northern Red Oak: Interactions

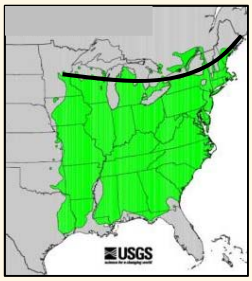
- Grows best on moist enriched sites
  - *But competitively displaced there by sugar maple*
- On moist, fertile till sites: *Displaces pine*

  but…
- On dry, less fertile sites: *Outgrown by pine*

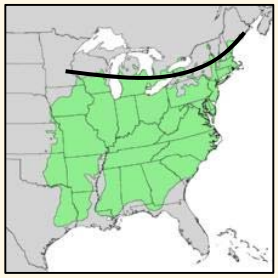
The other oaks…



Northern Red Oak



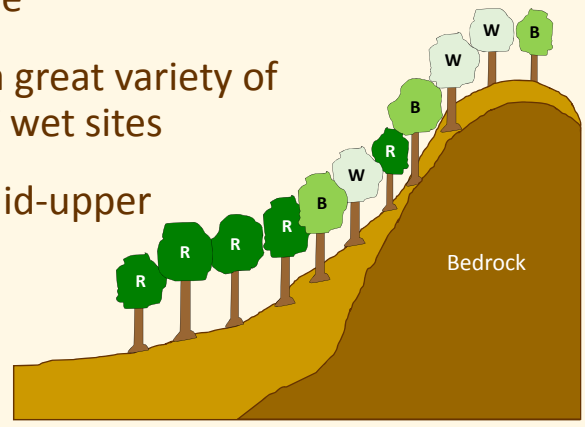
White Oak



Black Oak

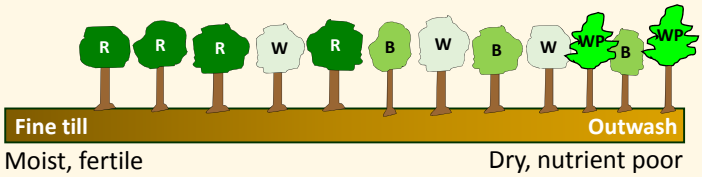
Black Oak, White Oak

- Less abundant in northern portion of zone
- *Can* grow on a great variety of sites, but NOT wet sites
- Typically on mid-upper slopes



Black Oak, White Oak

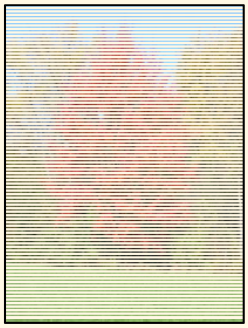
- Also occur on dry, coarse-textured soils



- More tolerant of stress than red oak
- Displaced to warmer, drier, less fertile sites by COMPETITION with red oak and others
- Mix with white pine on coarse soils

Red Maple

- Incredibly broad tolerances to moisture level and soil fertility
- Persists in standing water
  - *Forms pure stands in flooded areas*



- Occurs with black and white oak on ridges

Sweet Birch

- Avoids extremely dry or wet sites
- Grows on shallow rocky soils, deep sandy soils

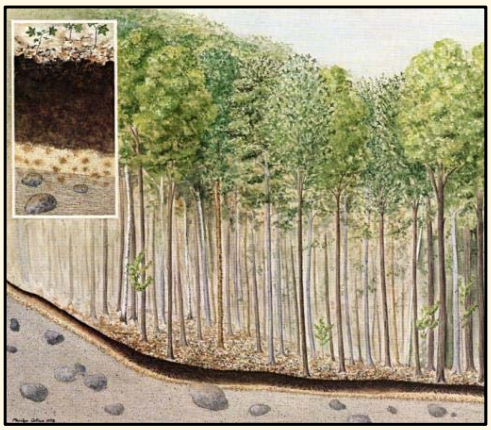
American Beech

- Associated with deep, well-drained coarse till, or washed glacial till
- Not as flood tolerant as red maple or ash
- Reduced on enriched sites by competition with sugar maple

Leak and Riddle (1979)

Sugar Maple, White Ash

- Associated with moist, fertile ("enriched") sites
  - *Less acidic*
  - *High levels of calcium*
- Lower slopes, coves, fine marine deposits



Leak and Riddle (1979)

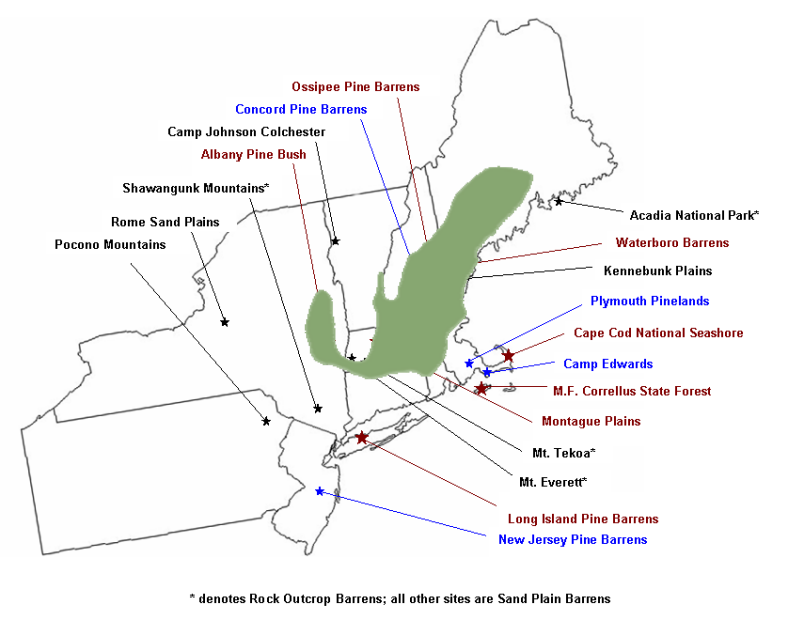
Paper Birch, Gray Birch, Quaking (& bigtooth) Aspen

