# Forest Ecology!

# Forest Ecology?
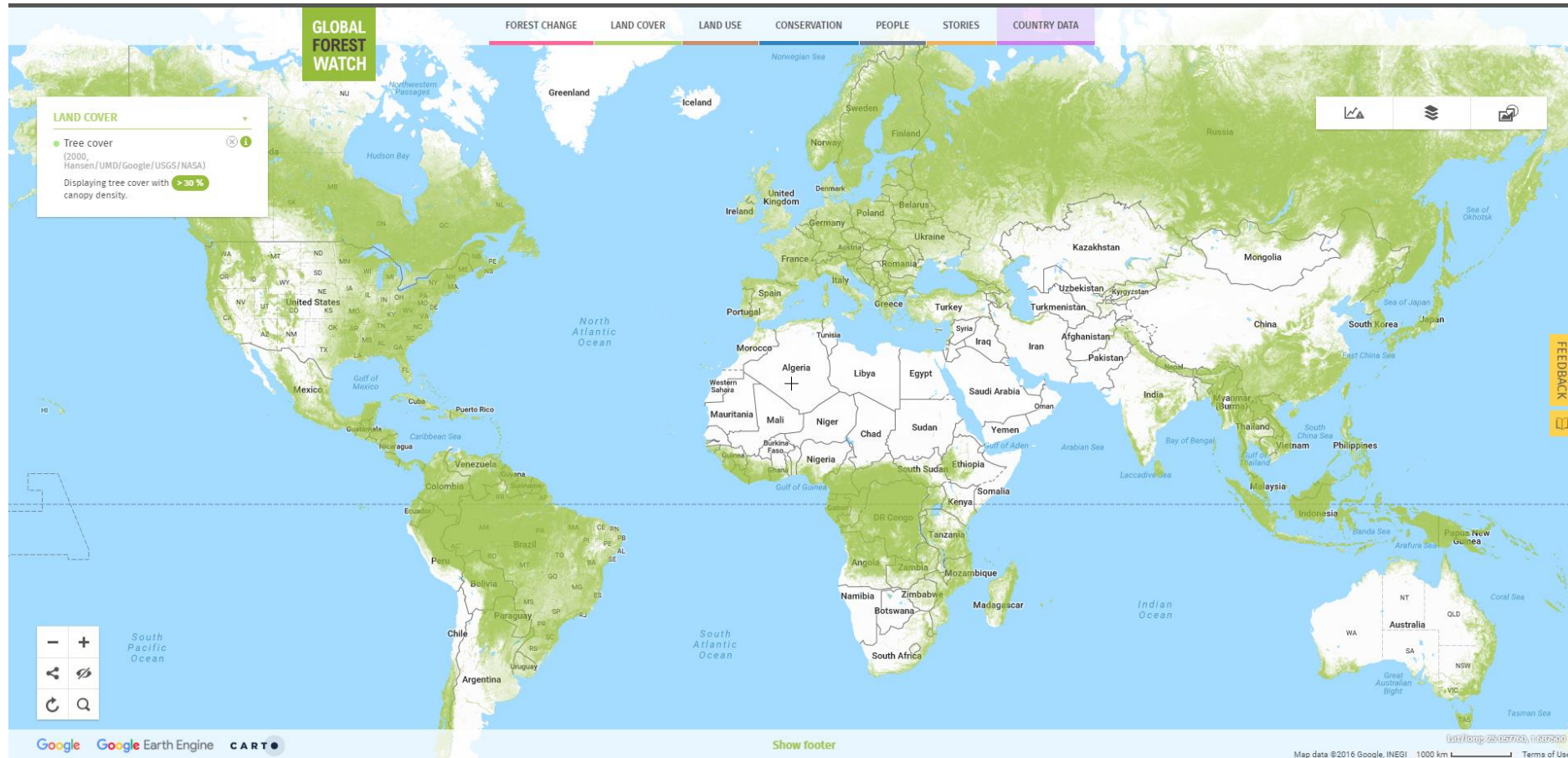
Why do we care?

- Carbon storage

- Biodiversity

- Forest products

# Forests of the World

Global forest cover - ~30% of land area



http://www.globalforestwatch.org/map

# Forests of the World

Biomes and biogeographic regions



Tropical forest | Polar and high-mountain ice | Temperate deciduous forest
Savanna | Chaparral | Coniferous forest
Desert | Temperate grassland | Tundra (arctic and alpine)

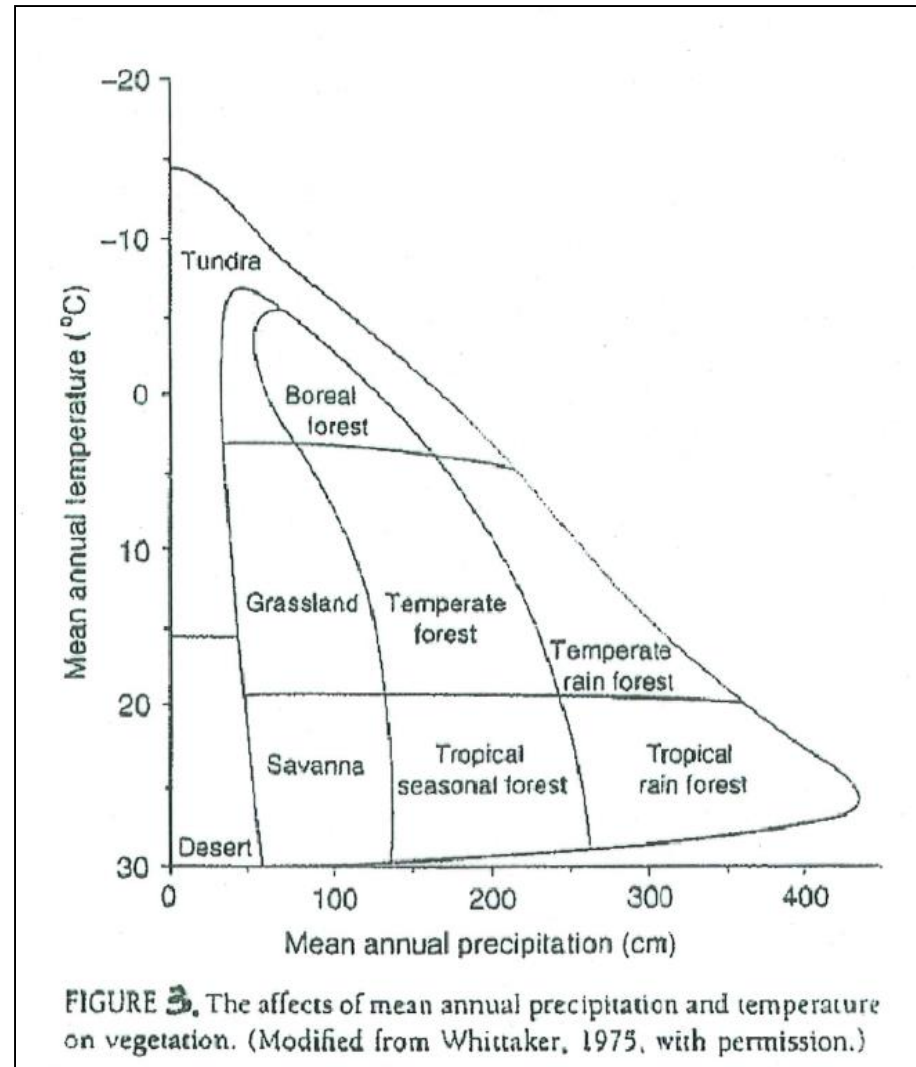Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.
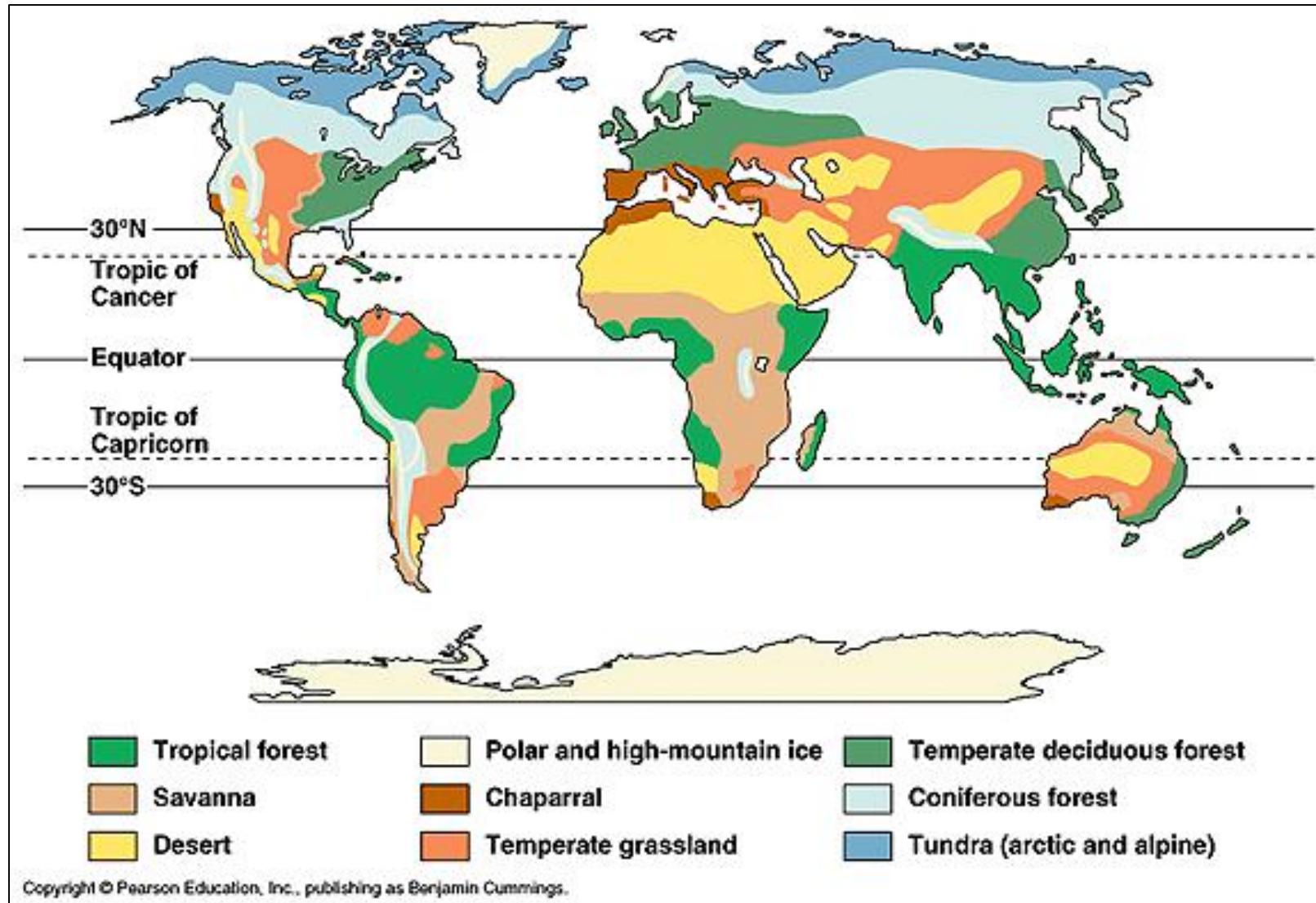
# Forests of North America

- Boreal
- Temperate deciduous
- Temperate coniferous
- Temperate rainforest
- Montane
- Mixed
- Tropical and sub-tropical

# Forests of the World

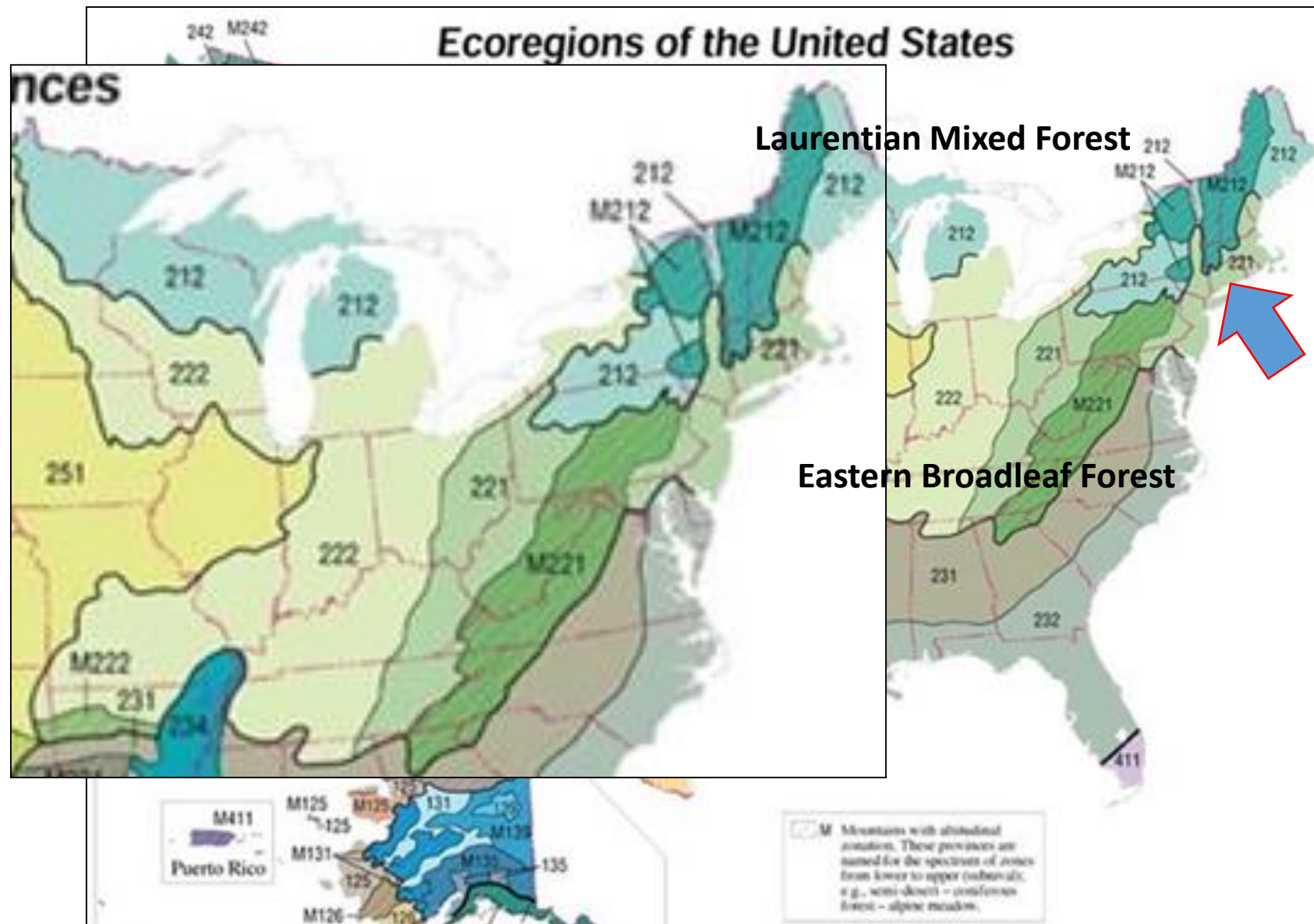## Temperature and precipitation gradients



FIGURE 3. The affects of mean annual precipitation and temperature on vegetation. (Modified from Whittaker, 1975, with permission.)