- Fairly broad tolerances to physical factors

Pitch Pine

- Naturally occurs on dry, sandy outwash, ridges
- Drought tolerant
- Promoted by – and tolerant of – fire

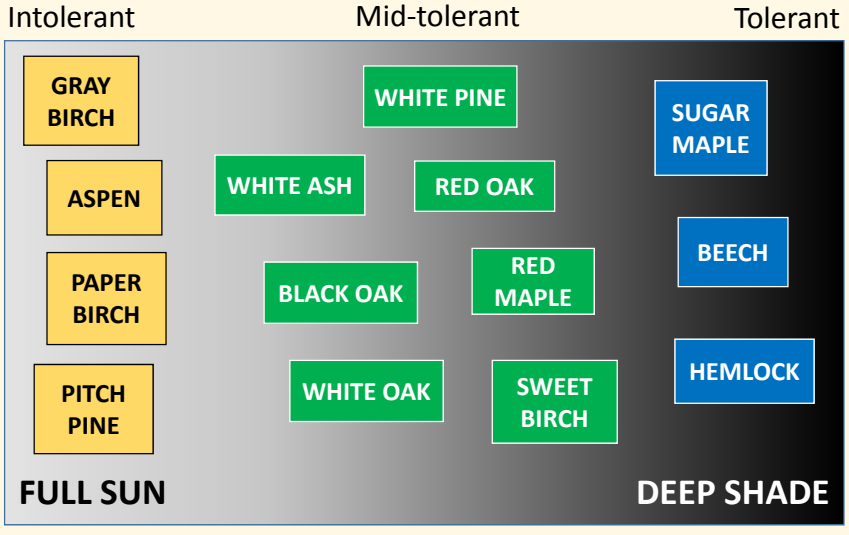
Pitch Pine Barrens in the Northeast



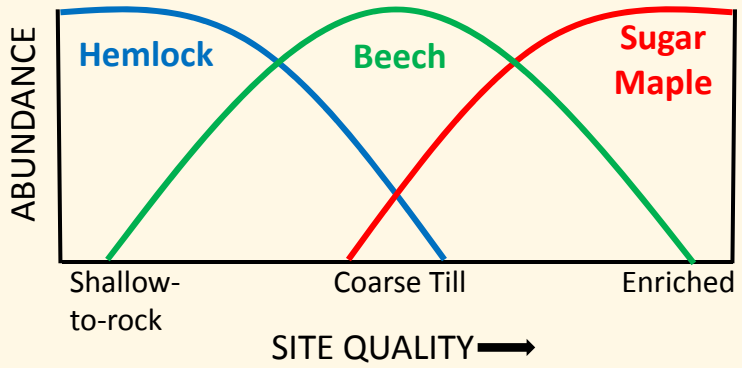
Topics

- Where is pine-oak-hemlock forest?
- Silvics of individual species
  - *Site affinity*
  - *Life history characteristics*
- Succession and stand dynamics, including the effects of land use history
- Climate change adaptation and restoration

Shade tolerance



Shade tolerant species and site



Regeneration characteristics

- Eastern white pine
  - *Irregular, large seed crops*
  - *Site scarification aids establishment*
- Oaks
  - *Irregular seed crops*
  - *Animal-dispersed*
  - *Burying aids establishment*
- Eastern hemlock
  - *Low fecundity, poor dispersal*
  - *Advance regeneration*
  - *Scarification aids establishment*

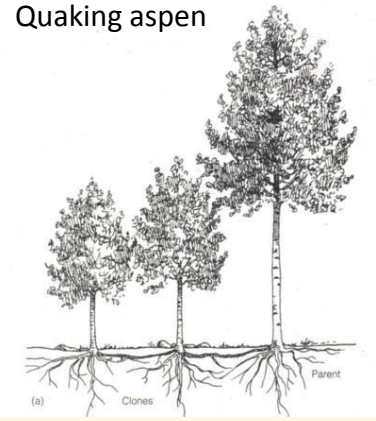
TIMING OF TREATMENT IS IMPORTANT!


Hemlock advance regen

Regeneration characteristics

- ROOT SPROUTERS

Quaking aspen



American beech

Regeneration characteristics

- ROOT SPROUTERS
  - *Aspen* — **(+) USEFUL IN PROMOTING ASPEN AFTER LOGGING**
  - *Beech* — **(-) MAY DOMINATE UNDERSTORY**
    (-) ALLOWS POST-LOGGING RESPONSE
- STUMP SPROUTERS
  - *Most of the hardwoods: OAKS, RED MAPLE, SWEET BIRCH*

Regeneration characteristics

- STUMP SPROUTERS

Eli Sagor, University of MN Extension

Growth characteristics

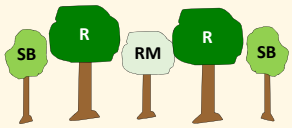
- Eastern white pine
  - *Height growth slow first few years*

Third year

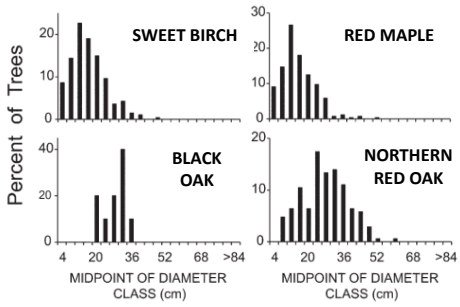
Fifth year

Growth characteristics

- Northern red oak
  - *Remarkable height and radial growth*
  - *Can overtop other mid-tolerant species of same age*



Diameter distributions 60 years after 1938 hurricane
College Woods, NH



	R. OAK	BIRCH	MAPLE
50-year radial growth (mm)	107	75	68

Topics

- Where is pine-oak-hemlock forest?
- Silvics of individual species
- Succession and stand dynamics, including the effects of land use history
- Climate change adaptation and restoration

Stand dynamics (focus on uplands)

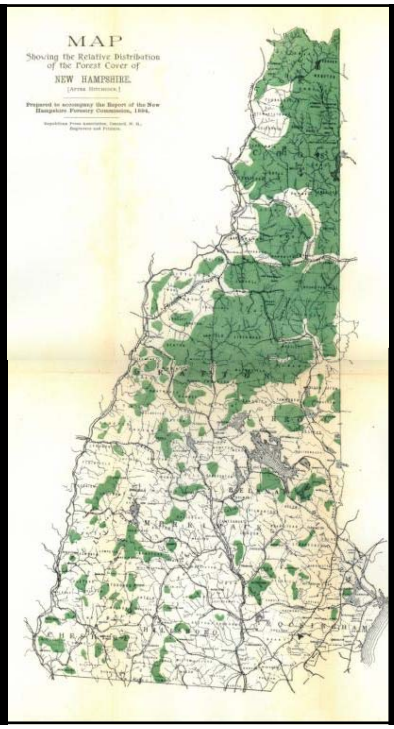
- Old-field succession
- Succession after clear-cutting
- Effects of opening size on stand dynamics

Old-field succession

- 1600-1850: Much of pine-oak-hemlock region deforested for agriculture
- Late 19th Century: most land in pasture or cultivation

Height of agriculture (1830)

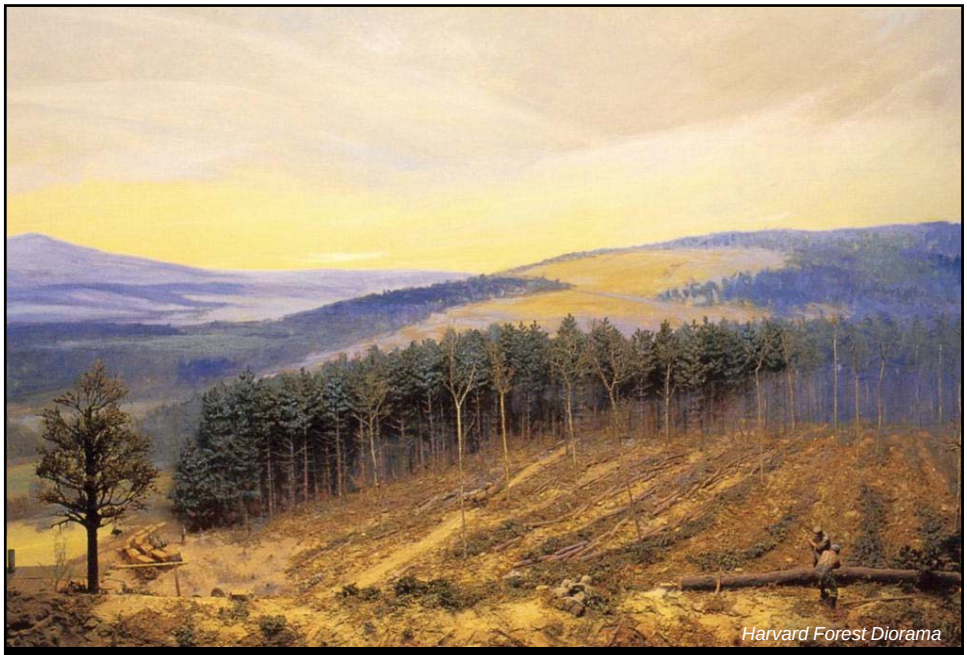
Distribution of forest in New Hampshire in 1894



"Old-field" white pine on abandoned pasture

Why pine successful in old fields?

1) Pine competes well with herbaceous plants
2) Takes time for other woody plants to arrive on-site and compete
3) Meadow voles – a common herbivore – prefer hardwood seedlings *(Ostfeld et al. 1993, 2001)*



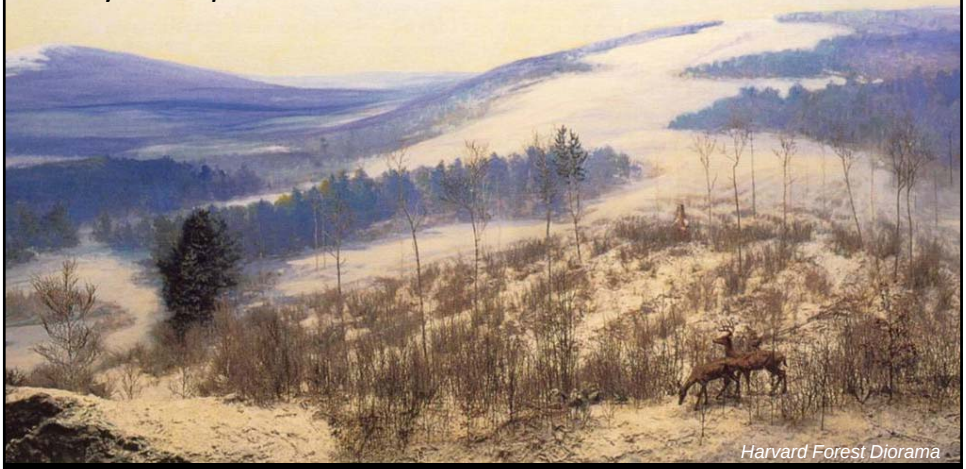
Logging “old-field” White Pine on Abandoned Land (1910)