# Forests of the US
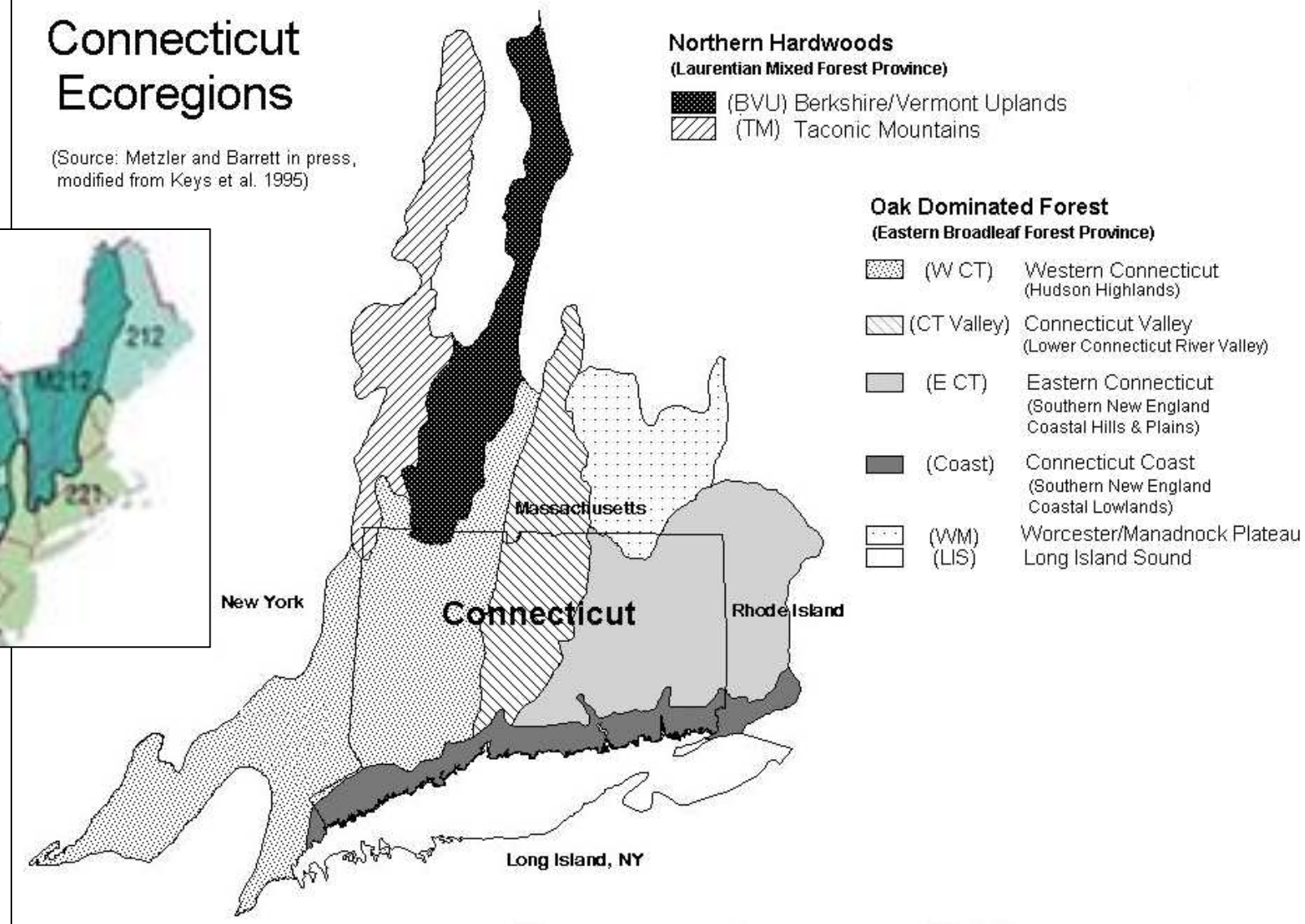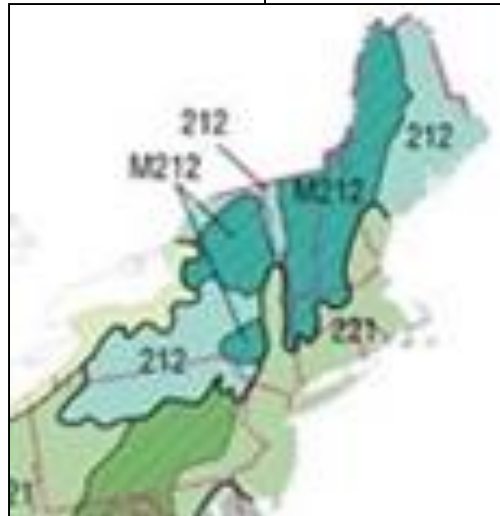
Around 30% - near the global average

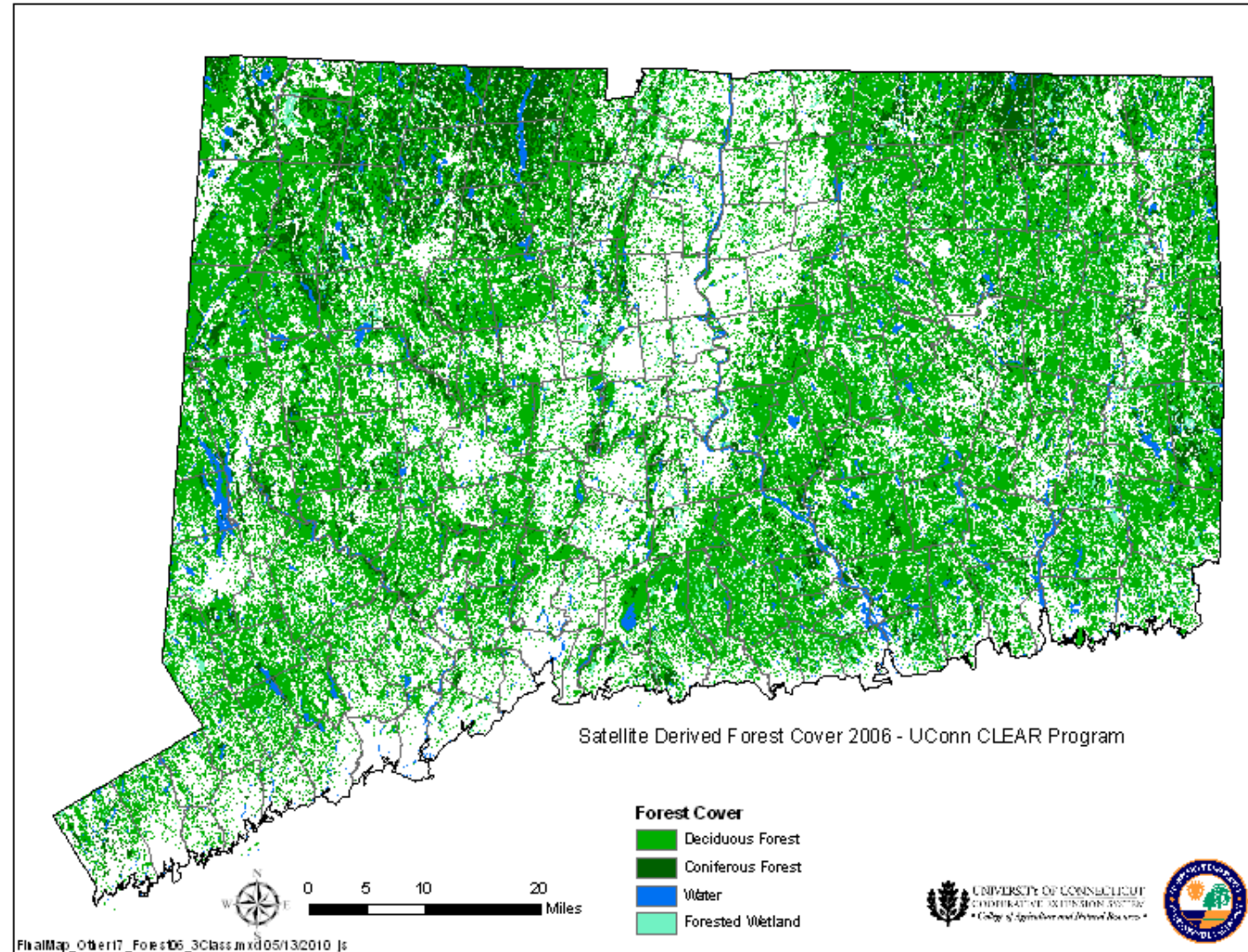# Ecoregions of the US

# Ecoregions of Connecticut



Connecticut Ecoregions

(Source: Metzler and Barrett in press, modified from Keys et al. 1995)

**Northern Hardwoods**
(Laurentian Mixed Forest Province)
- (BVU) Berkshire/Vermont Uplands
- (TM) Taconic Mountains

**Oak Dominated Forest**
(Eastern Broadleaf Forest Province)
- (W CT) Western Connecticut (Hudson Highlands)
- (CT Valley) Connecticut Valley (Lower Connecticut River Valley)
- (E CT) Eastern Connecticut (Southern New England Coastal Hills & Plains)
- (Coast) Connecticut Coast (Southern New England Coastal Lowlands)
- (WM) Worcester/Manadnock Plateau
- (LIS) Long Island Sound

New York
Massachusetts
Connecticut
Rhode Island
Long Island, NY

# Forests of Connecticut

>70% Forest Cover



Satellite Derived Forest Cover 2006 - UConn CLEAR Program

**Forest Cover**
- Deciduous Forest
- Coniferous Forest
- Water
- Forested Wetland
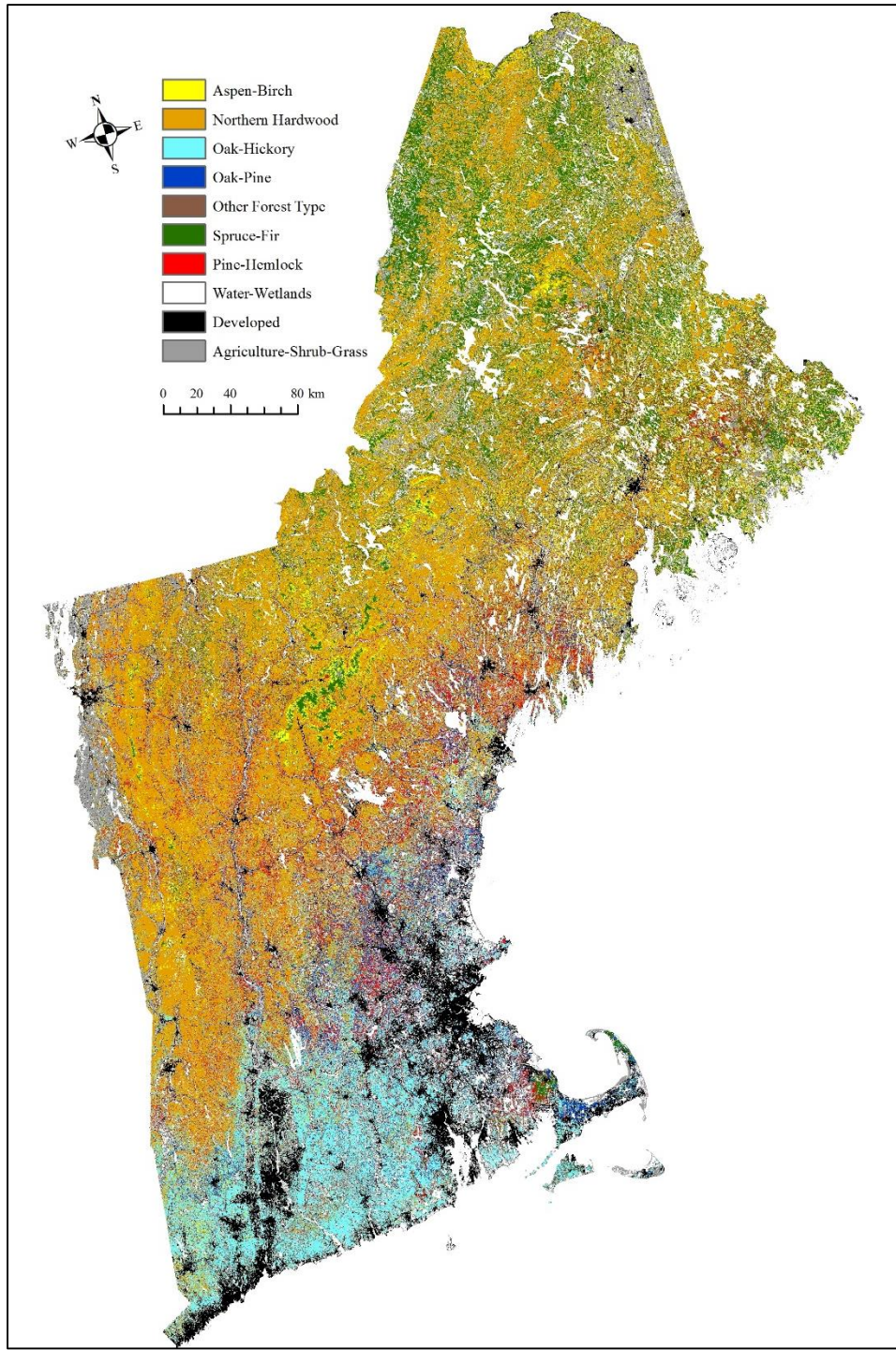
Forest Types of New England

# Forests of Connecticut
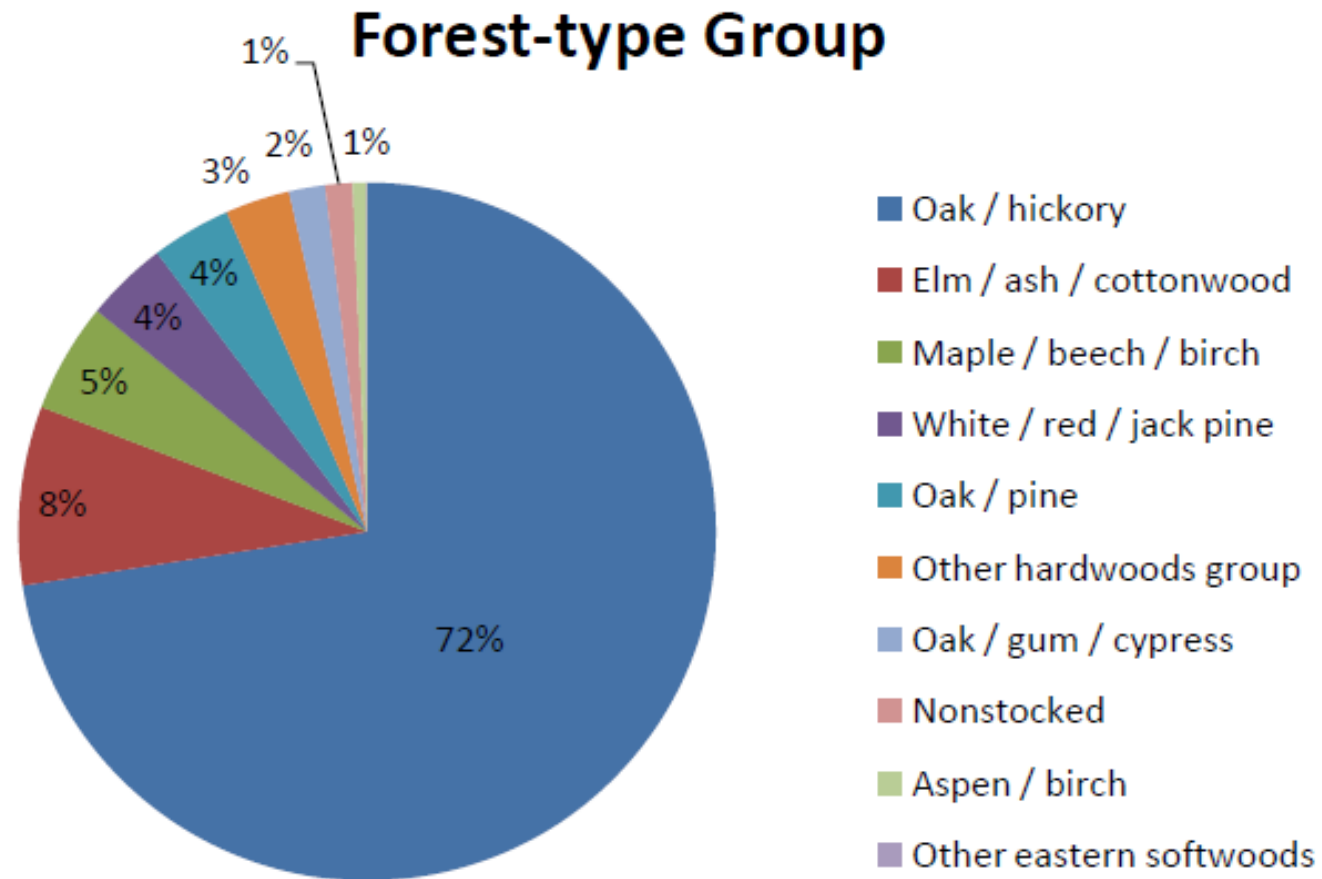


## Forest-type Group

- 1%
- 2%
- 1%
- 3%
- 4%
- 4%
- 5%
- 8%
- 72%

Legend:
- ■ Oak / hickory
- ■ Elm / ash / cottonwood
- ■ Maple / beech / birch
- ■ White / red / jack pine
- ■ Oak / pine
- ■ Other hardwoods group
- ■ Oak / gum / cypress
- ■ Nonstocked
- ■ Aspen / birch
- ■ Other eastern softwoods