Stand dynamics (focus on uplands)

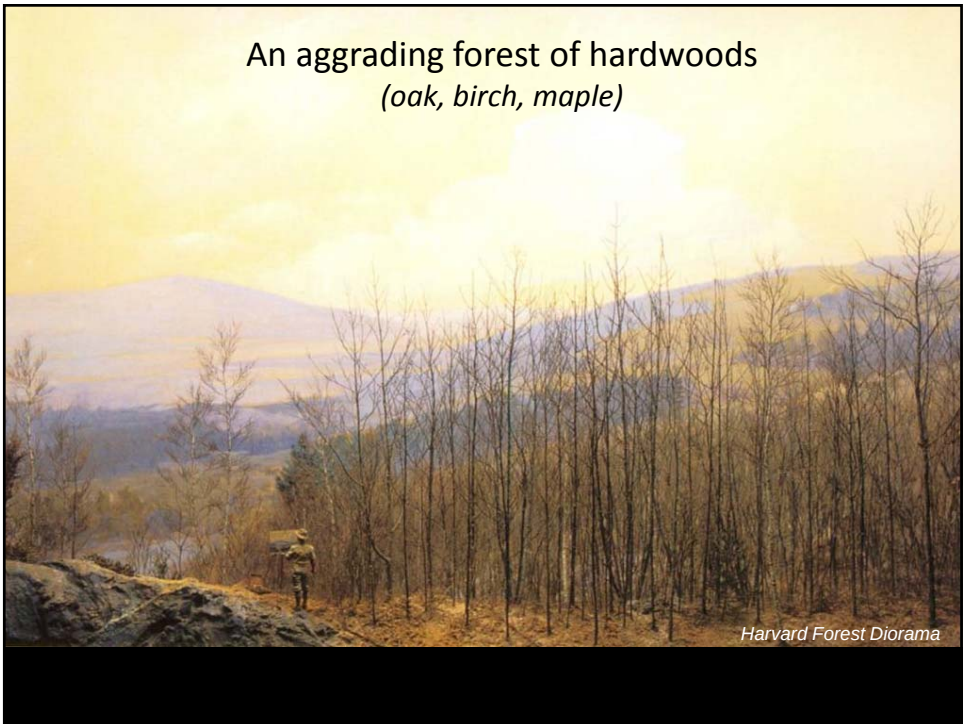
- Old-field succession
- Succession after clear-cutting
- Effects of opening size on stand dynamics

On most sites, logged white pine succeeded by hardwoods, *not* white pine!

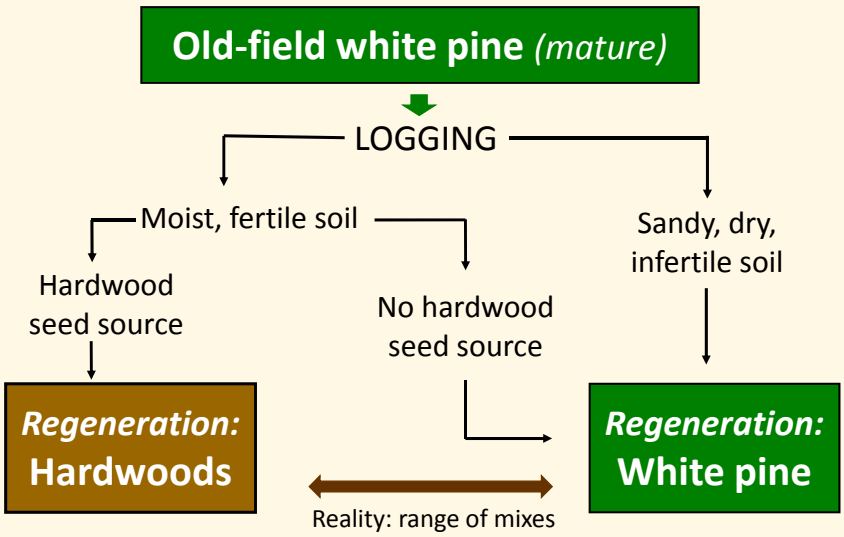
Why? *Competition with hardwoods*



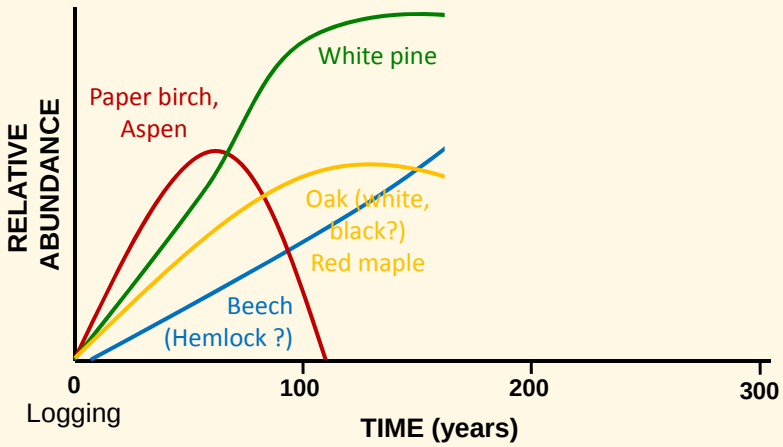
An aggrading forest of hardwoods
(oak, birch, maple)