Source: 2008 USFS Forest Inventory and Analysis Data

# Forests of Connecticut



**Top Ten Species**

- Red maple — 21%
- Northern red oak — 14%
- Eastern white pine — 8%
- Black oak — 7%
- Sweet birch — 7%
- White oak — 7%
- Eastern hemlock — 5%
- White ash — 5%
- Sugar maple — 4%
- Scarlet oak — 4%
- (Other) — 18%

Source: 2008 USFS Forest Inventory and Analysis Data

# Forests of Connecticut



**Stand Age Classifications**

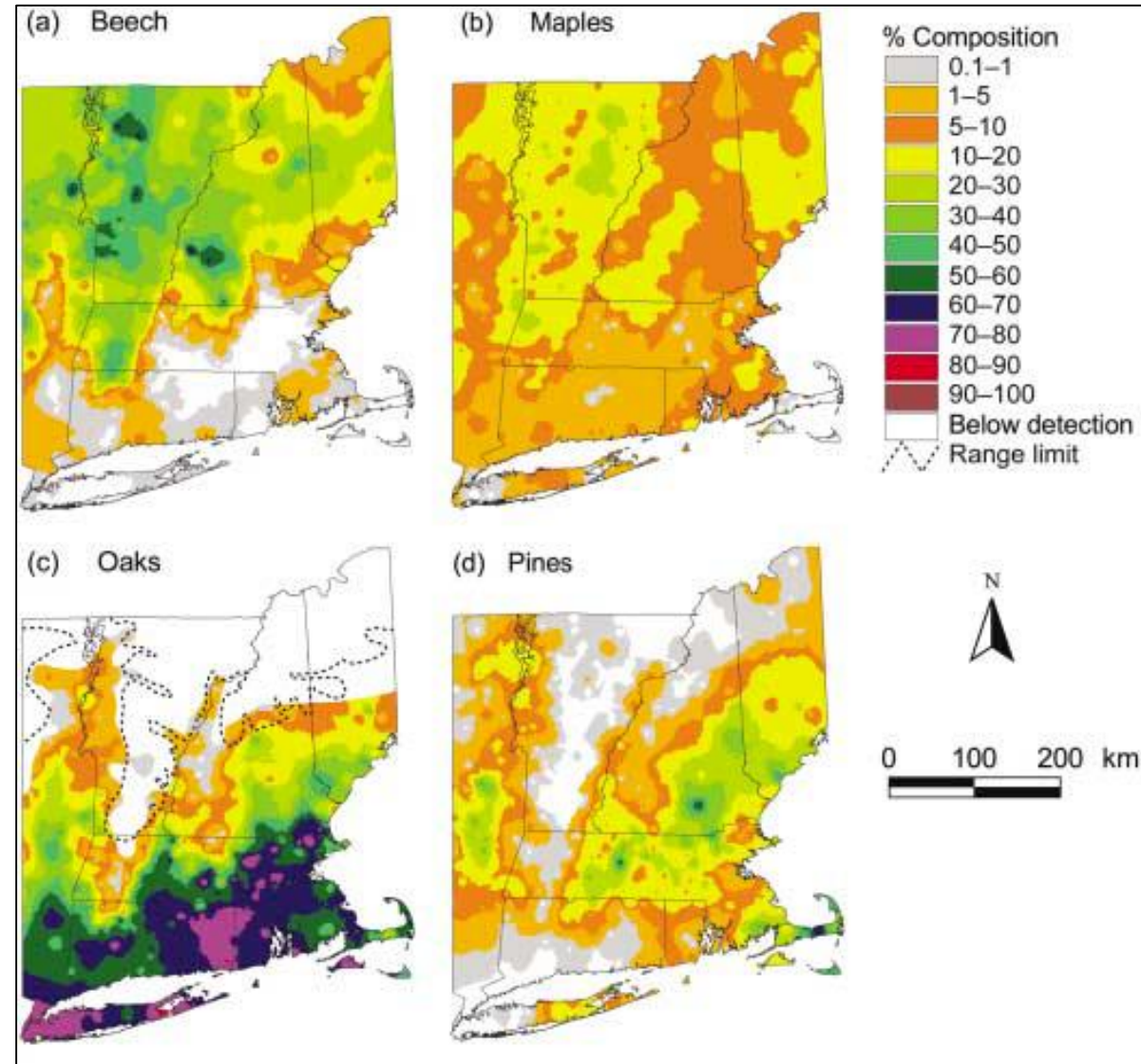| Age Class | Percentage |
|-----------|-----------|
| 0-19 years | 2.7% |
| 20-39 years | 4.1% |
| 40-59 years | 15.3% |
| 60-79 years | 36.7% |
| 80-99 years | 31.3% |
| 100-119 years | 8.9% |
| 120-139 years | 1.0% |
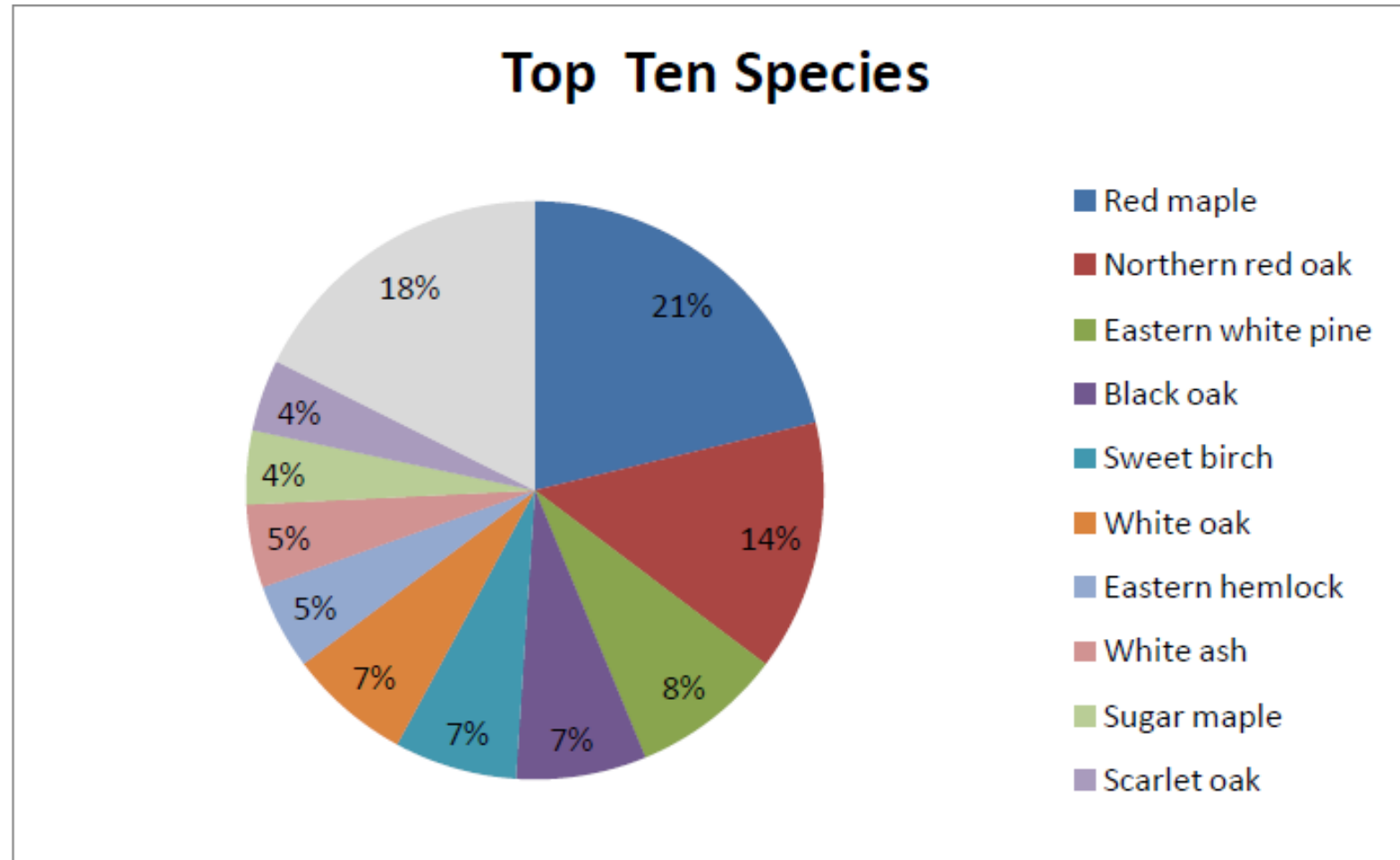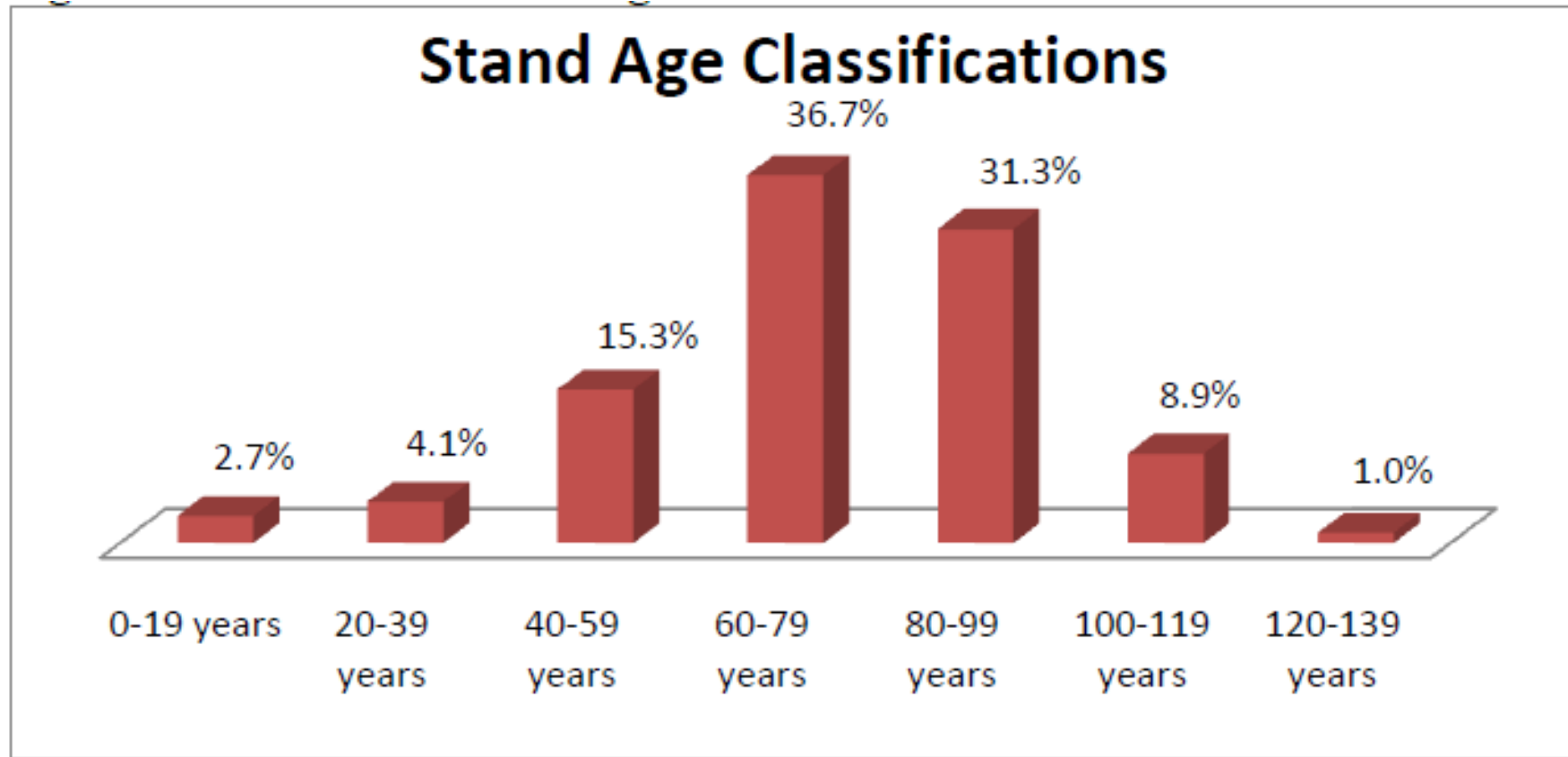
Source: 2008 Forest Inventory and Analysis Data

# Pre-European Forests

- Data on composition from Town surveys – C. Cogbill
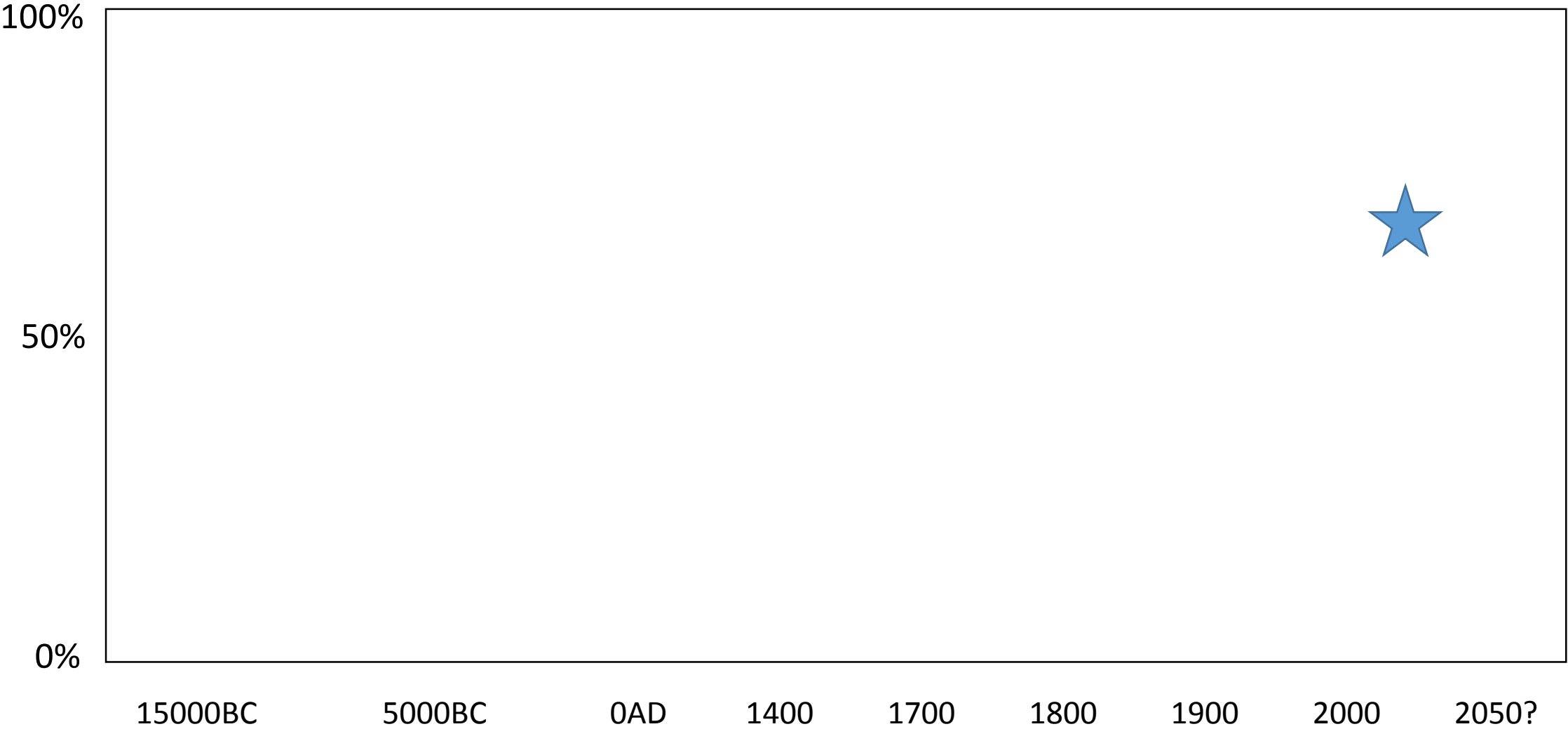
# Forests of Connecticut

In 2018:

- ~70% forest cover

- Oak hickory forests – with major component of maple, birch, & pine

- Transitional between Mid-Atlantic oak-hickory and New England maple-beech
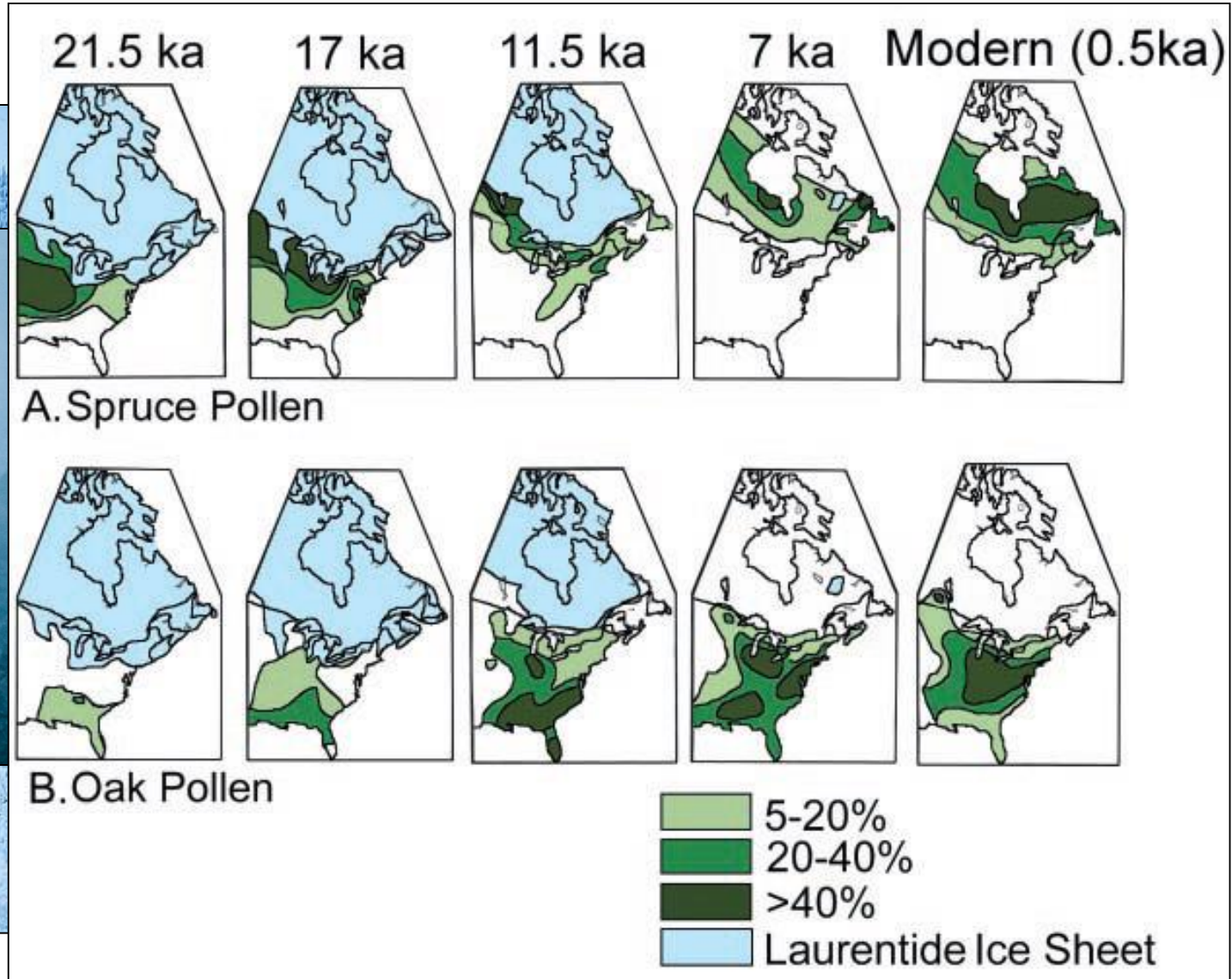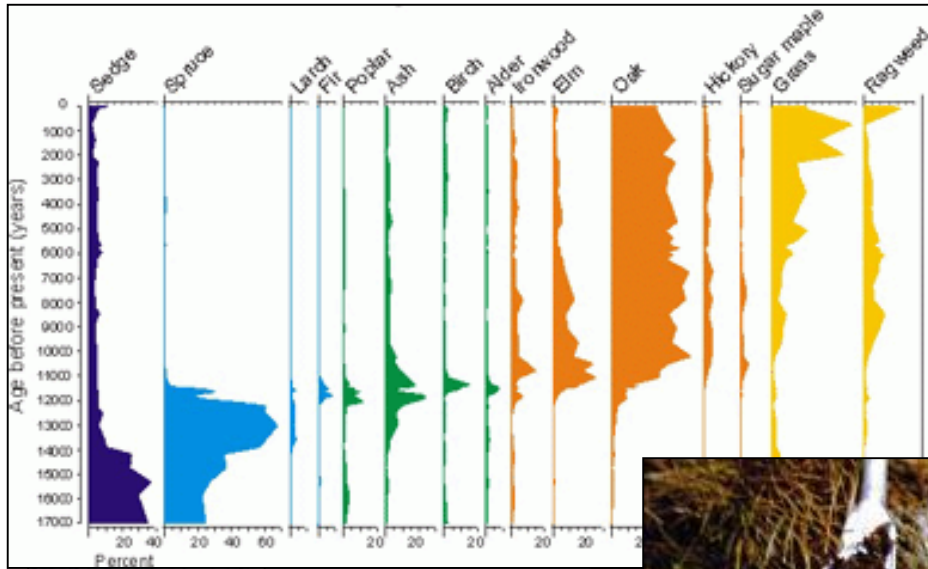
- Young-ish forests – largely ~100 years old

**Was this always the case? How did we get here?**
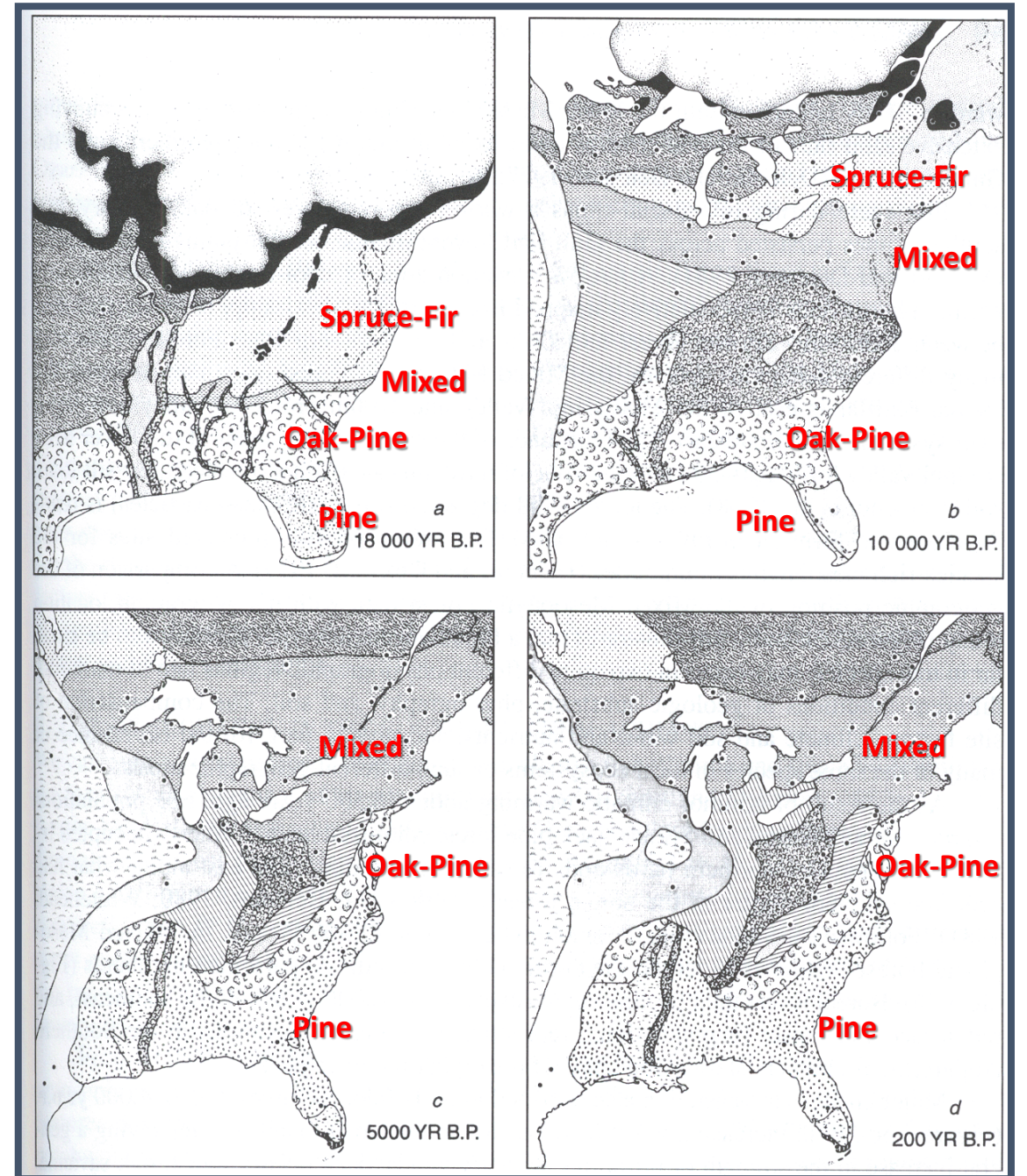
# Timeline of CT forest cover?

# Paleoecology

- What about 15000 years ago?



A. Spruce Pollen
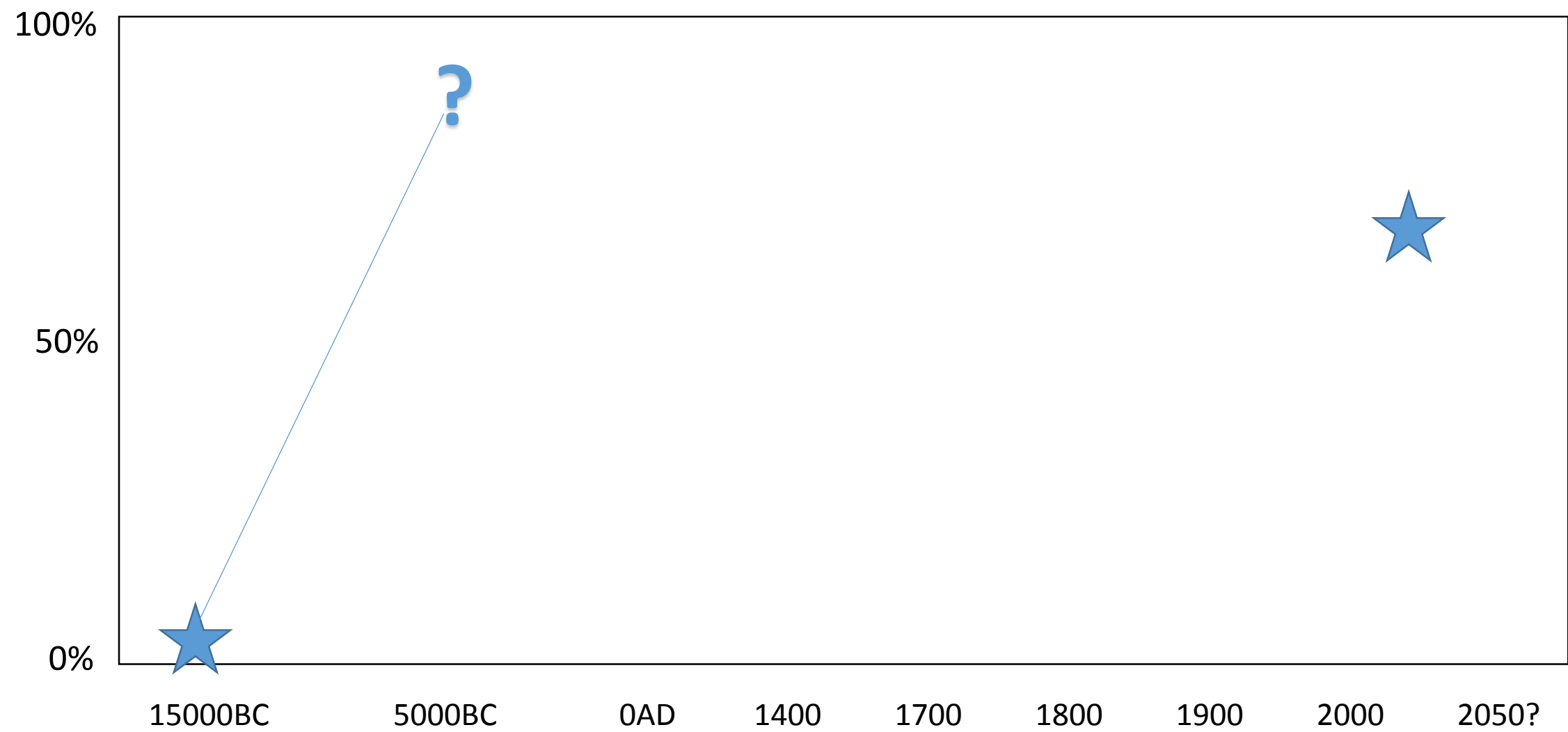
B. Oak Pollen

5-20%
20-40%
>40%
Laurentide Ice Sheet

# Paleoecology

- Post-glacial community and species migrations

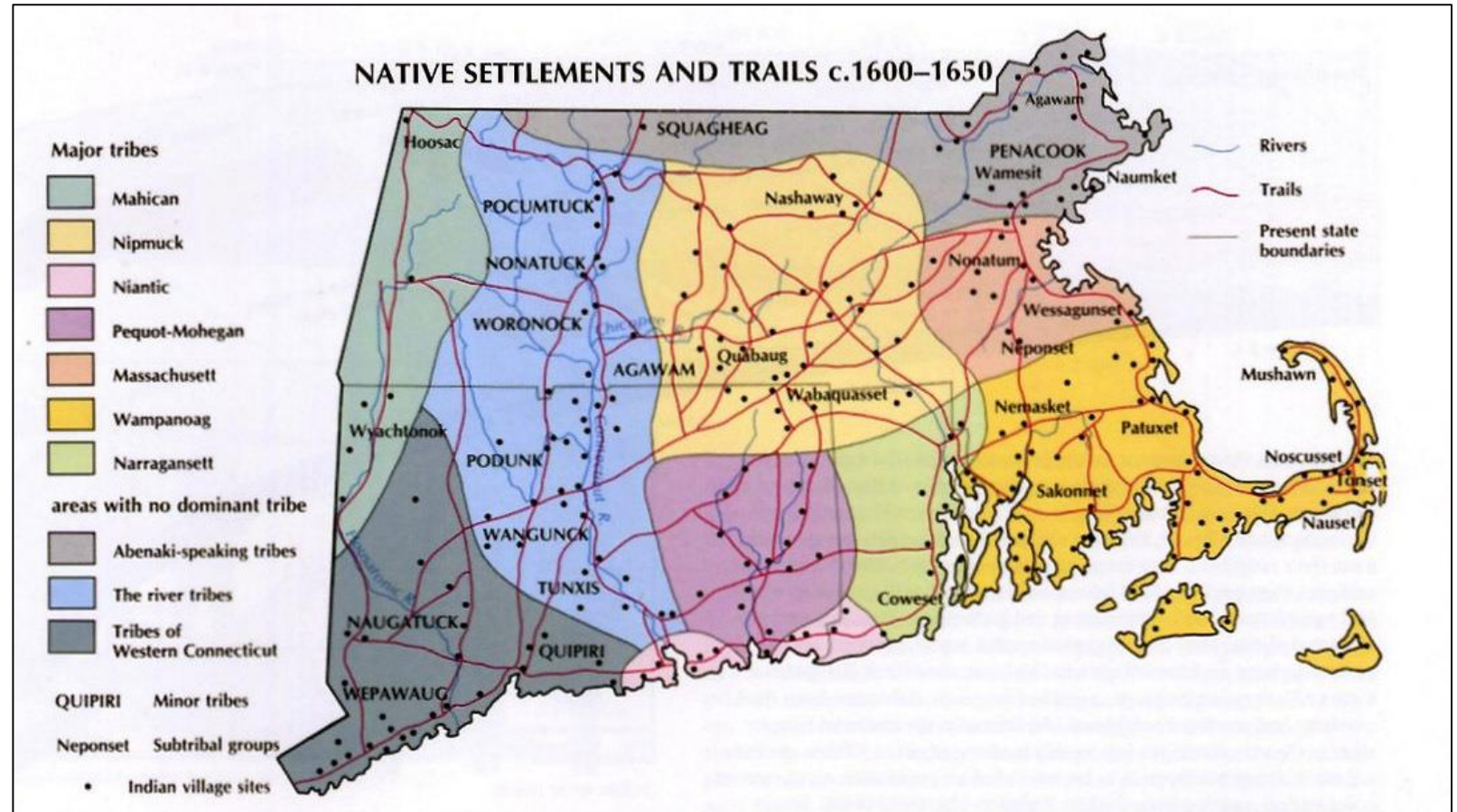- Not as much change in past 5000 years (at least until the 1600's…)

Timeline of CT forest cover?