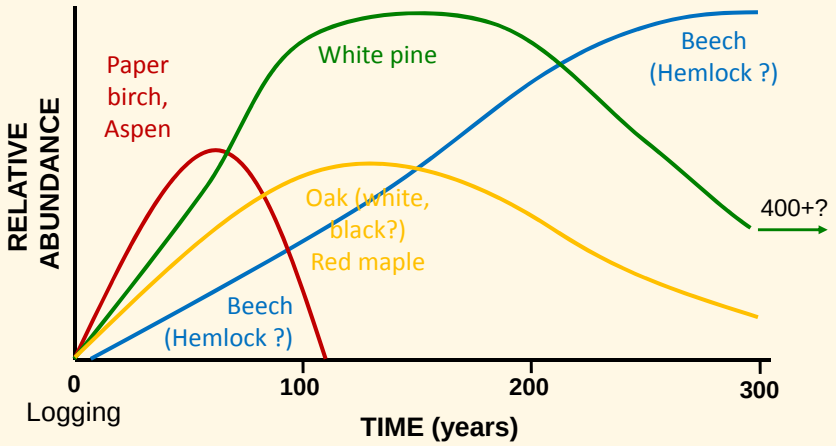
In fact, post-logging regeneration is site dependent…



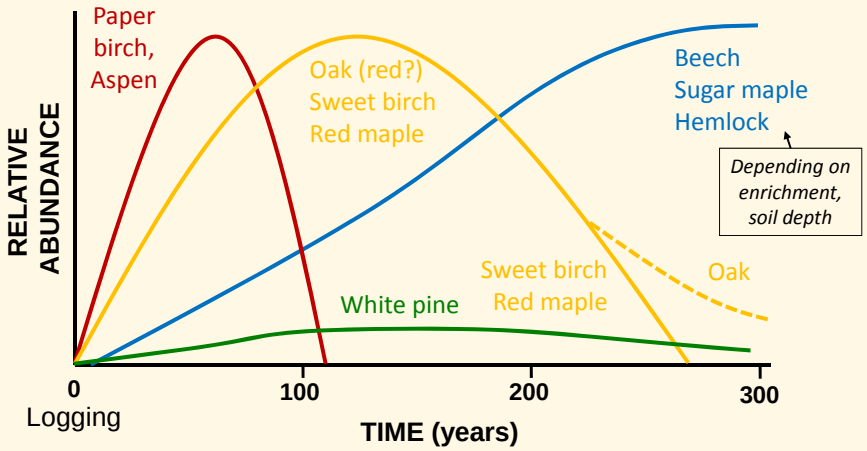
Succession on dry outwash *(post-logging)*



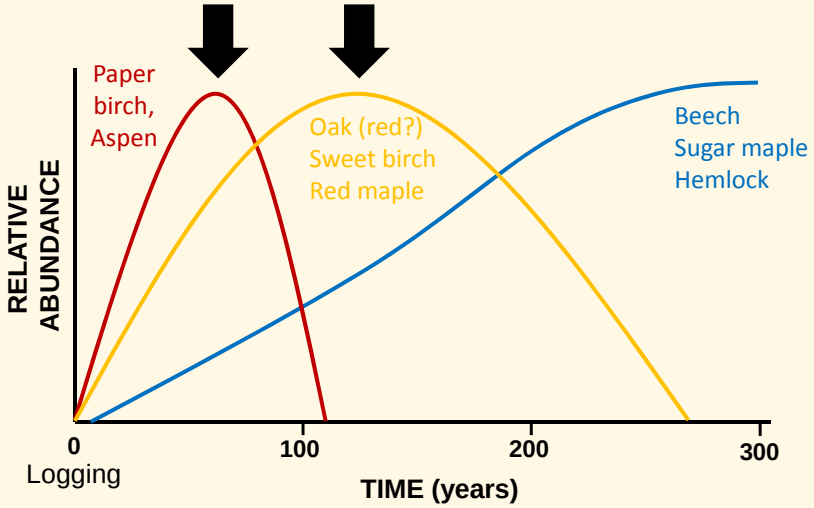
Succession on dry outwash *(post-logging)*



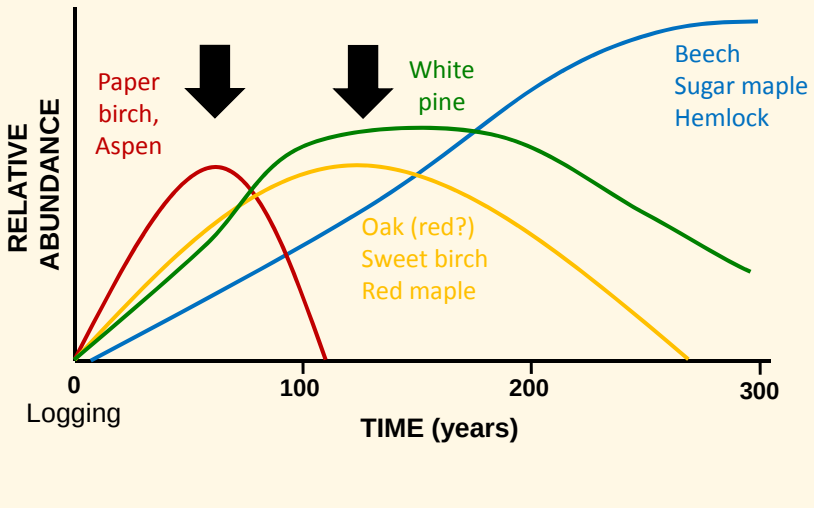
Succession on moist, fine till *(post-logging)*



To get pine on mesic till



To get pine on mesic till



Stand dynamics (focus on uplands)

- Old-field succession
- Succession after clear-cutting
- Effects of opening size on stand dynamics
  - *Relevance to silvicultural systems*

Relevance to silvicultural systems

- Large openings (> 1/4 acre)
  - *Regenerate most species*
  - *REQUIRED for paper birch, aspen*
  - *Allow faster growth of oak and pine*

Relevance to silvicultural systems

- Group selection
  - *Favors mid-tolerant hardwoods*
  - *Especially sweet birch, red maple, red oak*
  - *To some extent, pine (depends on site, size)*

Relevance to silvicultural systems

- Single-tree selection
  - *Favors shade tolerant species*

beech

sugar maple

hemlock

Topics

- Where is pine-oak-hemlock forest?
- Silvics of individual species
- Succession and stand dynamics, including the effects of land use history
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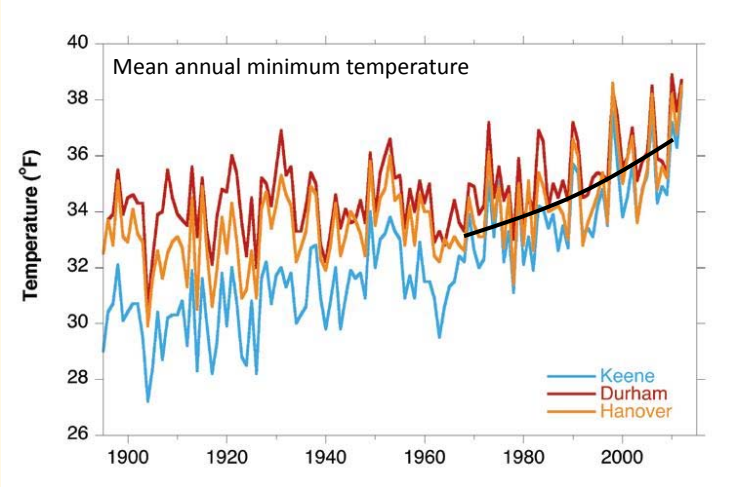
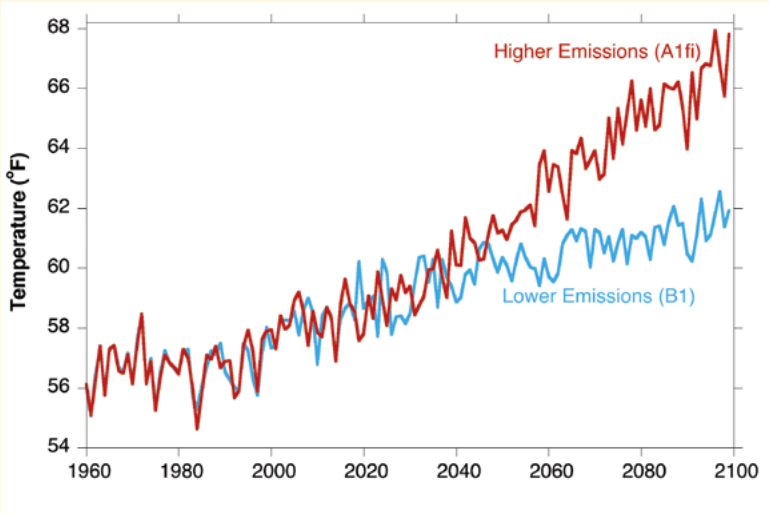
Climate is changing…



Wake et al. (2014)

Predicted annual *maximum* temperatures in southern New Hampshire

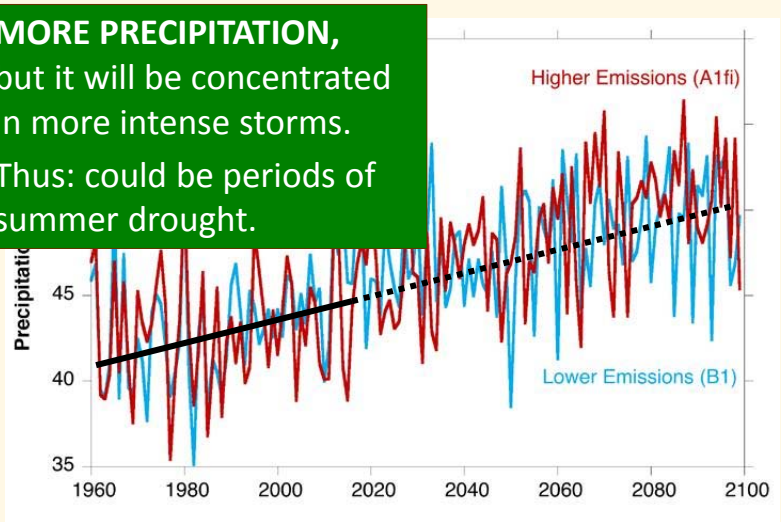


Wake et al. (2014)

Predicted annual precipitation in southern New Hampshire

MORE PRECIPITATION, but it will be concentrated in more intense storms.

Thus: could be periods of summer drought.