# Forest History

- Pre-European– large Native American populations for thousands of years
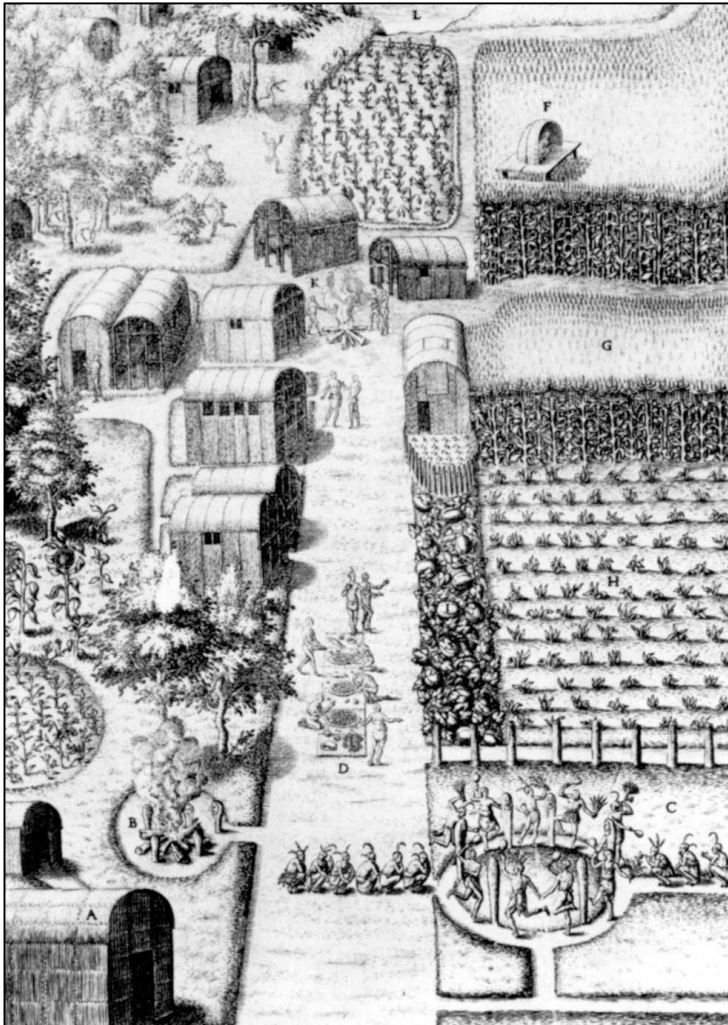
# Timeline of CT forest cover?
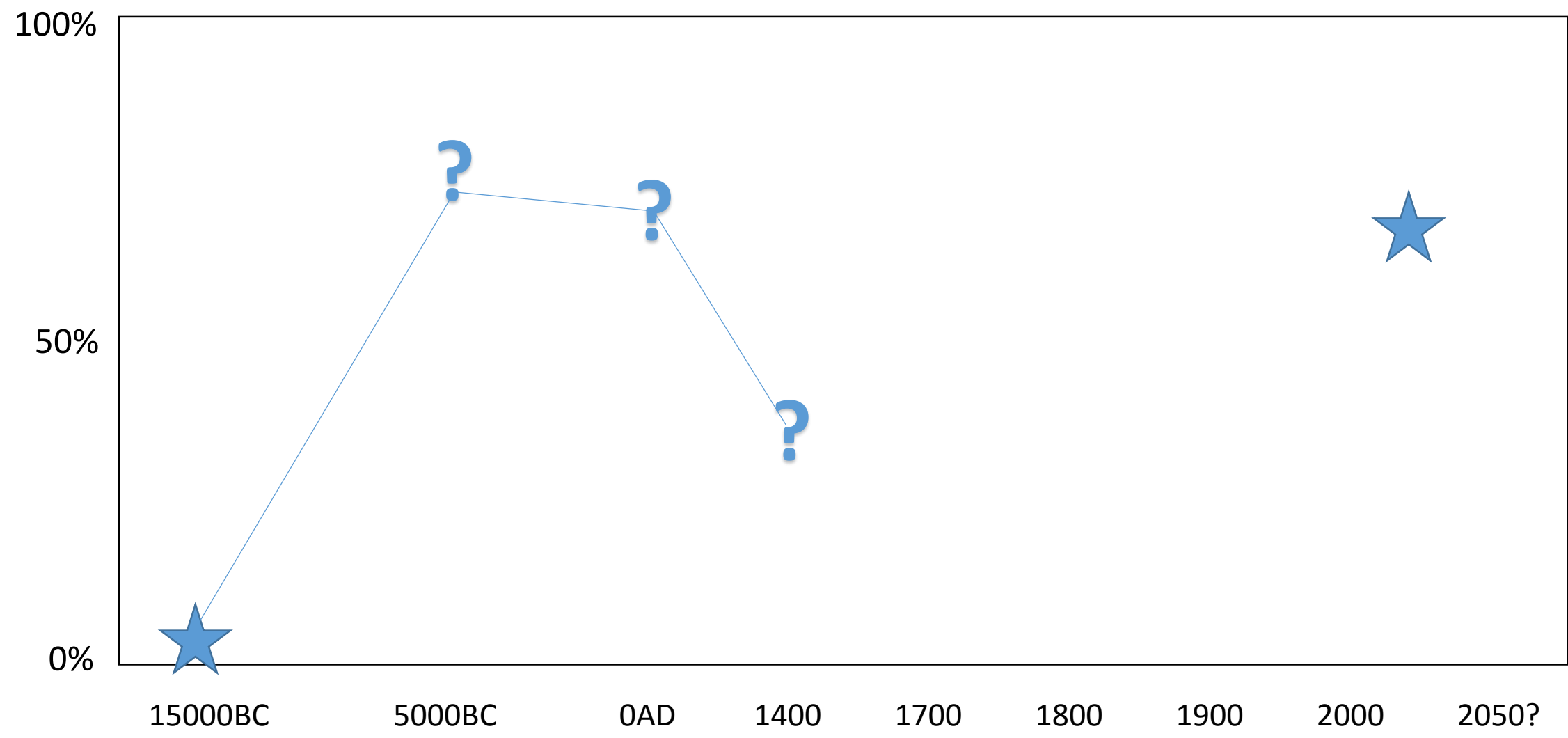
# Forest History

- Untrammeled Wilderness??? – 1500's

# Timeline of CT forest cover?
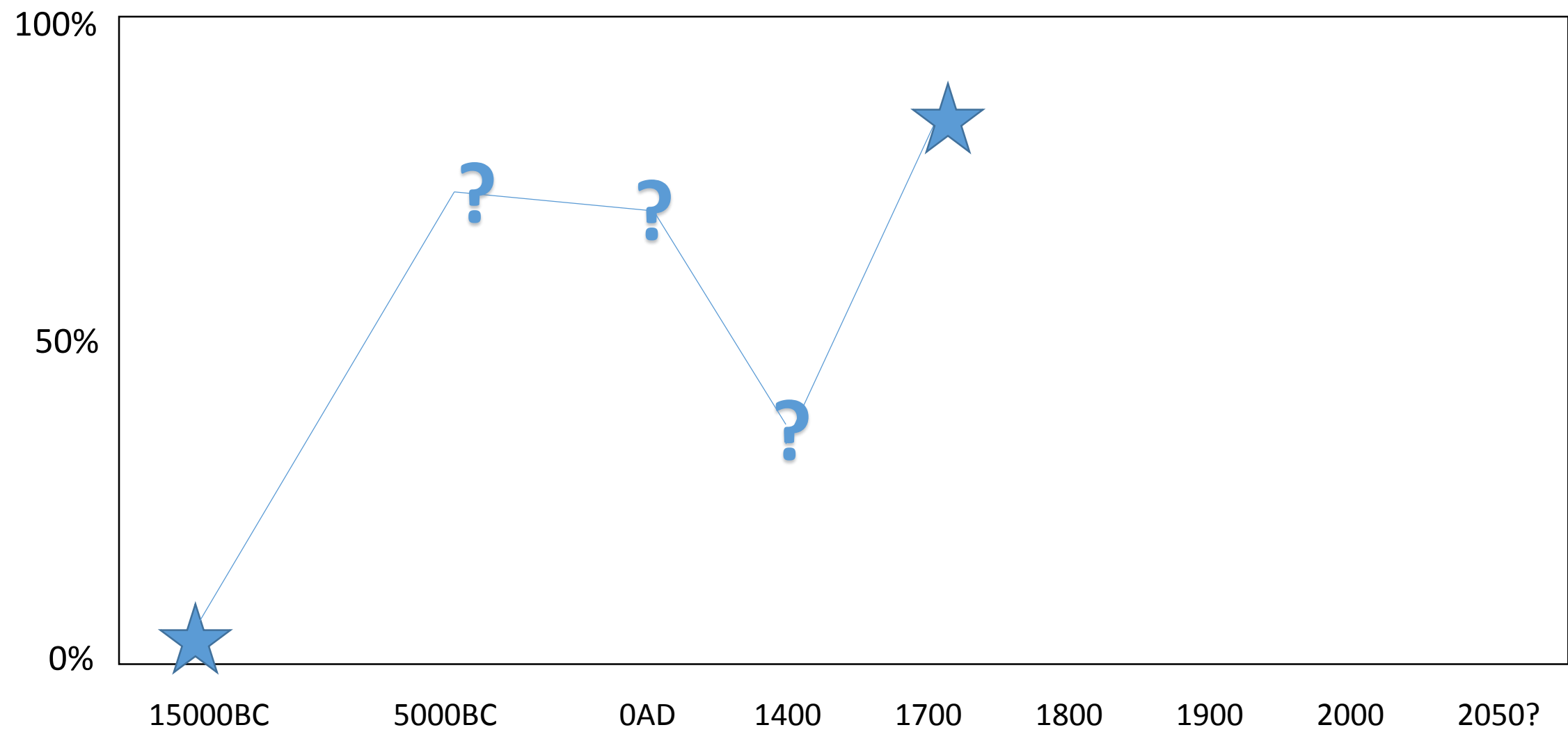
# Forest History

- European "settlement" – 1600's – 1700's

# Forest History

- Peak agriculture – early 1800's – **"Sheep Fever"**
- Very little forest cover remained

# Timeline of CT forest cover?
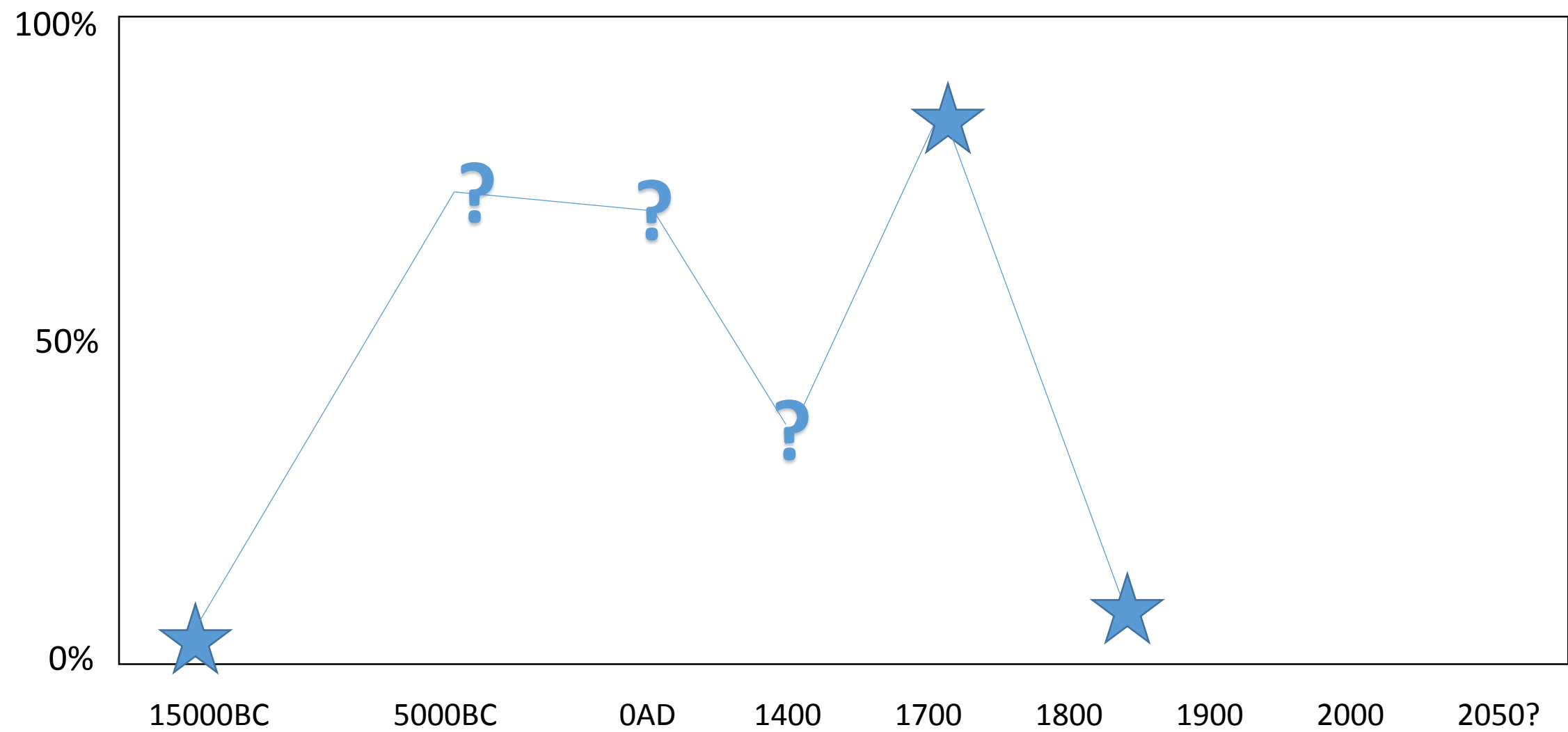
# Forest History

- Agricultural abandonment – late 1800's
- Trees reinvaded fields

# Forest History

- Return of forests – early 1900's



Stand Age Classifications

| Age Class | Percentage |
|-----------|------------|
| 0-19 years | 2.7% |
| 20-39 years | 4.1% |
| 40-59 years | 15.3% |
| 60-79 years | 36.7% |
| 80-99 years | 31.3% |
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Source: 2008 Forest Inventory and Analysis Data
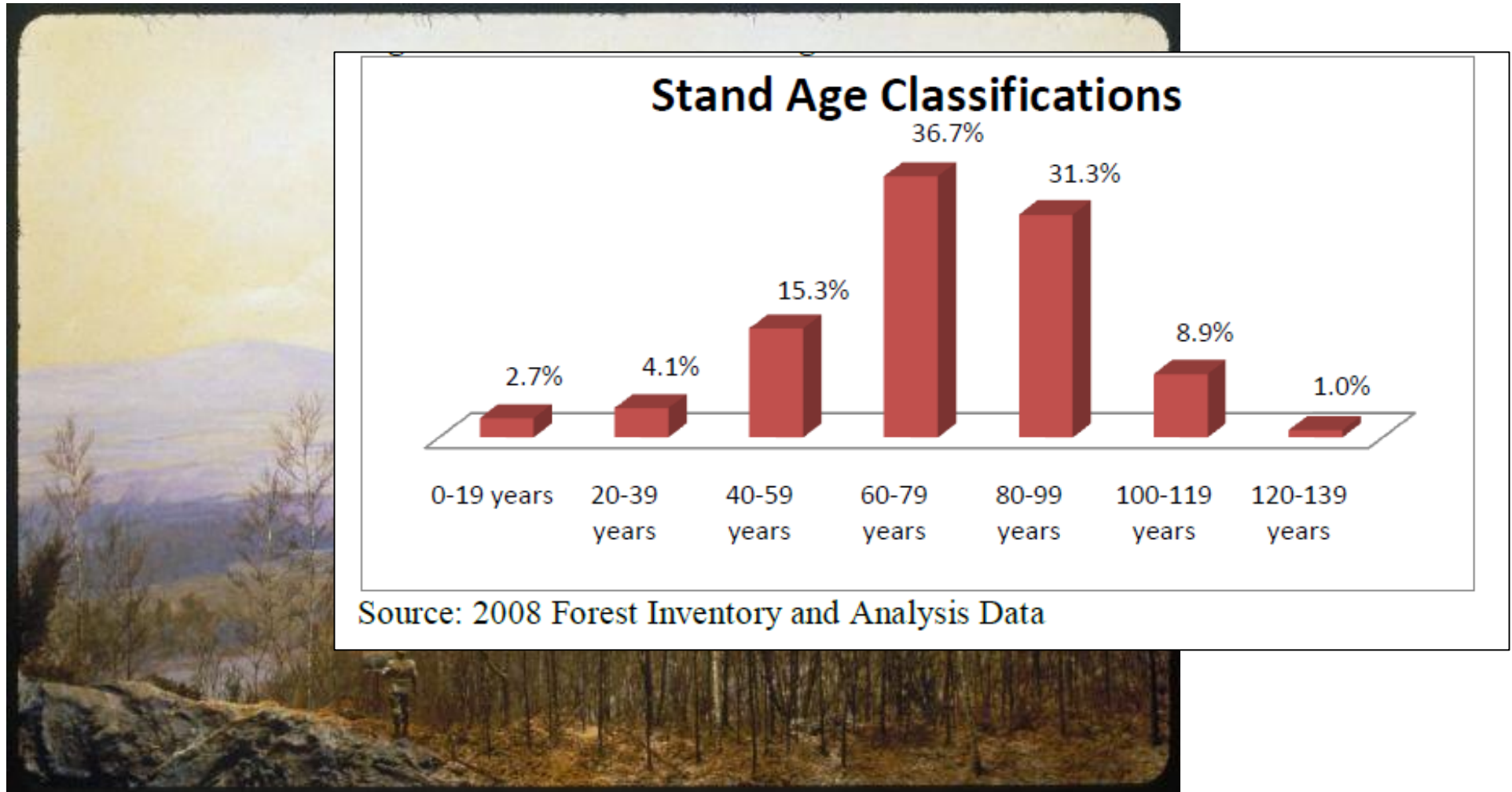
# Timeline of CT forest cover?
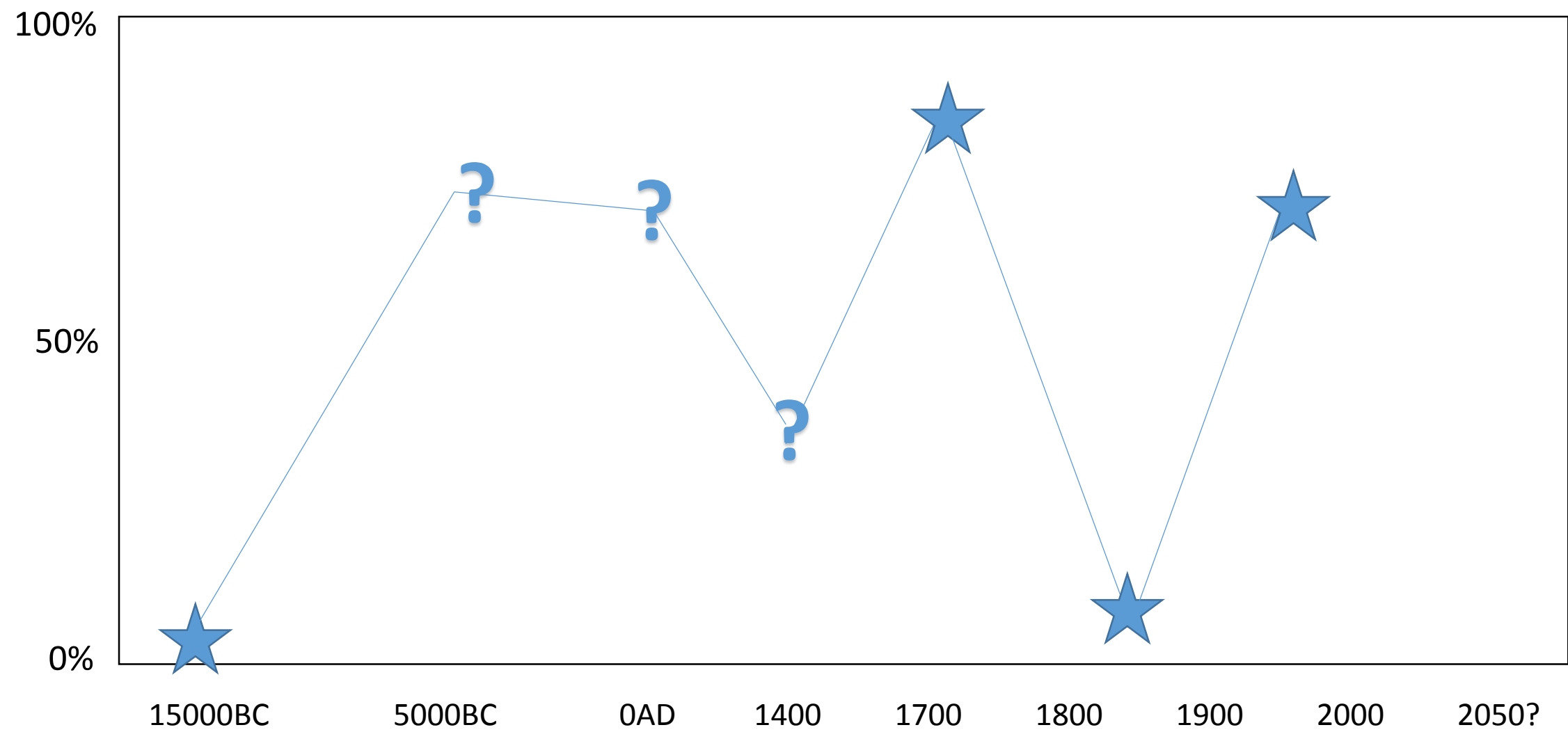
# Forest History

- Urbanization and exurbanization – late 1900's - early 2000's

Timeline of CT forest cover?

# Forest Change
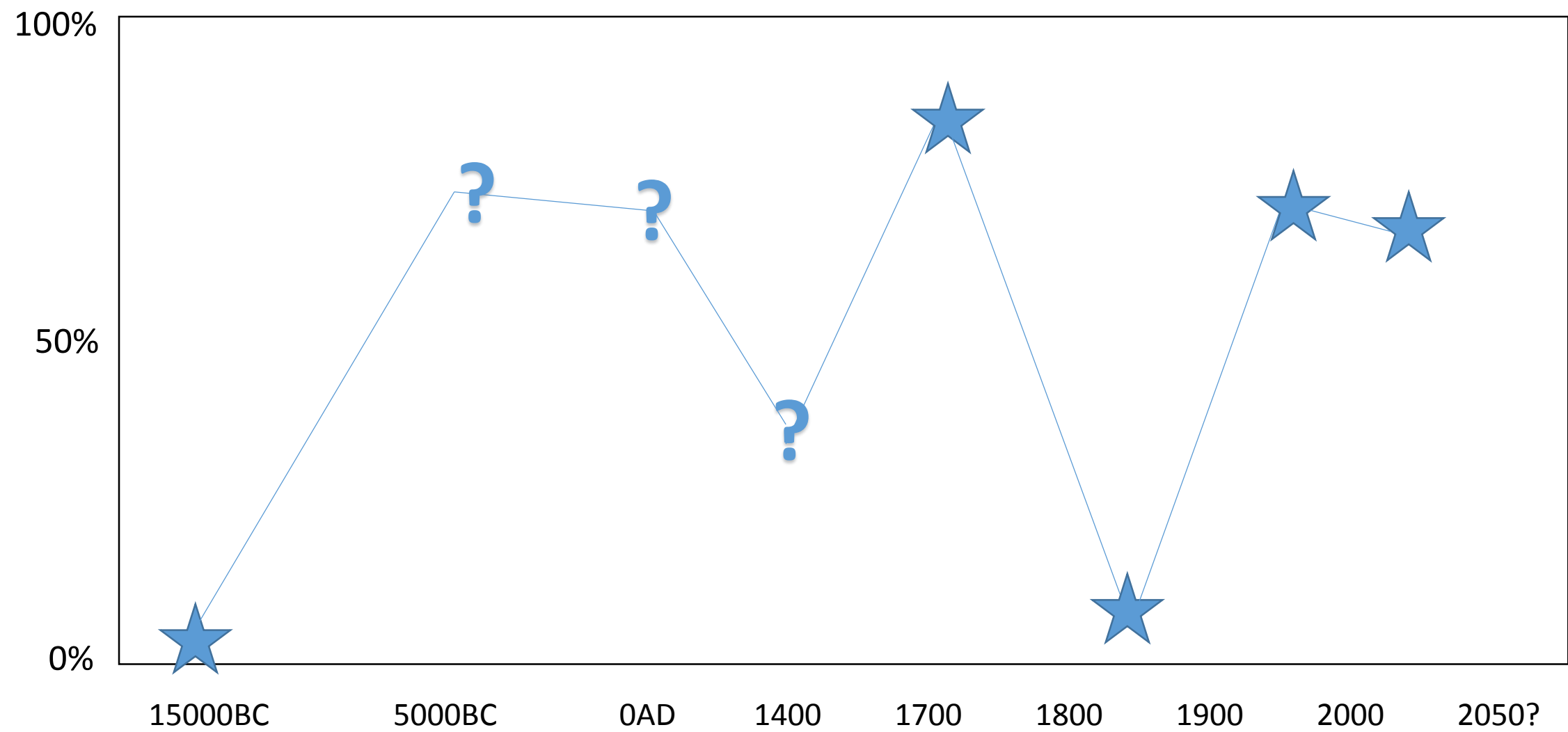
Competition, balance... pests and diseases...
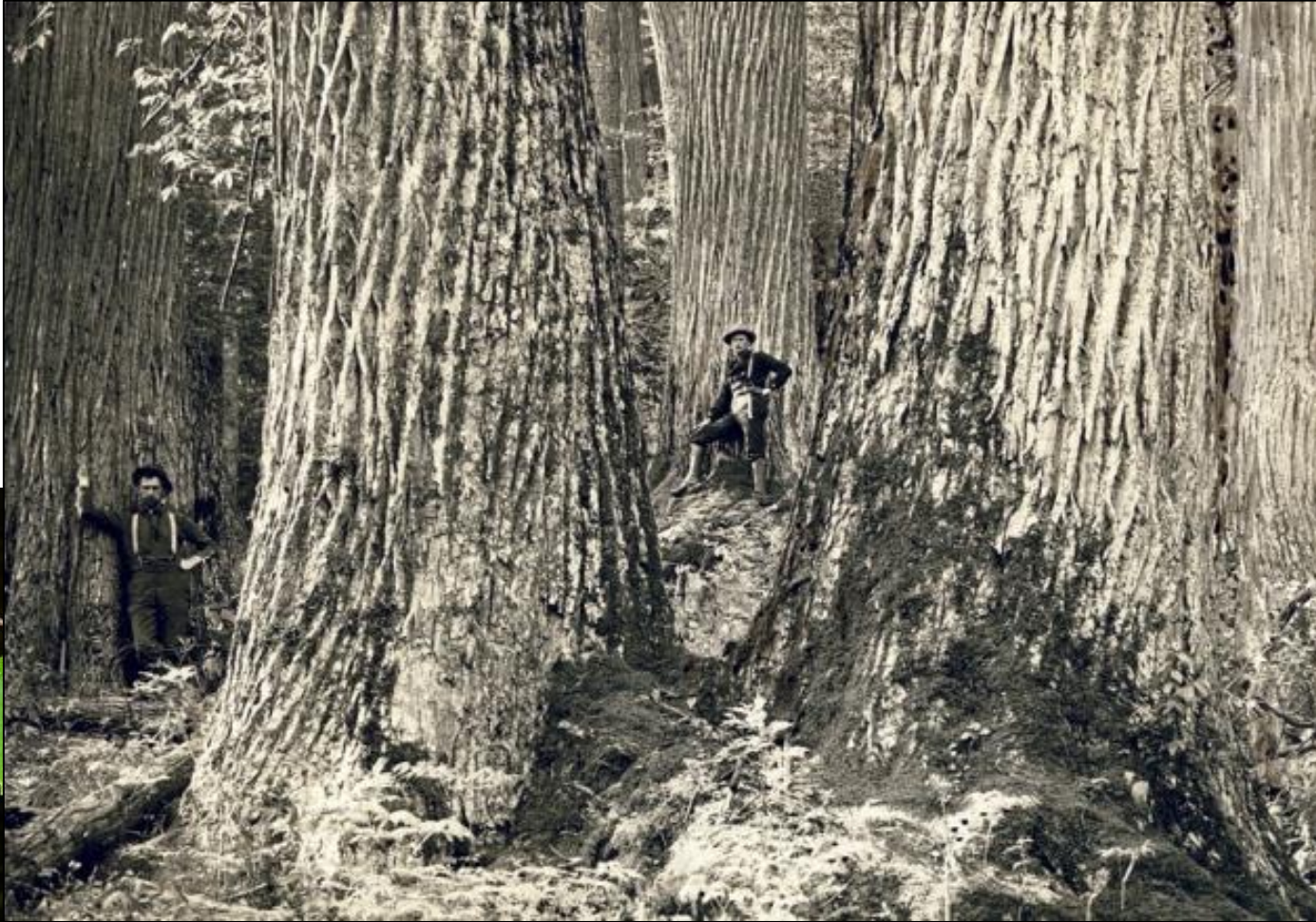
# Forest Change

- Compositional changes – pests and diseases…



## Top Ten Species



21%

14%

18%

8%

7%

7%

7%

4%

4%

- Red maple
- Northern red oak
- Eastern white pine
- Black oak
- Sweet birch
- White oak
- Eastern hemlock
- White ash
- Sugar maple
- Scarlet oak
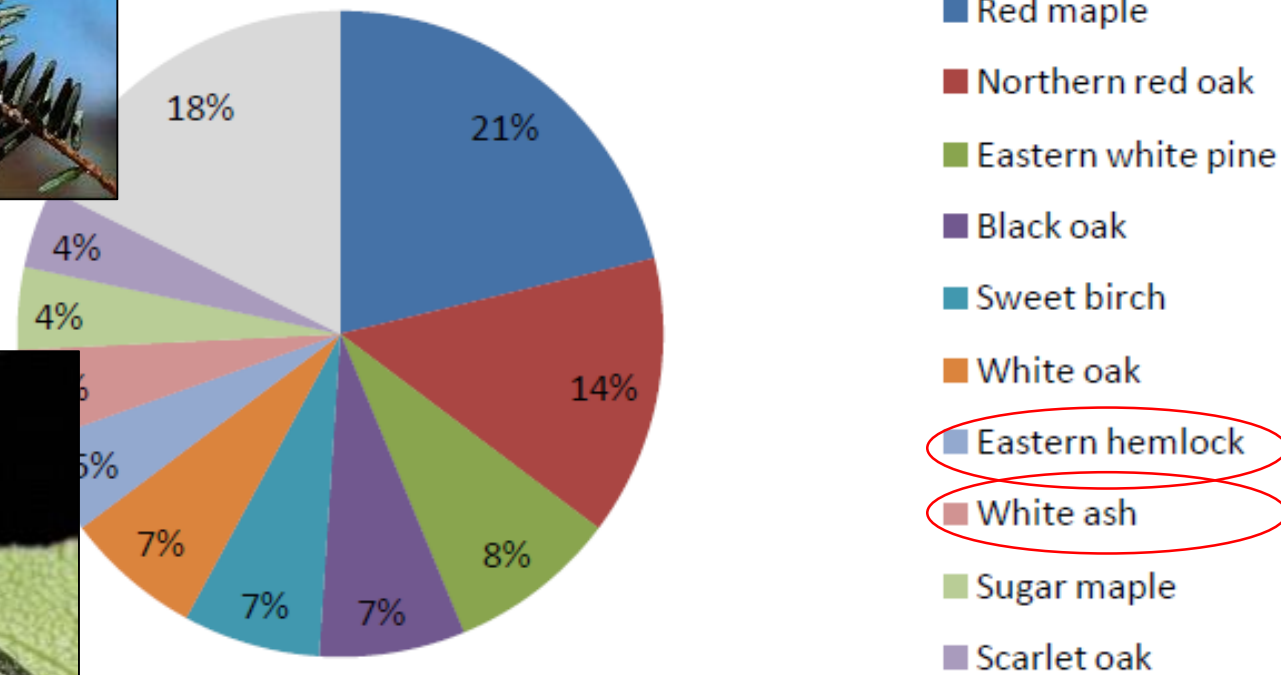
FS Forest Inventory and Analysis Data