Wake et al. (2014)

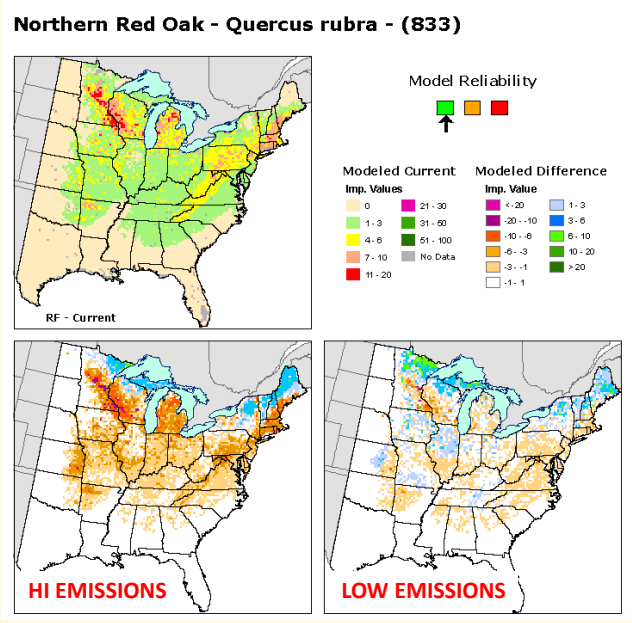
Climate change: Concerns

- OPERATIONS
  - *Shorter duration of frozen ground*
  - *Rainfall events impact infrastructure, access*
- DISTURBANCE (lots of uncertainty here)
  - *Increased storm intensity = more flooding?*
  - *Drought = more frequent fire?*
  - *More frequent impact on stand structure?*
- DIRECT EFFECTS ON TREES
  - *Productivity may increase*
  - *Tree species' DISTRIBUTIONS and ABUNDANCES*

CURRENT

USFS Climate Change Tree Atlas

DEGREE OF CHANGE
(by 2100)



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

USFS Climate Change Tree Atlas

"…we are predicting potential suitable habitat by year 2100 … NOT … where the species will be at that time, as great lag times are involved …

…the model does not account for future biotic interactions (competition…) or other human … or natural … disturbances …"

Pine-oak-hemlock region: Projected changes in abundance

DECREASE	INCREASE	LITTLE CHANGE
Eastern white pine Northern red oak	Black oak White oak Scarlet oak Hickories	Sweet birch
American beech Eastern hemlock Sugar maple	*Yellow poplar*	DEPENDS ON MODEL Red maple White ash
Paper birch Aspen		

DECREASE ≠ DISAPPEARANCE!

TRENDS?

Pine-oak-hemlock to *oak-hickory*

but at the same time

Nor. hardwoods to pine-oak-hemlock

Changes in tree composition will likely occur *slowly*

"GREAT LAG TIMES"

- Trees have broad responses to temperature
  - *New temperatures will not kill trees outright*
- Trees are long-lived; hold space
- Trees migrate *slowly* across landscape
- BUT, there are UNKNOWNS
  - *Disturbance, insects, and disease*

NO REASON TO MAKE HUGE CHANGES IN HOW WE MANAGE OUR FORESTS

How can we minimize negative effects of climate change on forestry?

"CLIMATE CHANGE ADAPTATION"



Three ADAPTIVE approaches
(Millar et al. 2007)

- **RESISTANCE** options
  - ***RESISTANCE:*** *Ability of a forest to remain the same in the face of some environmental change or disturbance*
- **RESILIENCE** options
  - ***RESILIENCE:*** *Ability of a forest stand to recover from impact and return to its previous state*
- **RESPONSE** options
  - ***RESPONSE:*** *transition of forest stand from present state to new, climate-adjusted state*

Consider two scales:

INDIVIDUAL STAND

LANDSCAPE

Gunn et al. (2009)

STAND LEVEL
Climate change RESISTANCE

- How to make a stand more RESISTANT to climate change?
- *Reduce* OTHER stresses
  - *Be pro-active in minimizing insect pest impacts*
    - **MONITORING!**
  - *Appropriate thinning to reduce competition, improve individual tree health*

LANDSCAPE LEVEL
Climate change RESISTANCE

- How to make a stands *in a landscape* more RESISTANT?
- Reduce OTHER stresses
  - *Maintain mature stands as wind protection for managed stands*

STAND LEVEL
Climate change RESILIENCE

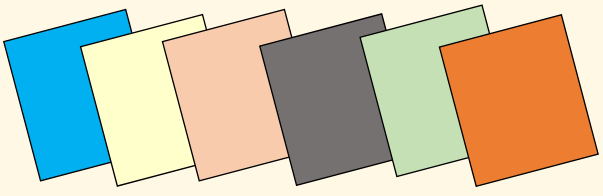
- Best predictor of RESILIENCE is diversity
- A more diverse stand is more resilient to climate change

WHY?

STAND LEVEL
Climate change RESILIENCE

PORTFOLIO EFFECT *(from finance)*

- Greater DIVERSITY of investments makes you more likely to survive change in the economy
- While some investments do *poorly* in periods of change, others will do *well*



STAND LEVEL
Climate change RESILIENCE

A stand with

high number of species or
high diversity of age classes, or
with species having high gene diversity

Should be more **RESILIENT**

LANDSCAPE LEVEL
Climate change RESILIENCE

A landscape with

high diversity of forest types
high diversity of stand ages, or
high diversity of stand structures

is likely more **RESILIENT** to climate change

Climate change RESILIENCE

SO, FOR RESILIENCE: Important to maintain biotic, age, and structural diversity at all scales

Three ADAPTIVE approaches
(Millar et al. 2007)

- **RESISTANCE** options
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Climate change RESPONSE

Here, we FACILITATE CHANGE TO NEW FOREST COMMUNITY

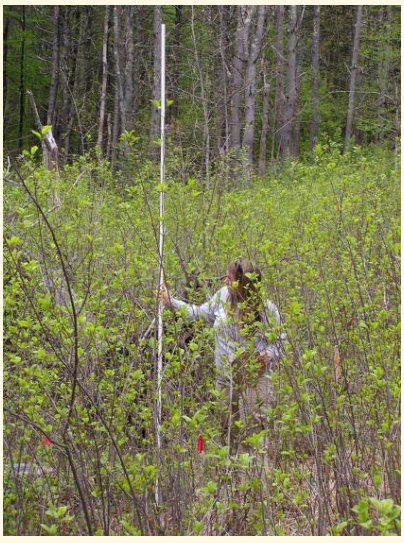
- **LANDSCAPE LEVEL**
  - *Promote connectivity of stands*
  - *Promote diversity of communities*
- **STAND LEVEL**
  - *Shorten rotation times*