# Forest Change

- Compositional changes – beneficiaries in CT



**Top Ten Species**

- Red maple — 21%
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- Sweet birch — 7%
- White oak — 7%
- Eastern hemlock — 5%
- White ash — 5%
- Sugar maple — 4%
- Scarlet oak — 4%
- (gray) — 18%

2008 USFS Forest Inventory and Analysis Data
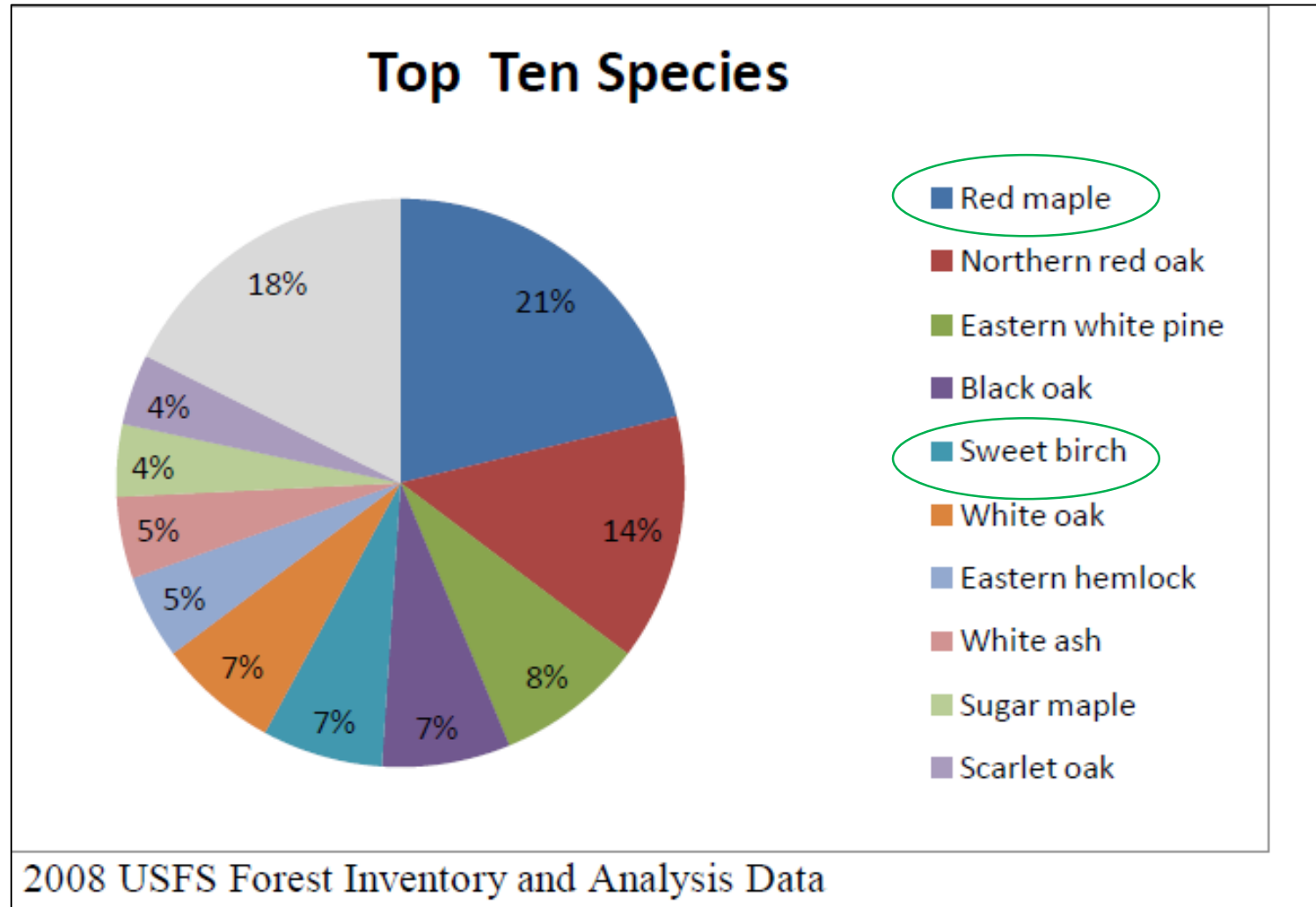
Exurban development – major land use change pattern across much of the US

# Shift to exurban forest

Ecological consequences

- Fragment the forest - Loss of ecosystem services
  - Loss of biodiversity, clean water
  - Loss of timber and non-timber forest products

Socio-economic consequences

- Shift in ownership and attitudes can effectively remove exurban forest from production

- Small parcels are difficult to manage and forestry sector can be affected

Timeline of CT forest cover?
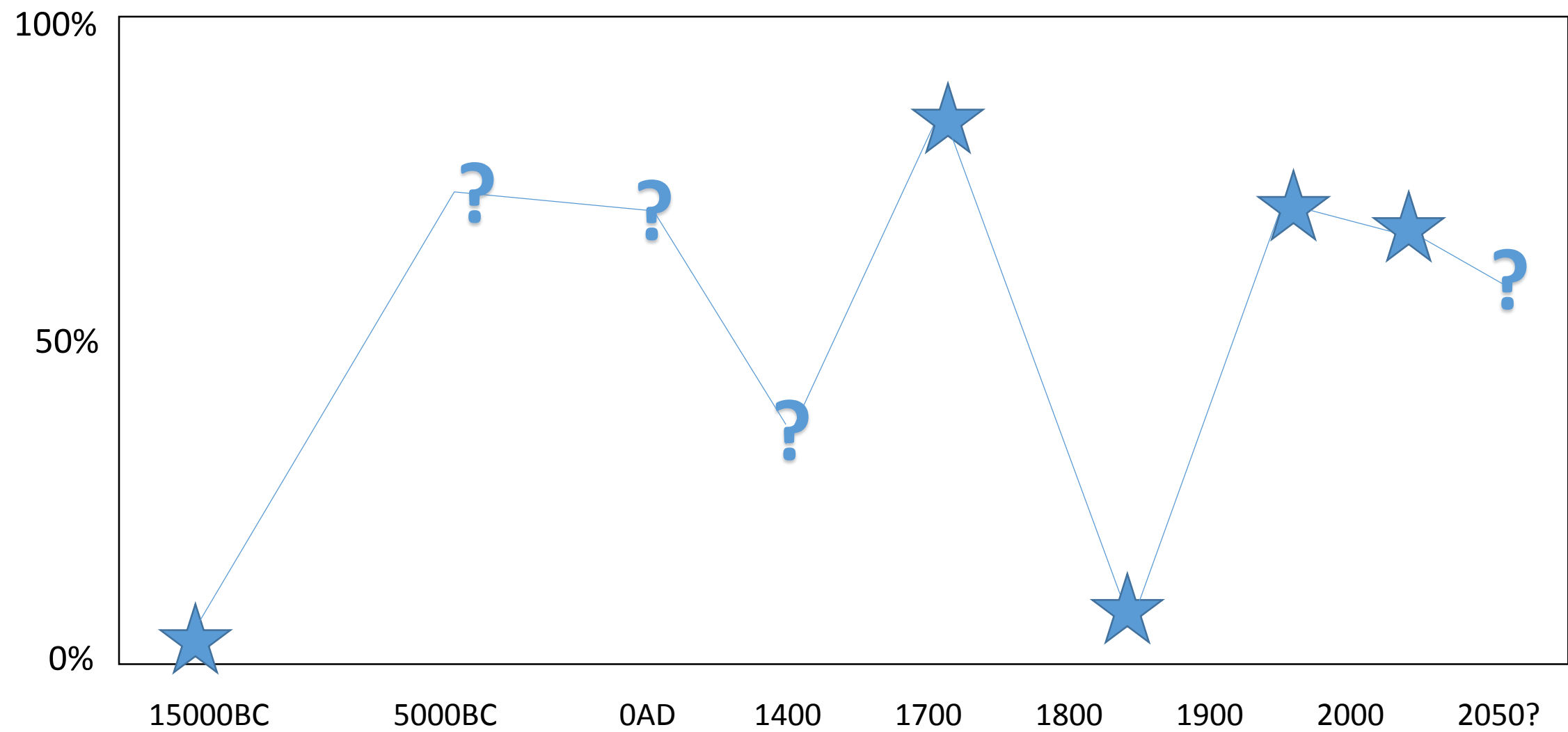
# Forests of New England/CT

- Modern forest composition is a construct of:

  - Post-glacial migrations

  - Human land use and abandonment

  - Indirect human impacts such as pests/disease and invasive species

  - Environmental gradients related to climate and geology/geomorphology

- Future is uncertain – cover may not decrease much, but function could
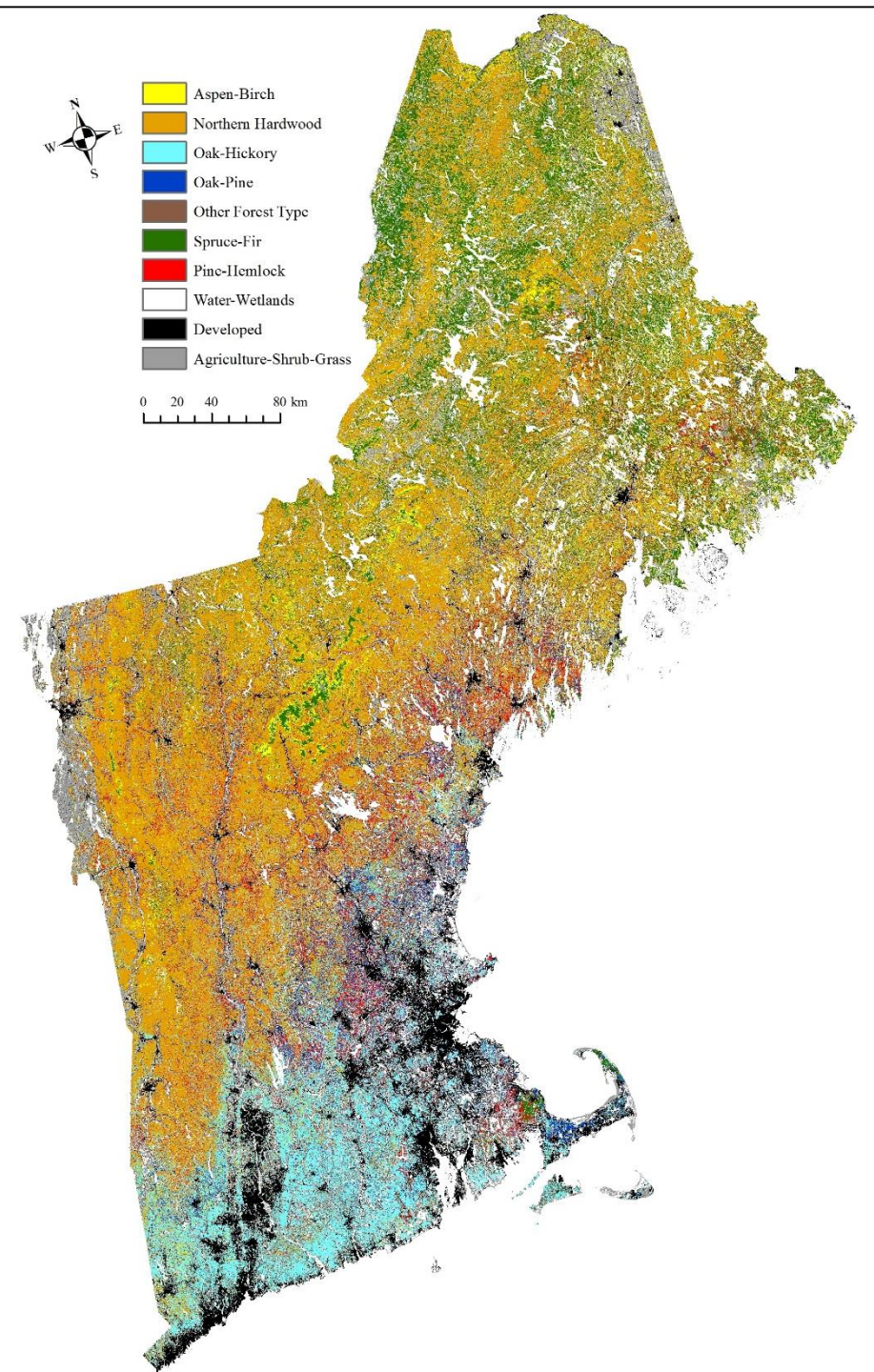
# Disturbance!

- Process that disrupts ecosystem composition, structure, and/or functioning

# Causes of Forest Disturbance

## Natural

- Wind
- Fire
- Pests/pathogens
- Floods
- Ice storms/snow
- Drought
- Landslides
- Volcanoes

## Anthropogenic

- Logging
- Agriculture
- Development

# Wind

- Tornado



Oconto County, north of Mountain, June 7, 2007



Dept. of Natural Resources
Oconto Co.

# Pests/Pathogens

- Can be exotic or native
- Often related to other disturbance or stressors
- Insects or pathogens (fungal, bacterial, viral)
- Often affect ageing stands

# Water

- Floods – abrupt vs. long-term
- Ice/snow storms – timing is key

# Fire

- Wide variety of intensity
- Natural or anthropogenic
- Habitat, topography, biota all affect frequency and intensity
- Timing, scale, intensity, frequency – all control severity of ecosystem impacts

# Anthropogenic Disturbance

- Often very intense and long-lived impacts
- Especially development
- But…



"This is one of the grandest thought experiments of our time, a tremendous feat of imaginative reporting!" —Bill McKibben
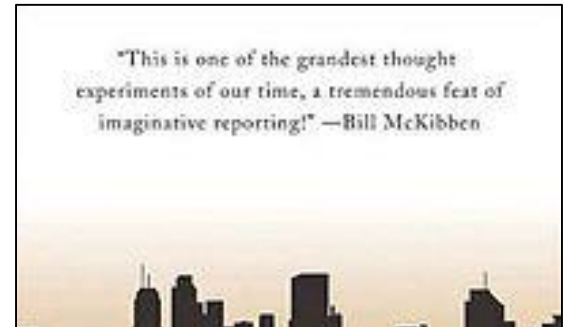
# Succession

- Change in species composition over time
- Happens in one place, over an extended period of time (as measured in 10s or 1000s of years)



weeds & grasses

shrubs

young forest community

mature forest community
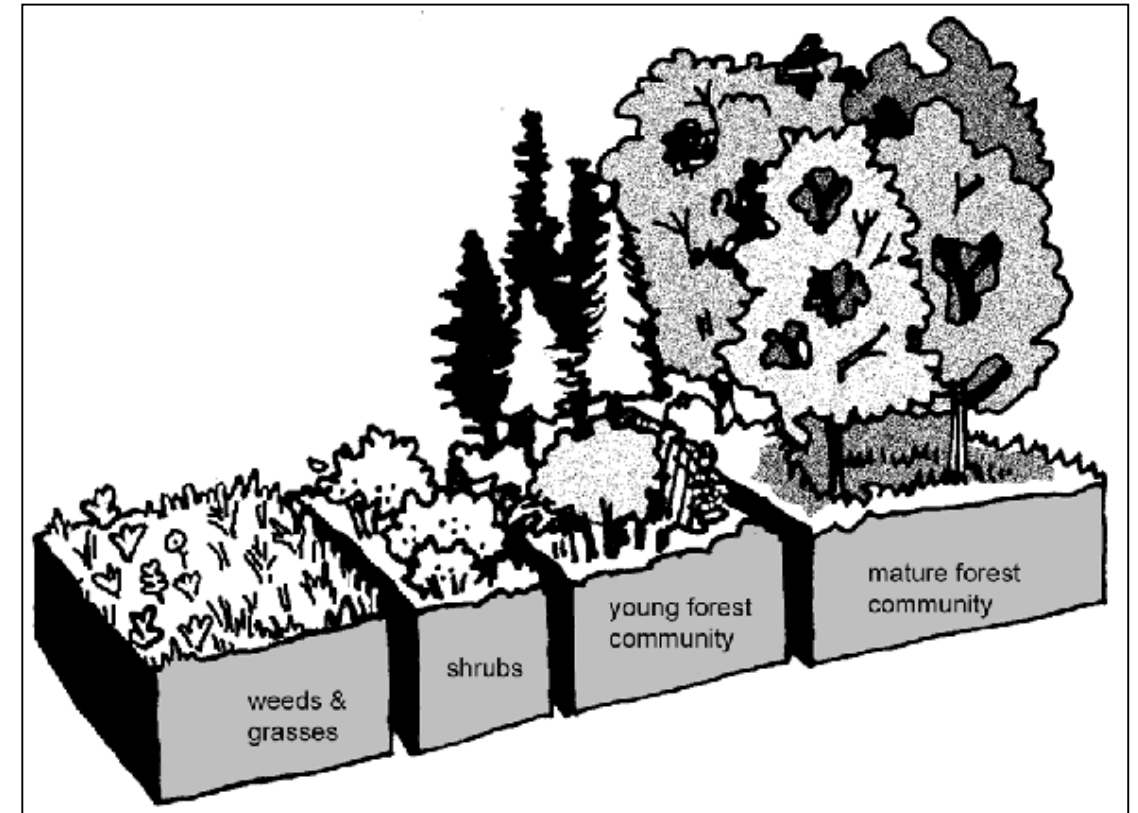
# Succession

Drivers of succession:

- Legacies

- Life history traits

- Species interactions (competition mostly)

- Disturbance/stochastic processes

- Resource depletion



Annual Plants | Perennial Plants and Grasses | Shrubs | Softwood Trees - Pines | Hardwood Trees

**Time** →
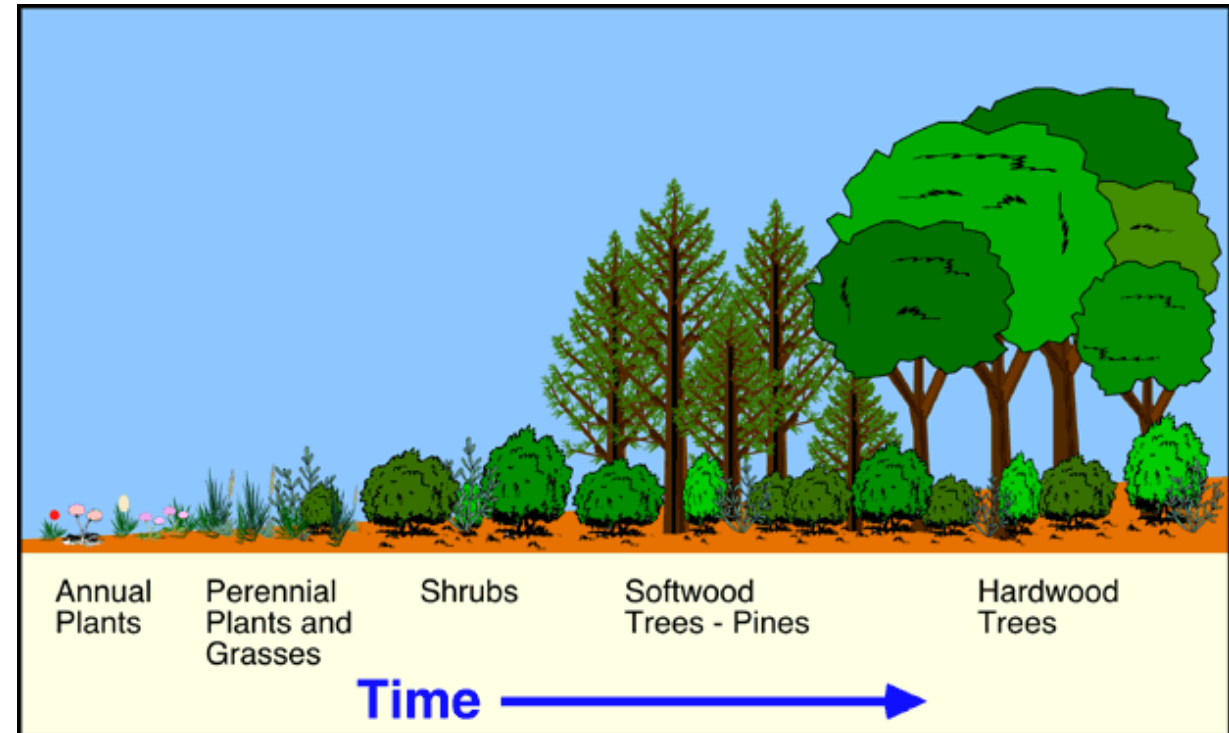
# Life History of Trees

- What does life history mean?
  - Investment in growth, reproduction, survival
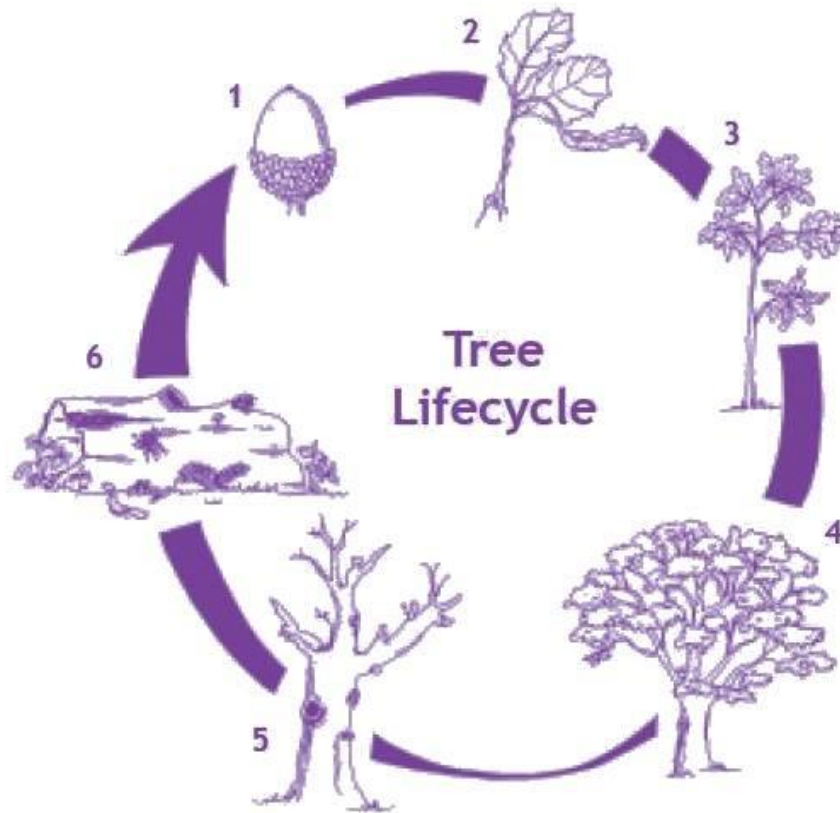
# Life History Traits of Trees

- What are some traits that might relate to life history in trees?

  - Life form – i.e., canopy vs. subcanopy

  - Longevity and growth rate

  - Shade Tolerance - Leaf type, morphology, longevity

  - Seed production & Dispersal strategy

  - Defense against herbivory

# Tree Reproduction

Steps in seed reproduction:

- Flowering/Pollination
- Seed production
- Seed dispersal/banking
- Germination
- Seedling establishment
- Recruitment

**Seed reproduction c[...]**

Sexually mature woody plant → Vegetative buds
- Climate
- Plant condition
- Resource availability

Sexually mature woody plant → Reproductive buds
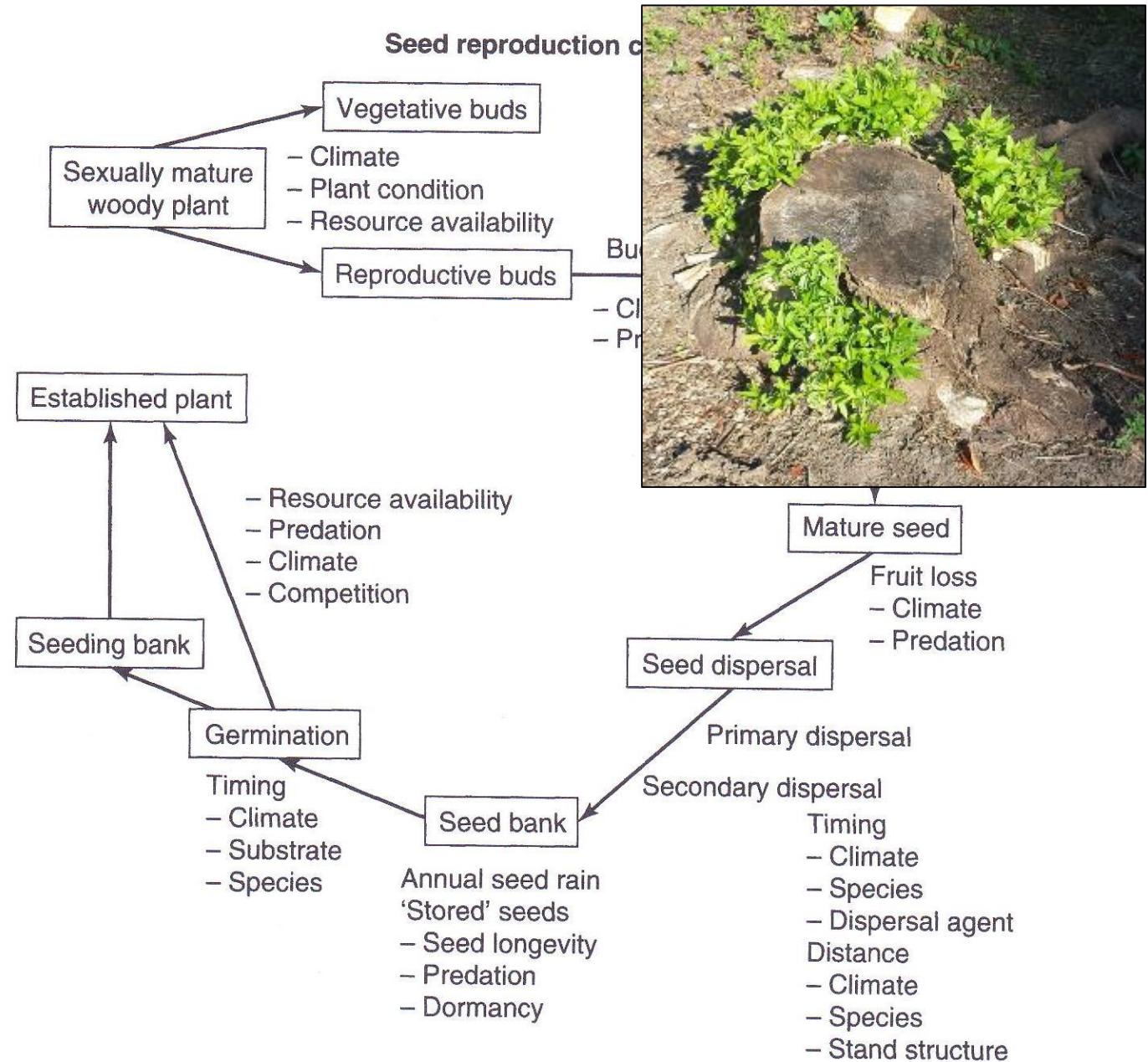Bu[...]
- Cl[...]
- Pr[...]



Mature seed
Fruit loss
- Climate
- Predation

Seed dispersal
Primary dispersal
Secondary dispersal
Timing
- Climate
- Species
- Dispersal agent
Distance
- Climate
- Species
- Stand structure

Seed bank
Annual seed rain
'Stored' seeds
- Seed longevity
- Predation
- Dormancy

Germination
Timing
- Climate
- Substrate
- Species

Seeding bank

Established plant
- Resource availability
- Predation
- Climate
- Competition

# Seed Reproduction

- Timing/Periodicity

- Amount

- Viability

- Size/resources

- Germination strategy

- Dispersal

Red oak



Yellow birch



| Factor | Yellow Birch | Red Oak |
|---|---|---|
| Timing | November | September |
| Periodicity | 1-3 years regular | 2-5 irregular |
| Amount | 2.5 – 89 million | 0 – 500,000 |
| Germination % | < 20% | > 50-90% |
| Dispersal | Wind (on snow) | Gravity (squirrels) |

# Seed Banking

- Some seed can remain viable in the ground for very long time periods – decades

- Advantage?

- Pin Cherry – 50 – 150 years! 10,000 – 1,000,000 per ha!

# Seed Banking

- Seed can also be banked on the tree
- Serotiny!

# Shade Tolerance

An important life history trait!

Basically comes down to whether you can survive in the shade of another species you are competing with

- Rankings among species are generally consistent, but:

- Varies across species' life stages

- Varies within species (among individuals) across sites

- Varies among ecotypes within species

# Shade Tolerance Rankings

| | Gymnosperms | Angiosperms |
|---|---|---|
| Very Tolerant | Hemlock<br>Balsam fir | Beech<br>Sugar maple<br>Hophornbeam |
| Tolerant | Spruces | Basswood<br>Red maple |
| Mid-tolerant | White pine | Yellow birch<br>White oak<br>Red oak<br>White ash |
| Intolerant | Red pine<br>Eastern redcedar | Black cherry<br>Black oak<br>Tulip poplar<br>Walnut<br>Black birch |
| Very intolerant | Jack pine<br>Tamarack | Aspens<br>Paper birch<br>Pin cherry |

# Longevity and Growth Rate

- An important life history tradeoff!

# Life History and Succession

- Early-successional species/communities – pioneers, ruderals

- Traits?

# Life History and Succession

- Late-successional species/communities
- Traits?

# Future of CT Forests

- Currently oak-hickory dominated forest ~100 years old

- Succession – more shade tolerant species – maples, beech, hemlock

- Exotic insect pests and pathogens – beech, ash, hemlock, oaks

- Invasive plant species

- Exurban development

- Climate change
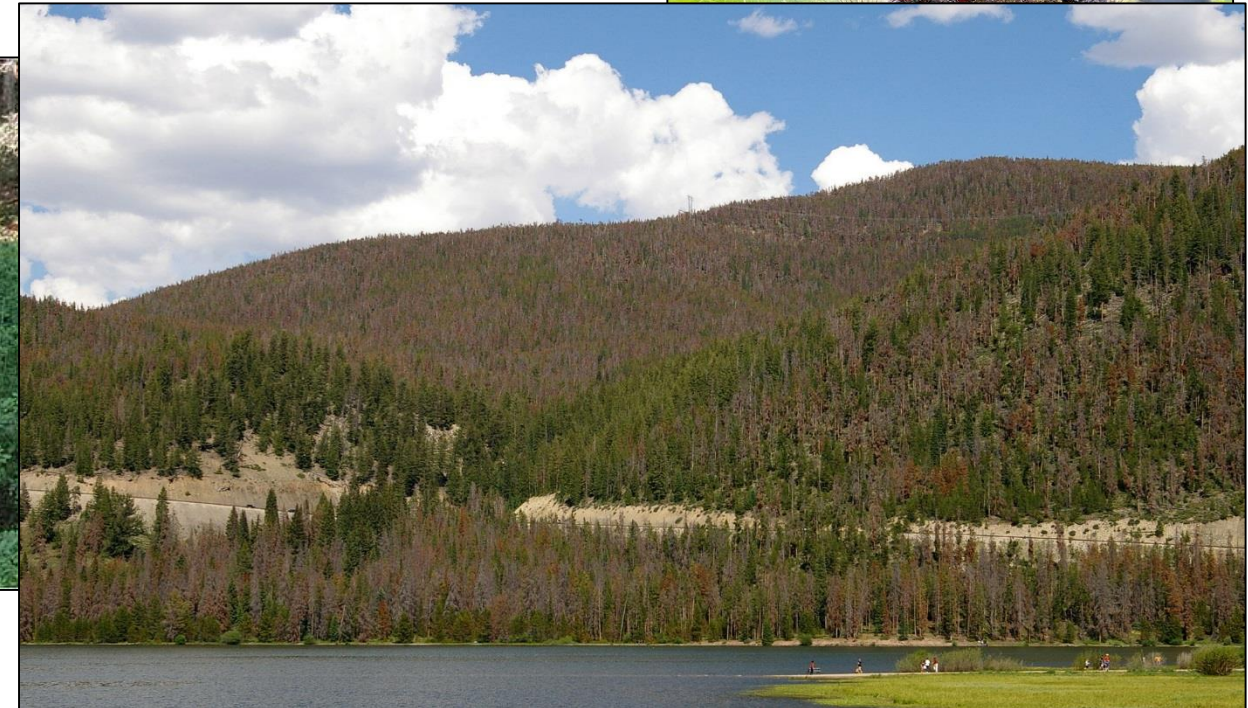
# Forests of the Future?

- Altered composition and structure

- Changes to functioning

- But forests are resilient!