Topics

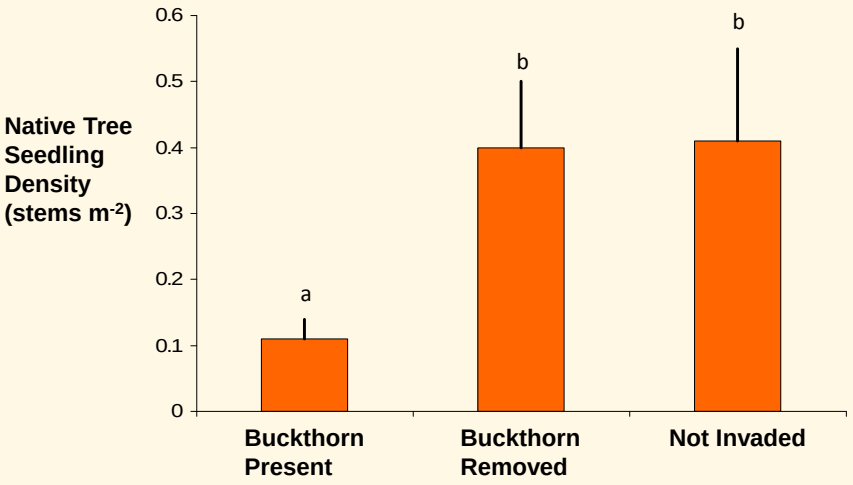
- Where is pine-oak-hemlock forest?
- Silvics of individual species
- Succession and stand dynamics, including the effects of land use history
- Climate change adaptation and restoration

Common invasive plants of pine-oak-hemlock forests

Invasives alter stand properties



Glossy buckthorn alters forest stands

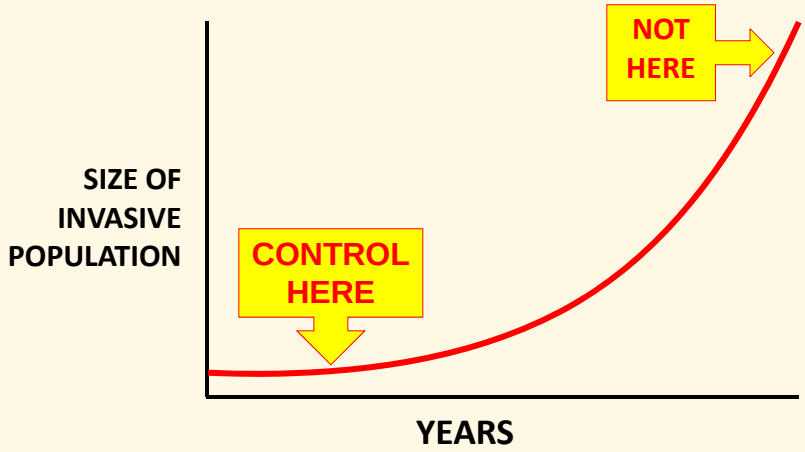


Frappier et al. (2004)

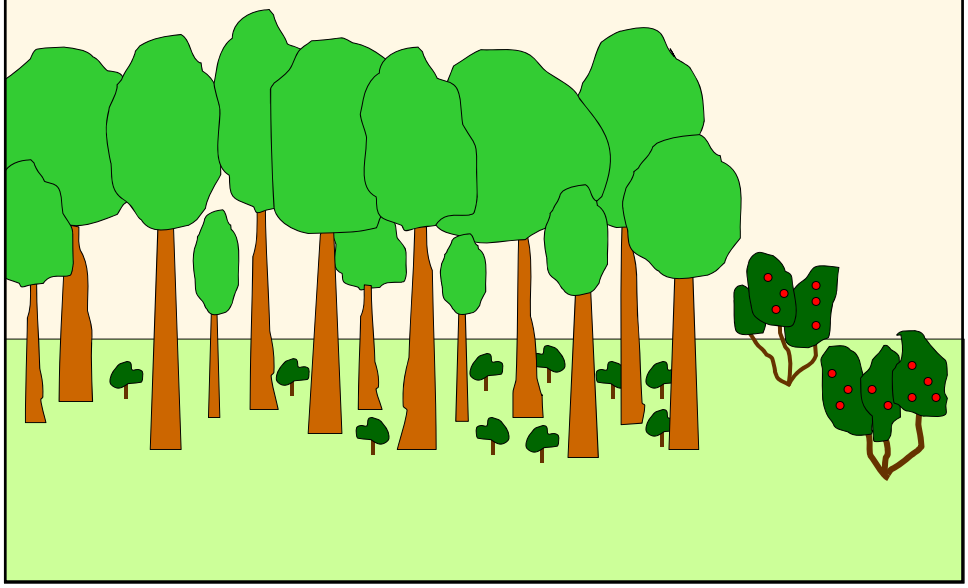
What can we do about invasive species?

- Prevention
  - *Effective, involves politics and policy*
- Early detection, rapid response (EDRR)
  - *Quickly identify new invasive species*
  - *Find populations and reduce them*
  - *Requires **MONITORING!***

Timing is everything!



Rapid response: Get the sources first!



Once you have this… It will cost you!


~~Eradication~~ Control

- Herbicides
- Mechanical approaches


Topics

- Where is pine-oak-hemlock forest?
- Silvics of individual species
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Forest Types *(uplands)*

Site characteristics, disturbance history